Luxembourg in the Middle Ages - An Anthropological Study of the Living Conditions of the Rural Society of Grevenmacher

Dissertation
der Mathematisch-Naturwissenschaftlichen Fakultät
der Eberhard Karls Universität Tübingen
zur Erlangung des Grades eines Doktors der Naturwissenschaften
(Dr. rer. nat.)

vorgelegt von
Bernd Trautmann M.A.
aus Ravensburg

Tübingen
2012

Tag der mündlichen Qualifikation: 12.02.2013

Dekan:	Prof. Dr. Wolfgang Rosenstiel
1. Berichterstatter:	Prof. Dr. Joachim Wahl
2. Berichterstatter:	Prof. Nicholas J. Conard Ph.D.

"The present project is supported by the National Reasearch Fund, Luxembourg"

Fonds National de la Recherche Luxembourg

Table of contents

1. Introduction

The Grand Duchy of Luxembourg provides a great amount of archaeological sites from prehistory until modern times. Quite a few of these sites also revealed human remains (Weidig et al. 2011). However, only in the last few years some of these skeletal series were evaluated by physical anthropologists with modern scientific methods. The focus is thereby on the medieval period. There are several reasons for this. On one hand sites from older time periods often revealed only isolated individuals or bone remains. Therefore a comprehensive study of statistical significance is not possible. On the other hand bone preservation is often better in remains from younger ages due to a shorter period of embedding in the ground. With the evaluation of the skeletal remains from the medieval cemetery of Grevenmacher a series is now added, representing the population of a rural settlement that is promoted to the rank of a town. In general, studies of remains from a rural background are rare. This fact is quite surprising considering that almost 90% of the population in medieval times lived in rural environments (Rösener 1987, Vogt-Lüerssen 2001).

1.1. Archaeological background

The town of Grevenmacher is located about 24 km northeast of the city of Luxembourg directly at the German border (fig. 1).

fig. 1. Map of Luxembourg with the location of Grevenmacher

It is situated at a protected location on a lower terrace at the upper Moselle where an old trade route from Trier leaves the Moselle and ascends the plateau in the direction of the city of Luxembourg. Historical records refer to the possibility to cross the Moselle via a little island between the two supply streams "Gehaansbach" and "Rouderbach". This physiographical favourable location attracted people to settle in this area from a very early time on. Numerous archaeological finds from different time periods in the surrounding area as well as in the town, substantiate the assumption that this place was frequented repeatedly since prehistoric times (Bis-Worch 2005).
In the years 2003 till 2005 several excavation campaigns were carried out under the direction of Christiane Bis-Worch, conservator of the section of medieval studies at the Centre National de Recherche Archéologique Luxembourg. The focus of these archaeological studies has been mainly on information about the structural development and function of the town. During these excavations, in the area of the so called "Baxerasgarten", building structures from the roman period as well as the early and high medieval times were discovered. The earliest medieval building structures are pit houses and pits dating between the 8th and 12th century. Ceramics as well as residential waste indicate a domestic use of the houses. The pits were mainly used for storage and the extraction of calcareous tufa. This material was most probably used for the construction of the first stone buildings. Rests of associated foundations were unearthed on the other side of the Baxerasgarten. Noteworthy in this context are fundaments of a church located within the remains of a previous building from the roman period. Finds of ceramics as well as human skeletal remains lead to the assumption that a church with an associated cemetery already existed in the earliest phases of the medieval settlement (Bis-Worch 2005, 2010). In 1252 Grevenmacher received the town charter. Around that point of time the existence of a church building with three naves can be assumed. This building had dimensions of 14 meters in length, the main hall was 5,2 meters wide and the side aisles measured 2,5 meters each. The choir in the south-eastern area was constructed as semicircular apse within a squared ground (fig. 2). In the north-western area of the main fundaments, some basements form a kind of entrance hall (Raum B) separated from the main hall. This entrance hall is again separated by two smaller side rooms, of those only one room is still preserved (Raum A). Within the basement of this side room a very uncommon accumulation of human remains was discovered. It is a package of cremated human bones that is 30 to 40 cm thick. At the bottom of the filling the bones are only partly burned or completely unburned. The rest of the burned bones were found in the main hall of the church as well as above the basement wall adjacent to the main hall (Bis-Worch 2005). The amount of the filling material is approximately 1536 kg and consists of burned and unburned human bones mixed with animal bones, sediment, mortar remains and further matter such as iron nails. A coin dates the entire complex between 1346 and 1386. A random sample of 37,1 kg from the filling was evaluated by the author as part of a Magister thesis at the University of Tuebingen, Germany (Trautmann 2007).

Some results of this study are part of the discussion in chapter 13 (comparison of the data from the inhumation graves and the burned bone complex). The point of abandonment of the church as well as the older settlement is dated with the help of coins and ceramic shards of near-stoneware and dates in the late 14th or early 15th century (Bis-Worch 2005, 2010).

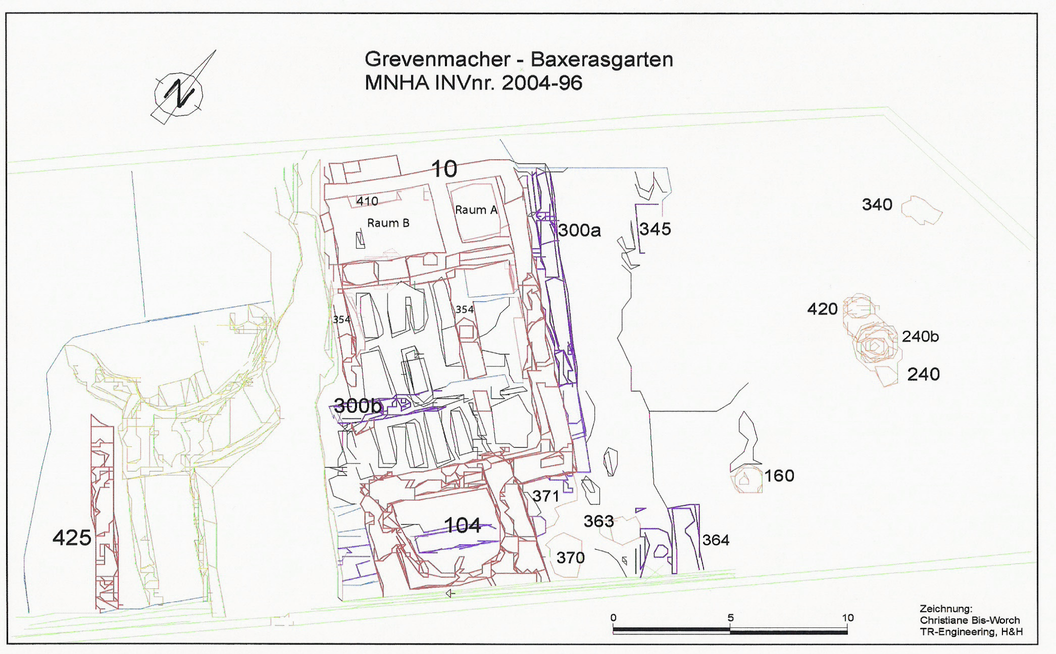


fig. 2. Overview of the structures in section 1 (picture: CNRA Luxembourg)

1.2. The cemetery

The cemetery is located east of the church building and covers an area of approximately 270 m^2 (fig. 3). This area is disrupted by a lot of pits and furnaces. Due to the form of these constructions and the connected finds of charcoal layers, burned clay and slags of non-ferrous metal, these complexes were used for bell casting associated with the construction of the church in the middle of the 13th century. On one hand graves disturb some of these constructions, on the other hand graves are disturbed by the pits. This implies that they were in use during the occupation time of the cemetery.

Graves are located in the cemetery area as well as within the church building. The buried individuals were oriented with the skulls in the west. Some graves are laterally faced with stones. Hints of wooden furnishing are only present in graves within the church. This implies that the majority of the individuals were buried in shrouds. The individuals showed different positions of their arms. Some were folded over the pelvis others were crossed over the breast or they were located elongated laterally at the body.

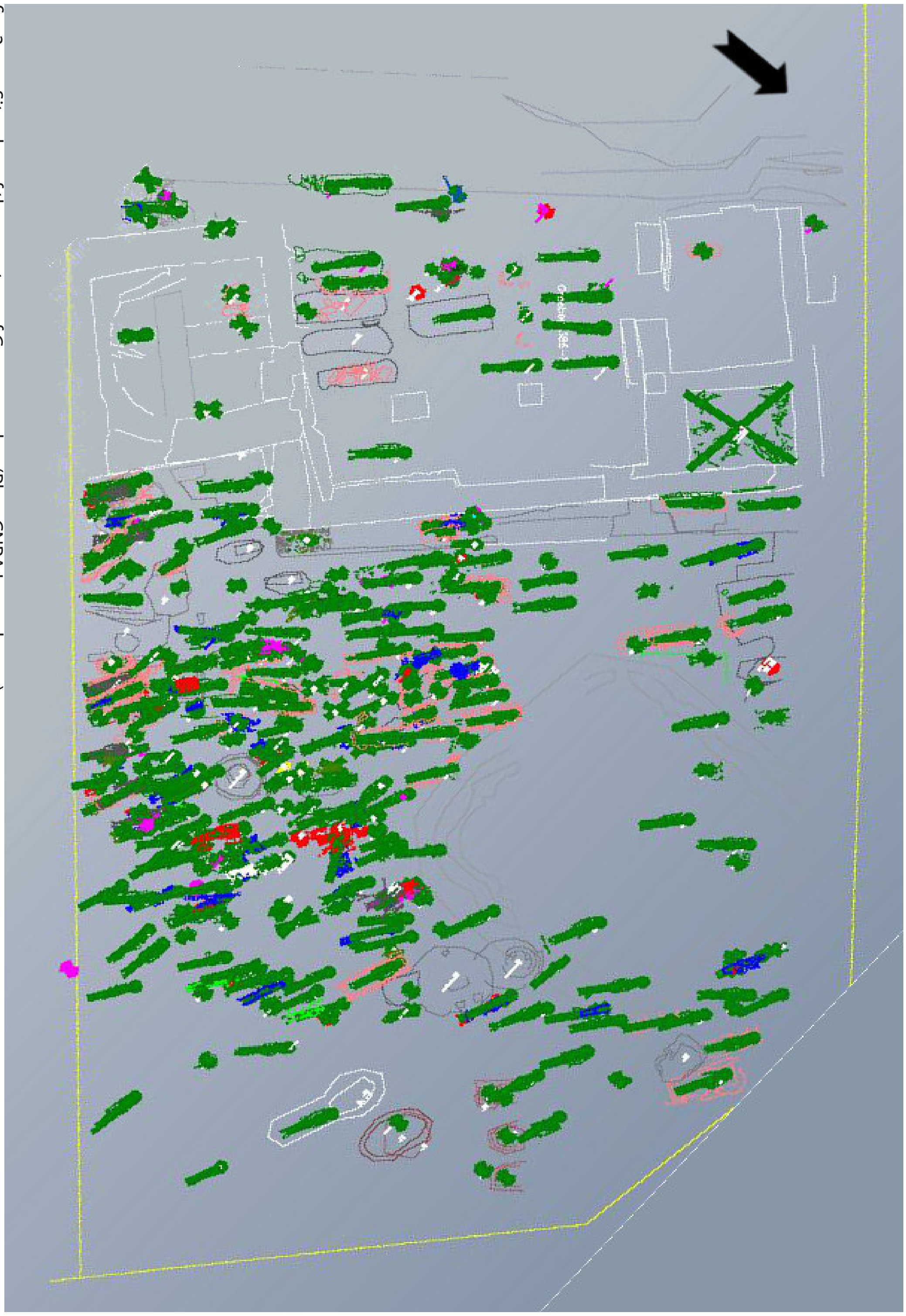


fig. 3. Site plan of the cemetery of Grevenmacher (Plan: CNRA Luxembourg)

Grave goods were found just in exceptional cases. Some graves contained spindle whorls, two individuals were buried with rosaries. In one grave a bronze ring that was part of hair accessory was found. At the feet of one individual, two mugs made from near-stoneware were discovered. The most curious find is a cow horn placed between the legs of one individual (fig. 4). A grave within the church contained a scallop which is generally considered as a pilgrims badge. It can be assumed that with the abandonment of the church and older settlement in the late 14th or early 15th century, the occupation of the cemetery came also to its end. Within an overall small area of the cemetery a great amount of individuals were buried. This led to a very dense and repeated occupation of the cemetery, were often individuals were laid in already existing graves. This complicates the assignment of graves respectively individuals to specific time periods. Therefore it can be assumed that most of the inhumation graves under study can be assigned to the later chronological stage of occupation, dating to the 13th and 14th century. Some graves are disturbed in the course of the construction of a garden in the baroque period as well as modern walls (Bis-Worch 2005). Some of the bones where collected and reburied in pits (fig. 5), but it can also be assumed that during construction bones where destroyed or disposed of with the back-dirt. So certainly the excavations did not include all the outlying districts of the cemetery and it is to be expected that an unknown amount of graves are lost.

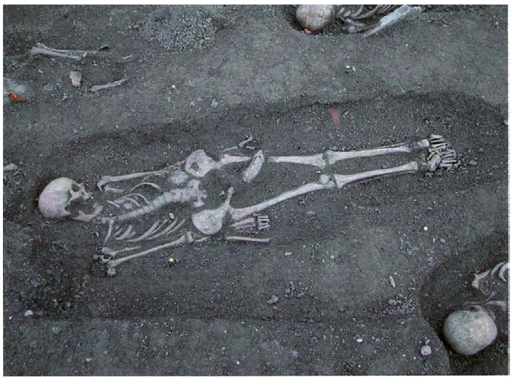


fig. 4. Grave 47 with cowhorn (picture: C. Bis-Worch, CNRA Luxembourg)

fig. 5. One of the graves disturbed during the construction of the baroque garden (picture: C. Bis-Worch, CNRA Luxembourg)

1.3. Aim of the study

While the archaeological examination of the building structures as well as the finds from Grevenmacher are concerned with the material and cultural aspect of the population, the main focus of this anthropological study is the human remains. The remaining bones and teeth are at first unique sources of individual data like age, sex, body height, physical adaptations as well as the burden of disease of a single individual. However, if a whole cemetery with hundreds of individuals is available, the individual data can be combined to allow reconstructions of population structures including age and sex relations, child mortality, pathological burden as well as statements about nutrition, economy and social structure of a specific population (Wahl 2007). An interdisciplinary approach of archaeological and anthropological data lead to a comprehensive understanding of ancient populations. The archaeological site of Grevenmacher provides favourable conditions for such a study. On one hand the archaeological and historical evaluations reveal a lot of information about the origin and development of the medieval town. On the other hand, the human remains from the cemetery allow an extensive study of the associated population. The cemetery of Grevenmacher has an exceptional character for anthropological studies in Luxembourg. For the first time a statistically relevant amount of human remains from medieval times was studied with modern anthropological methods, coming from a rural settlement and therefore represent a cross-section of a population, that did not face a special selection as it can be assumed for individuals originating from convent cemeteries like Luxembourg St. Esprit (Rehbach 2008), Luxembourg Neumünster (d'Hollosy and de Meulemeester 1999) or Luxembourg Hospice civil (Nothwang et al. 2004). Due to the rural background of the inhabitants, one focus of the evaluation is on activity related adaptations on the bones as well as pathological features that can possibly lead back to specific activities or labour. Furthermore the series of Grevenmacher includes a great amount of non-adult individuals. This fact allows a detailed evaluation of a group of individuals that is inadequately represented in other series from Luxembourg. Thus, special studies were implemented concerning demography, child mortality, growth and pathological burden of a subgroup never evaluated so extensively before. Therefore Grevenmacher can be considered as a reference series for medieval Luxembourg. Comparisons of data from Grevenmacher with other series from Luxembourg especially from convents and urban environments should indicate possible differences or similarities and therefore help to complete the picture of the population of medieval Luxembourg.

2. The bone material

The skeletal human remains unearthed during the excavation at Grevenmacher, were stored in 311 wooden boxes at the Musée National d'Histoire et d'Art, Luxembourg. As a first work step the remains had to be prepared for examination. This included cleaning of the bones from soil and sediment. This work was carried out at the working area and with the help of A&O Anthropologie und Osteoarchäologie, Praxis für Bioarchäologie, Tuebingen. The bones were cleaned under running water with soft brushes and sponges. Drying of the bones was carried out in special sieves at room temperature. Finally, broken and fragmented bones were glued together with water soluble wood glue to restore measuring sections that were destroyed by bone fragmentation.

2.1. Bone fragmentation and state of representation

The first step of the examination was the assessment of bone fragmentation, the state of representation of the skeleton as well as the condition of the bones. Overall, the degree of fragmentation of the bones was very low. The ribs were often highly fragmented. Bones of the skull, in particular the facial skeleton showed also a higher level of fragmentation, however the single parts were on average not smaller than 2 cm. Bones of the upper and lower limbs as well as the pelvis region showed just minimal fragmentation or they were completely unfractured.
The term representation refers to the number of bones of the skeleton that are still preserved. It is expressed in percentage as part of the skeleton. Therefore, a skeleton was divided in five major parts: skull, thorax/shoulder, arms/hands, pelvic region and legs/feet. Every part counts 20% of the skeleton. For every part that is missing the according percentage was deducted. This was recorded for every skeleton under study, adults as well as non-adults. Table 1 shows the average percentage of representation for the particular part and the skeleton as a whole.

tab. 1. Average percentage of representation of the particular part and the skeleton as a whole

	Skull	Thorax/ Shoulder	Arms/Hands	Pelvis	Legs/Feet	Entire Skeleton
adults	9,8%	9,7%	10,4%	10,2%	10,4%	49,5%
non-adults	10,4%	8,3%	7,3%	6,2%	7,4%	39,6%
total	10,1%	9,0%	8,9%	8,2%	8,9%	45,1%

The skeleton of an adult individual is represented to an average of 49,5%. The particular skeletal parts show no big difference in their state of representation. All parts are preserved to an equal degree of about 10%.

The skeleton of a non-adult individual is represented on an average of 39,6%, which is approximately ten percent less compared to an adult individual. However, the values of the respective parts of the skeleton show a greater difference compared to the adults. The skull is the part with the highest state of representation of about 10,4%. The pelvis region is preserved just to an average of 6,2%. No difference is visible in the particular age classes. All categories from neonatus to juvenis show the same state of representation. Reasons for the differing values between non-adults and adult are dicussed in detail in chapter 4.

In their study of six medieval and post-medieval collections Bello and Andrews (2006) calculated so called bone representation indices (BRI) to express the representation of specific bones of the evaluated skeletons. Summarizing the BRI of all bones, an average preservation of all skeletons of the specific collection can be calculated. These average preservations result in values from 48% to 73,9% for cemeteries and 76,2% to 77,9% for mass graves and crypt burials including adult and non-adult skeletons. However a comparison between the values of Grevenmacher and the values from Bello and Andrews (2006) is not without difficulties. First, the different methods that were used to estimate the respective figures complicate a direct comparison. Second, every bone collection has its own specific kind of formation and preservation and therefore the reasons of decay and bone loss are again not directly comparable. Despite the mentioned reasons, the results from Grevenmacher allow at least a rough classification. With 45,1% of representation it is on the lower end of the scale. Only the cemetery of Hauture/France got a similar value of 48% (Bello and Andrews 2006). Altogether data for skeletal representation in medieval cemeteries is rare. On one hand due to the lack of standardized recording methods, on the other hand influences on bone decay and bone loss in cemeteries and other burial grounds are diverse and therefore difficult to compare.

2.2. Condition of the bone material

The term condition refers to the level of destruction of the bones by external influences of the surrounding soil and the level of fragmentation. This was expressed by using four grades according to Trautmann (2012).

Hard: the bone was hardened post-mortem by mineral deposition. It is break-proof, resistant to water and it sounds like burned ceramics when it is hit with a metal probe.

Solid: the bone is not or just slightly decalcified. The surface structure is unchanged, the compact bone is dense, the cancellous bone is preserved to a great extent. It is break stable and resistant to water. It sounds like wood when it is hit with a metal probe.

Fragile: the bone is considerably decalcified, the surface is rough and cracked. The compact bone in some parts come off in flakes, the cancellous bone is mostly destroyed. The bone has to be treated with caution to prevent it from spontaneous breakage. It sounds like cardboard when it is hit with a metal probe.

Brittle: The bone structure is mostly resolved. It keeps its form just with the help of adhesive dirt. The bone crumbles to needle like particles when it gets in contact with water or after drying. Working with the bone is only possible after hardening.

A vast majority of the bone material is in a very good condition. 92,6% of the material can be categorised as hard. 6,6% of the material falls in the category solid and just 0,8% is categorised as fragile. In no case hardening of a bone was necessary. The bones of non-adults show no difference in their condition. 94,6% can be categorised as hard, the remaining 5,4% as solid. That means when bones of non-adults are present, they are mostly in good condition. There is also no difference in the particular age categories. Bones of newborns are as well preserved as bones of juveniles.

2.3. Summary

The absence of single bones, parts of skeletons or whole individuals from a burial site is mostly the result of two main factors. Taphonomic processes as well as cultural or social behaviours (Bello & Andrews 2006). The good condition of a vast majority of the bones from Grevenmacher leads to the conclusion that the sediments in which the bodies were buried exhibit good conditions for bone preservation. The main factors that influence soft tissue and bone decomposition in the ground are temperature, moisture, soil pH and associated materials (Carter and Tibbett 2008). This is visible in different kinds of discolorations of bones originating from humidity, different soil chemistry or traces of plant or animal effects. To what extent taphonomic processes are responsible for bone decay and loss of bone material especially in non-adult bones in Grevenmacher can not be expressed in figures. It is presumed that the main cause of an average representation of only 49,5% respectively 39,6% of a skeleton is disturbance after the burial. One probable reason is the fact that in the course of time a lot of individuals were buried in a limited area of a churchyard. It is very likely that when a new grave was opened, bones from earlier burials came to light. In medieval times this kind of problem was handled in different ways. Either the bones were collected and reburied somewhere else or some selected bones (often skulls and femora) were collected and stored in charnel houses. In the simplest case the bones were just pushed aside and the new body was buried in the same pit (Ohler 1990). The same treatment can be assumed on the cemetery of Grevenmacher. During the first operation single bones were very often overseen by the gravedigger or not all of the bones were collected properly. This fact is mirrored by the absence of little bones like phalanges of the hands and feet. However, when these bones are present in a burial they are in a good condition. So the absence of these bones can be only explained with the sloppy handling of the remains of former burials. The burial in a grave that was already in use leads to a mixture of bones from different individuals. At the cemetery these kinds of mixtures are present in different stages. They range from single bones that do not belong to a certain individual, to big concentrations of remains from different individuals accumulated in one pit (fig. 5). This is represented by the big amount of bone accumulations as part of the bone material.

3. Number of individuals, age and sex evaluation

3.1. Number of individuals

From the 311 boxes with bone material, each includes different numbers of individuals. To facilitate the evaluation, the boxes were separated in six categories (tab. 2) and every individual received its own identification number.

tab. 2. Classification of boxes and the respective number of individuals

category	number of boxes	number of individuals
Only one adult individual per box	147	147
More than one adult individual per box	14	29
One or more adults and one or more non-adults per box	27	72
One or more non-adults per box	26	54
Boxes with bone accumulations from which single individuals could be distinguished	38	69
Bone accumulations	59	
Total	311	371

The total number of 371 identified individuals serves as basis for the reconstruction of the population of Grevenmacher. All necessary data for the anthropological analysis were recorded from these individuals.

The term bone accumulation was used for boxes that contained bones from several individuals, often more than five. The possible occurrence of these bone accumulations was discussed in the previous chapter. As shown in table 2, two categories of bone accumulations were created. In the first category it was possible to identify 69 individuals out of 38 boxes. These individuals are included in the total number of individuals. Bone elements that were not assigned to a certain individual were used to calculate a minimum number of individuals (mni). This kind of estimation provides just an approximate value but it is at least possible to distinguish non-adult individuals from adults. The other category includes 59 boxes. Here it was not possible to distinguish any individuals. It was only possible to estimate a minimum number of individuals between non-adult and adult individuals. The determination of the minimum number of individuals includes a maximum and a minimum number. The intention was to limit the range within the real value must be located theoretically.

tab. 3. Estimated number of individuals

	estimated min. number of individuals	estimated max. number of individuals	identified individuals	total min. number of individuals	total max. number of individuals
adults	566	785	257	823	1042
non-adults	379	435	114	493	549
total	945	1220	371	1316	1591
non-adults %	40,1	35,6	30,7	37,5	34,5

(min.=minimum, max.=maximum)

As shown in table 3, the estimated number of individuals ranges from a minimum of 1316 and a maximum of 1591. The 371 individuals that are used for further examination is just a proportion of 28,2% respectively 23,3% of the possible total number of individuals. The percentages of the non-adult individuals range between 37,5% and 34,5%. The cemetery was used from the 8th to the early 15th century. That means an occupation time of almost 700 years. However most of the individuals can be assigned to the later phase from the 13th to 14th century. A long occupation time in connection with the limited area of the cemetery as well as within the church supports an overcrowding of the cemetery. It is not possible to reconstruct the real amount of properly arranged graves. But due to the limited area a value between 300 and 350 graves was recorded by the archaeologist. However, this area was finally occupied with an amount of individuals exceeding this number by a factor of four.

3.2. *Age determination*

The determination of the respective age and sex of every individual is the foundation of every population study. It should be noted that it is only possible to determine a physiological age of a skeleton. The large variability of age related changes on the bones make an exact age determination in terms of a chronological age impossible (Wahl 2007). Therefore age determinations are assigned to anthropological ranges or age classes. In this work age determination followed the classification of Martin (1957) shown in table 4.

tab. 4. Age estimation according to Martin (1957)

neonatus	infans I	infans II	juvenis	adultus	maturus	senilis
0- < 1 year	1-6 years	7-14 years	15-20 years	21-40 years	41-60 years	61 and older

Age determination of individuals, in this study, was determined using morphological criteria and metrical features following established methods according to different authors. Ageing of non-adult and adolescent individuals is possible with a considerable reliability. The most important method for the ageing of non-adults is the state of tooth development and eruption. In this work, schemes for tooth eruption established by Ubelacker (1979) and AlQahtani et al. (2010) were used. Another method is the measurement of long bone diaphysis. Some authors developed different tables in which they listed the length of different long bones to the respective age. In this work, tables of Kósa (1978), Stloukal and Hanáková (1978), Scheuer and Black (2000) as well as tables in Schaefer et al. (2009) were used for ageing. The age determination of adolescent and young adult individuals is based on the gradual adhesion of the epi- and apophysis of the bones. Here again several authors developed tables and schemes where they correlate the different states of adhesion with the respective ages. In this work schemes and tables of Gerhardt (1985), Baker et al. (2005), Scheuer and Black (2000) and tables in Schaefer et al. (2009) were used for ageing.

Age determination of adult individuals is a matter of much more uncertainty. Depending on the preservation and condition of the skeleton, it is often not more than an estimation. The fact that the remains of Grevenmacher are well preserved allows in many cases a relatively secure age determination. Here the state of fusion of cranial sutures was used according to the scheme after Vallois (1937) in Herrmann et al. (1990). Another method is the age related changes of the Facies symphysialis of the pubic bone after Brooks and Suchey (1990). Furthermore additional methods were used, e.g. the age related change of the sternal ends of the ribs according to Isçan and Loth (1986), the structures of the spongy parts in proximal humerus and femur after Nemeskéri et al. (1960) as well as degenerative changes in the spine and joints. In every individual as many methods as possible were applied for age determination. In general, due to the good preservation of the human remains, it was possible to subdivide the age categories adultus and maturus from ranges of twenty into ranges of ten years respectively in an early and late stage.

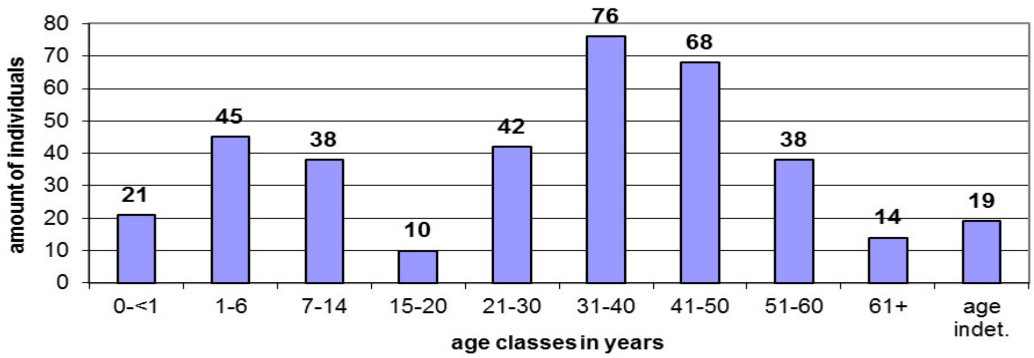


fig. 6. Age distribution of all individuals (n=371)

Figure 6 shows the age distribution of the 371 individuals under study. 257 adult individuals are spread over the three age categories adultus, maturus and senilis. In 19 individuals an exact age determination was not possible. They only could be assigned to adultus or older. 114 children and adolescents fill the age classes from neonatus to juvenis. So every age class is represented. The proportion of the non-adult individuals is calculated as a percentage of 30,7%. The expected proportion of non-adults in (pre-) historic populations is about 45% to 60% (Dollhopf 2002, Kölbl 2004). So in the case of Grevenmacher we have to mention a deficit in non-adults. (The reasons for such a deficit is discussed in the upcoming chapter 4: Paleodemography). The children show the highest rates of mortality in the age classes infans I and infans II, followed by the neonate individuals within their first year of life. The main reasons for these values is an increased risk of infection at and shortly after birth and at the time of weaning with the age of 2-3 years is assumed. Children and juveniles between 10 and 19 years of age have in general a lower mortality risk (Lewis 2007). This is mirrored in the decreasing values in the categories infans II and juvenile. The mortality rate increases again in the age class of early adultus (21-30 years) and reaches the highest values in the age categories of late adultus (31-40 years) and early maturus (41-50 years). Only a few individuals reach the oldest categories late maturus (51-60) and senilis (60+).

3.3. *Sex determination*

Sex determination of individuals is based on the evaluation of shape and size related features on the skeleton that mirror the sexual dimorphism within a population. These features are variable on one hand between the two sexes on the other hand between populations separated geographically and temporally (Herrmann et al. 1990).
Sex determination of non-adult individuals is limited by an important factor. Morphologically comprehensible features that describe sexual dimorphism are not developed until puberty. In all former age categories these features are very limited in their significance. Some authors developed methods for sexing non-adults referring mostly to the skull and the Os ilium. In this work, the methods used were established by Schutkowski (1993), Molleson and Cruse (1998), Loth and Henneberg (2001) and Cardoso and Saunders (2008). Metrical approaches for sex determination in non-adults are developed by Schutkowski (1987), concerning measures of the Os ilium and the femur diaphysis. Black (1978) used measures of tooth crown diameters of deciduous teeth.
The sex determination of adults, in contrast to sexing non-adults, is reliable with the help of two main fields of application. The combination of morphognostic and metrical traits allow determinations with a very high level of accuracy. The only limit is bone preservation and condition (Wahl 2007). In this work, sex determination of adults on the basis of morphognostic features follows the guidelines of Ferembach et al. (1979), Herrmann et al. (1990) and Rösing et al. (2005). Metrical features of the pelvis were used according to the method of Murail et al. (2005). Individuals were classified as male respectively female or rather male respectively rather female when the classification is not sure.

Sex distribution

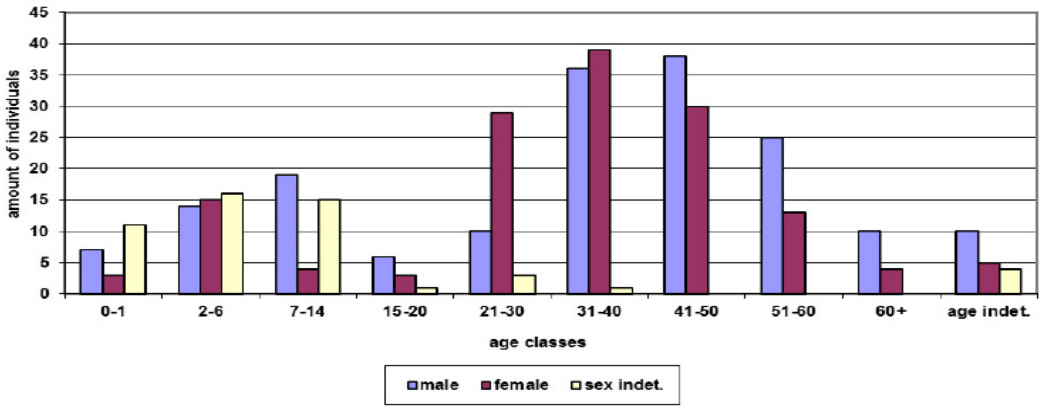


fig. 7. Age and sex distribution of all individuals (n=371)

Out of 257 adults, 129 individuals could be identified as male or rather male, 120 individuals as female or rather female. Only eight individuals did not allow a secure classification (fig. 7, tab. 5).

tab. 5. Age and sex distribution of the adult individuals (n=257)

	21-30	31-40	41-50	51-60	60+	age indet.	total
males	10 (23,8%)	36 (47,4%)	38 (55,9%)	25 (65,8%)	10 (71,4%)	10 (52,6%)	129 (50,2%)
females	29 (69,1%)	39 (51,3%)	30 (44,1%)	13 (34,2%)	4 (28,6%)	5 (26,3%)	120 (46,7%)
indeterm.	3 (7,1%)	1 (1,3%)	0 (0,0%)	0 (0,0%)	0 (0,0%)	4 (21,1%)	8 (3,1%)
total	42 (16,3%)	76 (29,6%)	68 (26,5%)	38 (14,8%)	14 (5,4%)	19 (7,4%)	257 (100,0%)

The relation between the two sexes is determined with the so called index of masculinity. It indicates the ratio of males and females in a population. It is calculated as follows: amount of males/amount of females x100 (Herrmann et al. 1990). For the Grevenmacher sample this index results in a value of 107,5. That means only a slight surplus of males. An almost balanced relation of men and women correlates with the expectations of a stable population. As seen in figure 7, the mortality of males and females differ significantly. Whereas in the age class adultus (21-40 years) more women than men died, this relation is inverted in the age class maturus (41-60 years). Here considerably more males than females are present. This trend continues till the age category senilis (60+). This relation is typical for (pre-)historic series. The reason for a surplus of women that died in the adult age class, especially in the category early adult (21-30 years) is assumed in the high risk of giving birth. Complications during birth and infections in connection with birth induced a higher mortality in women because of the limited medical treatment in medieval times (Grupe et al. 2005).

tab. 6. Age and sex distribution of the non-adult individuals (n=114)

	neonatus	infans I	infans II	juvenis	total
males	7 (33,3%)	14 (31,1%)	19 (50,0%)	6 (60,0%)	46 (40,4%)
females	3 (14,3%)	15 (33,3%)	4 (10,5%)	3 (30,0%)	25 (21,9%)
indeterminate	11 (52,4%)	16 (35,6%)	15 (39,5%)	1 (10,0%)	43 (37,7%)
total	21 (18,4%)	45 (39,5%)	38 (33,3%)	10 (8,8%)	114 (100,0%)

Table 6 shows the sex distribution of the non-adult individuals for the respective age classes. 43 individuals could not be classified, that means a percentage of 37,7%. The proportion of indeterminate individuals is the highest in the neonates with 52,4% and decreases to 10,0% in juveniles. Particularly striking is the high amount of male individuals in comparison to the females. In total almost twice as much individuals (46) were determined as males than females (25). In every age class from neonatus to juvenis the male values exceed the female values. In the category infans II even four times more males than females are present. The dominance of non-adult males is not unusual in (pre-)historic graveyards (Lassen et al. 2000). However, the circumstances are of various reasons and some of them are discussed in the following section. Studies of Bello et al. (2006) and Bello and Andrews (2006) showed that taphonomic processes affect bones of neonates and infants in different ways relating to sex. In their studied osteoarchaeological samples the skeletons of females aged from zero to four years were less well preserved and less well represented than male skeletons. However the reasons for this fact are not quite clear. It is assumed that differences in bone mineral content or bone mass acquisition are possible causes. Differences in sex ratios of newborns are also noticed after long lasting catastrophic impacts like famines (Song 2012). The predominance of vulnerability in males especially in perinates and infants is supported also by medical literature. The reasons therefore are still under discussion. Factors of natural selection are assumed as well as genetic diseases linked to the X chromosome (Stevenson et al. 2000, Wells 2000, Ulizzi u. Zonta 2002, Grupe et al. 2005). These are possible reasons for the surplus of males in the neonate category. However, we have to take into consideration the low number of identified individuals. 52,4% of all individuals are indeterminate and therefore, could change the sex ratio. The distribution in the category infans I however is again in balance. In the course of time, in this age class, male disadvantages seem to be equalized and the vulnerability in the time of weaning seems to affect both sexes the same way. The high rate of male children in the age class infans II raises some questions. One cause could be assumed in the integration of children in the working processes at an early stage of childhood. In medieval times children had to start work from the age of seven to eight years (Ulrich-Bochsler 1997, Orme 2001). While female children had to carry out mostly housework, male children had to do physically demanding and dangerous jobs in the fields, workshops and with animals. This fact increases the susceptibility for infections and accidents that lead to an early death. But this fact alone cannot justify such a high difference between males and females. Furthermore some authors claim that the division of labour in children was not that significant (Shahar 1991). A further possible cause is that males were buried in the cemetery while females were buried somewhere else. This differentiated treatment could be associated with the different status of males and females in medieval times. The higher status of males in general causes a preference of male offspring. In rural areas a preference of male children is conceivable because of the expected higher manpower for the often hard physical work in farming and craftsmanship (Schutkowski 1991, Shahar 1991, Orme 2001). One argument against this thesis is the fact that there are female children buried in the cemetery. It is not comprehensible why only in the age class infans II a separation of males and females in the burial rites was carried out. A further reason in the high rate of imbalance of the sexes could be seen in the overall unstandardised methods for sex determination in non-adults. This fact was mentioned before and it is quite possible that the integration of unsure determinations in the results lead to an apparent excess mortality in male children.

Age, sex, representation and condition of all 371 individuals under study

tab. 7. Adult individuals, only one individual per box

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
1	2004-96/957	369	50-60	male	79%	hard
2	2004-97/324	185	30-40	female	72%	hard
3	2004-96/322	172	30-40	male	83%	hard
4	2004-96/309+310	197	55-65	male	78%	hard
5	2004-96/948	312	35-45	male	94%	hard
6	2004-96/916	368	30-40	female	78%	hard
7	2004-96/319	169	20-25	female	88%	hard
8	2004-96/940	362	30-40	male	78%	hard
9	2004-96/687	278	30-40	male	35%	hard
10	2004-96/1292	373	40-50	(male)	44%	hard
11	2004-96/1161	388	50-60	male	92%	hard
12	2004-96/180	61	30-40	female	92%	hard
13	2004-96/838	339	50-60	female	35%	hard
14	2004-96/312	202	40-50	male	44%	hard
15	2004-96/313	201	30-50	(female)	40%	hard
16	2004-96/750	279	30-40	female	50%	hard
17	2004-96/793	290	50-60	male	87%	hard
18	2004-96/918	356	ad.o.o.	(male)	8%	hard
19	2003-96/146	35	ad.o.o.	(male)	12%	hard
20	2004-96/864	317+318	30-40	male	49%	hard
21	2004-96/1027	418	20-40	(male)	29%	hard
22	2004-96/408	147	60+	male	78%	solid
23	2004-96/308	192	ad.o.o.	(male)	26%	hard
24	2004-96/140	43	30-40	female	65%	hard
25	2004-96/260	96	20-30	female	62%	hard
26	2004-96/825	317	60+	male	88%	hard
27	2004-96/778	292	30-40	(female)	52%	hard
28	2004-96/233	89	40-50	female	29%	hard
29	2004-96/314	204	30-40	female	72%	hard
30	2004-96/973	375	60+	(female)	52%	solid
31	2004-96/923	346	20-25	female	51%	hard
32	2004-96/828	338	30-40	male	76%	hard
33	2004-96/917	358	40-50	male	26%	hard
34	2004-96/181	60	40-50	female	37%	hard

(tab. 7. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
35	2004-96/326	175	30-40	male	47%	hard
36	2004-96/434	163	20-30	(male)	54%	hard
37	2004-96/360	150	30-40	(male)	73%	hard
38	2004-96/915	313	50-60	male	77%	hard
39	2004-96/646	268	50-60	male	88%	hard
40	2004-96/833	314	20-30	female	78%	hard
41	2004-96/658	272	50-60	male	88%	hard
42	2004-96/296	93	30-40	female	60%	hard
43	2004-96/1039	409	50-60	male	43%	solid
44	2004-96/629	258	40-50	female	84%	solid
45	2004-96/269	131	25-30	female	77%	hard
46	2004-96/617	155	30-40	male	74%	hard
47	2004-96/no No.	430	ad.o.o.	(male)	15%	hard
48	2004-96/132	41	30-40	female	62%	hard
49	2004-96/316	no No.	30-40	female	49%	hard
50	2004-96/824	no No.	40-50	male	19%	hard
51	2004-96/304	84	35-45	male	72%	hard
52	2004-96/330	173	20-30	female	44%	hard
53	2004-96/423	181	20-30	male	70%	hard
54	2004-96/373	154	30-40	male	74%	hard
55	2004-96/117	47	50-60	female	87%	hard
56	2004-96/311	199	30-60	(male)	40%	hard
57	2004-96/172	72	60+	male	65%	solid
58	2004-96/1053	429	40-50	(male)	48%	hard
59	2004-96/1024	392	ad.o.o.	female	33%	solid
60	2004-96/823	346/347	30-45	(female)	38%	hard
61	2004-96/1049	416	20-30	female	60%	hard
62	2004-96/68	18	30-40	(male)	42%	hard
63	2004-96/1042	417	60+	male	85%	hard
64	2004-96/873	326	40-50	female	65%	hard
65	2004-96/870	348	ad.o.o.	(male)	19%	hard
66	2004-96/174	56	30-40	male	51%	hard
67	2004-96/1016	422	20-30	female	79%	hard
68	2004-96/318	196	50-60	male	41%	hard
69	2004-96/297	95	50-60	male	62%	hard
70	2004-96/265	141	40-50	(female)	47%	hard

(tab. 7. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
71	2004-96/1048	409	50-60	male	56%	solid
72	2004-96/913	359	20-30	male	79%	hard
73	2004-96/298	125	35-45	(male)	59%	hard
74	2004-96/1046	393	30-40	male	49%	solid
75	2004-96/720	295	40-50	male	36%	hard
76	2004-96/562	198	40-50	female	74%	hard
77	2004-96/126	33	20-30	female	77%	hard
78	2004-96/559	230	45-55	male	37%	hard
79	2004-96/289	83	40-55	(male)	60%	solid
80	2004-96/286	113	40-50	female	73%	hard
81	2004-96/843	331	20-30	(female)	68%	fragile
82	2004-96/935	351	40-50	male	31%	hard
83	2004-96/862/872	323	40-50	(male)	56%	hard
84	2004-96/942	347	20-50	(female)	17%	hard
85	2004-96/848	341	30-40	male	29%	hard
86	2004-96/236	116	30-40	male	38%	hard
87	2004-96/1054	424	50-60	female	87%	hard
88	2004-96/631	228	50-60	(male)	94%	hard
89	2004-96/ 1001/1002	372	30-40	male	93%	hard
90	2004-96/871	329	40-50	female	94%	hard
91	2004-96/822	335	50-60	(female)	87%	hard
92	2004-96/818	307	60+	male	74%	hard
93	2004-96/532	209	20-25	female	93%	hard
94	2004-96/288	97	20-30	male	90%	hard
95	2004-96/679	274	50-60	female	81%	hard
96	2004-96/1017	423	35-45	female	86%	hard
97	2004-96/254	112	40-50	(male)	62%	hard
98	2004-96/996	380	20-30	female	84%	hard
99	2004-96/263	115	30-40	male	43%	hard
100	1004-96/294	100	20-30	female	72%	hard
101	2004-96/850	337	50-60	female	59%	solid
102	2004-96/325	no No.	30-40	male	24%	hard
103	2004-96/656	261	60+	male	78%	hard
104	2004-96/841	302	50-60	female	84%	hard
105	2004-96/637	251	30-40	female	93%	hard

(tab. 7. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
106	2004-96/184	57	30-40	female	88%	hard
107	2004-96/1057	413	20-30	female	81%	hard
108	2004-96/295	92	25-30	female	92%	hard
109	2004-96/837	334	50-60	female	74%	hard
110	2004-96/334	148	45-50	male	58%	hard
111	2004-96/839	no No.	ad.o.o.	female	30%	hard
112	2004-96/1008	352	30-40	male	93%	hard
113	2004-96/175	58	40-50	male	56%	hard
114	2004-96/929	316	40-50	male	86%	hard
115	2004-96/135	40	60+	male	78%	hard
116	2004-96/591	55	30-50	male	27%	hard
117	2004-96/1014	421	20-25	male	86%	hard
118	2004-96/685	287	25-30	female	92%	hard
119	2004-96/410	167	40-50	female	72%	hard
120	2004-96/130	45	45-55	male	87%	hard
121	2004-96/865	318	20-25	female	89%	hard
122	2004-96/716	276	20-30	male	49%	hard
123	2004-96/134	42	40-50	male	81%	hard
124	2004-96/440	170	50-60	female	90%	hard
125	2004-96/1192	303	30-40	female	91%	solid
126	2004-96/372	149	45-55	male	83%	hard
127	2004-96/443	87	30-40	male	50%	hard
128	2004-96/1009	387	50-60	male	50%	solid
129	2004-96/782	263	30-50	female	58%	hard
130	2004-96/558	229	30-50	female	76%	hard
131	2004-96/323	188	50-60	male	62%	hard
132	2004-96/958	349	40-50	male	87%	hard
133	2004-96/874	322	45-55	male	79%	hard
134	2004-96/128	54	20-30	male	88%	hard
135	2004-96/409	153	50-60	female	78%	solid
136	2004-96/868	328	50-60	female	90%	hard
137	2004-96/844	315	60+	female	84%	hard
138	2004-96/539	206	30-50	female	71%	hard
139	2004-96/792	285	30-40	female	94%	hard
140	2004-96/356	162	20-30	female	72%	hard
141	2004-96/933	355	40-50	female	67%	hard

(tab. 7. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
142	2004-96/119	38	30-40	female	84%	hard
143	2004-96/377	144	30-40	male	83%	hard
144	2004-96/998	381	30-60	male	23%	hard
145	2004-96/666	262	50-60	male	42%	hard
146	2004-96/375	140	30-50	female	60%	hard
147	2004-96/1189	275	30-40	female	50%	hard

tab. 8. Adult individuals, more than one adult individual per box (n=29)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
201	2004-96/1052	383	40-50	female	94%	hard
202	2004-96/1051	383	30-60	(female)	11%	hard
203	2004-96/1040	427a	40-50	male	83%	hard
204	2004-96/1040	427b	40-50	(female)	10%	hard
205	2004-96/965	375a	30-60	(female)	25%	hard
206	2004-96/965	375b	30-50	(male)	26%	hard
207	2004-96/659	257a	30-40	male	37%	hard
208	2004-96/659	257b	35-45	(male)	9%	hard
209	2004-96/683	271a	40-50	(male)	38%	hard
210	2004-96/683	271b	30-40	(female)	80%	hard
211	2004-96/259	121a	30-50	(female)	41%	hard
212	2004-96/259	121b	30-60	(male)	21%	hard
213	2004-96/535	208	30-50	female	13%	hard
214	2004-96/527	11	25-30	female	47%	hard
215	2004-96/954	353a	40-50	male	33%	hard
216	2004-96/954	353b	40-50	male	18%	hard
217	2004-96/819	311	30-50	male	44%	hard
218	2004-96/820	310	30-40	female	13%	hard
219	2004-96/927	330	ad.o.o.	indeterm.	16%	hard
220	2004-96/924	324	ad.o.o.	(female)	16%	hard
221	2004-96/628	232a	40-50	male	65%	hard
222	2004-96/628	232b	30-40	(female)	42%	hard
223	2004-96/859	332a	40-50	female	26%	hard
224	2004-96/859	332b	50-60	(male)	14%	hard
225	2004-96/859	332c	60+	(female)	10%	hard
226	2004-96/415	184	40-50	female	38%	hard
227	2004-96/417	187	30-40	(male)	24%	hard
228	2004-96/983	386	50-60	male	92%	solid
229	2004-96/984	386	40-50	(female)	26%	solid

tab. 9. Adult individuals, one or more adult and one or more non-adult individuals per box (n=35)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
301	2004-96/638	233	30-40	(female)	38%	hard
303	2004-96/327	171	30-50	male	37%	hard
305	2004-96/1010	361	60+	female	89%	hard
307	2004-96/176	68	25-35	female	95%	hard
309	2004-96/391	146	40-50	male	41%	hard
312	2004-96/846	344a	30-40	male	13%	hard
313	2004-96/846	344b	30-40	female	34%	hard
315	2004-96/no No.	Grab K15	40-50	male	24%	hard
316	2004-96/no No.	Grab K15	30-40	female	23%	hard
324	2004-96/654	255	30-60	(male)	14%	hard
325	2004-96/655	256	ad.o.o.	(female)	11%	hard
328	2004-96/616	248	30-50	(female)	38%	hard
333	2004-96/317	189a	30-40	male	30%	hard
335	2004-96/835	no No.	40-50	female	68%	hard
336	2004-96/835	no No.	40-50	female	16%	hard
339	2004-96/1160b	379	30-40	male	78%	hard
340	2004-96/1160a	379	30-50	(female)	40%	hard
342	2004-96/852	317	30-50	(male)	19%	hard
343	2004-96/858	319	30-60	(male)	16%	hard
345	2004-96/1086	306	30-40	(female)	13%	hard
346	2004-96/1087	308	30-60	(male)	18%	hard
349	2004-96/875	no No.	50-60	(male)	37%	hard
350	2004-96/875	no No.	30-40	(female)	14%	hard
352	2004-96/267	158	40-50	female	58%	solid
355	2004-96/370	137	25-35	female	60%	hard
357	2004-96/390	143	30-50	(female)	39%	hard
359	2004-96/834	333	30-40	female	78%	hard
361	2004-96/934	no No.	20-40	male	34%	hard
362	2004-96/934	no No.	20-40	female	19%	hard
364	2004-96/972	376	50-60	(male)	50%	fragile
366	2004-96/379	152	30-60	(male)	9%	hard
369	2004-96/381	132	40-60	male	50%	hard
371	2004-96/385a	130	30-40	(female)	20%	hard
374	2004-96/173	59	40-50	(male)	35%	hard
376	2004-96/241	111	40-50	female	49%	hard

tab. 10. Adult individuals out of bone accumulations (n=46)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
503	2004-96/1089	305	ad.o.o.	(male)	14%	hard
505	2004-96/239	118	ad.o.o.	(male)	15%	hard
506	2004-96/240	128	ad.o.o.	(male)	8%	hard
508	2004-96/412	149	50-60	female	10%	hard
510	2004-96/421	120a	20-30	female	31%	hard
511	2004-96/421	120b	30-40	male	30%	hard
512	2004-96/421	120c	40-50	male	18%	hard
514	2004-96/722	284	20-30	female	34%	hard
519	2004-06/644	231	20-30	female	57%	hard
521	2004-96/860	324	20-40	(female)	16%	hard
523	2004-96/1183	no No.	40-60	(male)	40%	hard
526	2004-96/920	349	30-40	(male)	19%	hard
527	2004-96/921	no No.	20-40	(female)	32%	hard
529	2004-96/549	220	30-40	(female)	51%	hard
533	2004-96/777	296	20-40	female	31%	hard
537	2004-96/691	no No.	50-60	male	40%	hard
542	2004-96/407	157	20-40	female	37%	hard
543	2004-96/614	239	ad.o.o.	(male)	15%	hard
546	2004-96/840	no No.	60+	male	14%	hard
548	2004-96/576	no No.	20-30	(female)	13%	hard
551	2004-96/720	295	20-40	(male)	31%	solid
552	2004-96/465	156	20-40	indeterm.	7%	hard
556	2004-96/842	no No.	30-40	female	34%	hard
557	2004-96/1007	371	20-40	(male)	14%	hard
558	2004-96/965	375	ad.o.o.	indeterm.	8%	hard
563	2004-96/583	273	20-40	indeterm.	18%	hard
564	2004-96/584	269	20-30	indeterm.	12%	hard
567	2004-96/361	136	40-50	female	43%	hard
581	2004-96/88	no No.	40-50	male	17%	hard
590	2004-96/355	168	30-50	(male)	50%	hard
598	2004-96/729	289	20-40	(female)	14%	hard
605	2004-96/393	193	20-40	female	17%	hard
610	2004-96/1194	270	30-50	male	38%	hard
612	2004-96/235	124	30-50	female	28%	hard
615	2004-96/1190	275	50-60	(male)	23%	hard
631	2004-96/1043	no No.	60+	(male)	14%	hard

(tab. 10. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
633	2004-96/398	203	40-50	(female)	11%	hard
639	2004-96/436	99	40-50	(male)	15%	hard
644	2004-96/646	260	ad.o.o.	(male)	16%	hard
648	2004-96/237	114	20-30	female	18%	hard
649	2004-96/238	117	20-25	indeterm.	13%	hard
654	2004-96/980	no No.	40-50	(female)	9%	hard
655	2004-96/673	235	30-50	female	29%	hard
661	2004-96/307	142	40-50	male	35%	hard
662	2004-96/274	127	ad. o.o.	indeterm.	12%	hard
685	2004-96/419	110	ad.o.o.	indeterm.	8%	hard

tab. 11. Non-adult individuals (n=54)

ID. No.	Befund No.	Complex	Age	Sex	Representa-tion	Condition
SA1	2004-96/299	94	12-14	(male)	42%	hard
SA2	2004-96/991	378	9-11	(male)	86%	hard
SA3	2003-96/14	17	5-7	(male)	89%	hard
SA4	2004-96/290	102	10-12	(male)	79%	hard
SA5	2004-96/321	138	5-8	(male)	85%	hard
SA6	2004-96/417	88	3-4	(male)	64%	hard
SA7	2004-96/418	85	13-15	(male)	63%	hard
SA8	2004-96/849	336	3-5	(female)	74%	hard
SA9	2004-96/847	342	~2	indeterm.	18%	hard
SA10	2004-96/911	320	5-6	(male)	93%	hard
SA11	2004-96/949	350	4-5	(female)	52%	hard
SA12	2004-96/182	62	8-10	(male)	29%	hard
SA13	2004-96/302	83	2-3	indeterm.	18%	solid
SA14	2004-96/136	34	15-20	male	49%	hard
SA15	2004-96/112	53	15-17	(male)	64%	hard
SA16	2004-96/587	250	18-20	female	94%	hard
SA17	2004-96/939	357	15-20	(male)	54%	hard
SA18	2004-96/332	179	12-15	(male)	51%	solid
SA19	2004-96/632	227	13-15	(female)	50%	solid
SA20	2004-96/665	267	15-20	female	91%	hard
SA21	2004-96/1011	415	16-20	male	95%	hard
SA22	2004-96/867	332	17-20	(female)	92%	hard
SA23	2004-96/869	325	9-11	(male)	63%	hard
SA24	2004-96/273	126	10-13	(male)	82%	hard
SA25	2004-96/271	165	4-7	(male)	85%	hard
SA26	2004-96/1293	441	7-9	indeterm.	32%	solid
SA27	2004-96/821	304	2-3	(male)	64%	hard
SA28	2004-96/827	302	7-8	(male)	48%	hard
SA29	2004-96/1083	304	2-3	indeterm.	11%	hard
SA30	2003-96/1085	301	9-10	(male)	18%	hard
SA31	2004-96/725	298	1-2	(male)	45%	hard
SA32	2004-96/760	302a	8-9	(male)	21%	hard
SA33	2004-96/760	302b	1-2	(female)	13%	hard
SA34	2004-96/739	291a	~10	indeterm.	19%	hard
SA35	2004-96/767	299d	3-6 months	indeterm.	13%	hard
SA35a	2004-96/767	299b	9-12 months	indeterm.	8%	hard

(tab. 11. continued)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
SA36	2004-96/769	299c	3-6 months	indeterm.	6%	hard
SA37	2004-96/718	299a	0-1	indeterm.	7%	hard
SA38	2004-96/745	301	1-2	indeterm.	4%	hard
SA39	2004-96/1035	397a	1-2	(male)	68%	hard
SA40	2004-96/1035	397b	1-2	(female)	23%	hard
SA41	2004-96/1036	396a	inf II	indeterm.	10%	hard
SA42	2004-96/1036	396b	inf I	indeterm.	18%	hard
SA43	2004-96/1044	403a	0-3 months	(male)	59%	hard
SA44	2004-96/1044	403b	7-9 lunar m.	(male)	73%	hard
SA45	2004-96/1058	404	0-6 months	indeterm.	25%	hard
SA46	2004-96/1059	407	7-9 lunar m.	(male)	57%	hard
SA47	2004-96/1060	406	0-3 months	indeterm.	85%	hard
SA48	2004-96/1061	no No.	2-4	indeterm.	12%	hard
SA49	2004-96/1062	395	0-3 months	(male)	51%	hard
SA50	2004-96/432	129	6-12 months	(male)	47%	hard
SA51	2004-96/1032	401a	0-6 months	(female)	83%	hard
SA52	2004-96/1032	401b	0-1	indeterm.	30%	hard
SA53	2004-96/1036	405	0-1	Indeterm.	19%	hard

tab. 12. Non-adult individuals in connection with adult individuals (n=37)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
302	2004-96/639	234	10-12	indeterm.	42%	hard
304	2004-96/327	171	5-7	(male)	37%	hard
306	2004-96/1010	361	7-9	indeterm.	15%	hard
308	2004-96/176	69	0-6 months	(female)	43%	hard
310	2004-96/392	186	5-7	indeterm.	11%	hard
311	2004-96/392	186	inf. I	indeterm.	8%	hard
314	2004-96/841	344	4-5	(female)	20%	hard
317	2004-96/955	360	3-5	indeterm.	12%	hard
318	2004-96/955	360a	11-14	(male)	25%	hard
319	2004-96/955	360b	4-5	(male)	70%	hard
320	2004-96/955	360c	11-14	(femlae)	18%	hard
326	2004-96/652	244	7-10	(male)	68%	hard
327	2004-96/653	63	7-9	indeterm.	18%	hard
329	2004-96/387	178	16-20	(male)	23%	hard
330	2004-96/574	266a	10-15	indeterm.	18%	hard
331	2004-96/581	266b	inf. II	indeterm.	11%	hard
332	2004-96/335	168	6-7	(male)	72%	solid
334	2004-96/317	189	12-14	indeterm.	17%	hard
337	2004-96/835	no No.	2-4	(female)	26%	hard
338	2004-96/835	no No.	~6 months	indeterm.	13%	hard
341	2004-96/1160a	379	0-6 months	(male)	47%	hard
344	2004-96/855	321	14-18	indeterm.	19%	hard
351	2004-96/875	no No.	15-20	(male)	30%	hard
353	2004-96/267	158b	5-8	(female)	20%	hard
354	2004-96/267	158c	3-5	indeterm.	16%	hard
356	2004-96/371	138	5-7	(female)	53%	hard
358	2004-96/390	143	inf I	indeterm.	11%	hard
360	2004-96/834	333	0-1	indeterm.	13%	solid
363	2004-96/934	no No.	9-11	indeterm.	19%	hard
365	2004-96/845	315	9-11	(male)	30%	hard
367	2004-96/379	252	4-6	(male)	76%	hard
368	2004-96/379	151	7-8	(male)	48%	hard
370	2004-96/380	145	8-9	(female)	65%	hard
372	2004-96/385a	130	0-1	indeterm.	5%	hard
373	2004-96/385a	130	inf I	indeterm.	4%	hard
375	2004-96/173	59	12-14	indeterm.	24%	hard
377	2004-96/241	111	2-4	indeterm.	19%	hard

tab. 13. Non-adult individuals out of bone accumulations (n=23)

ID. No.	Befund No.	Complex	Age	Sex	Representation	Condition
501	2004-96/1089	309	6-7	indeterm.	27%	hard
502	2004-96/1089	303	9-11	indeterm.	8%	hard
513	2004-96/421	120d	4-7	(female)	12%	hard
524	2004-96/404	131b	9-10	(male)	30%	hard
534	2004-96/420	122	4-6	(male)	74%	hard
535	2004-96/776	302	2-3	indeterm.	10%	hard
549	2004-96/577	249	3-5	(female)	24%	hard
562	2004-96/582	264	5-8	(male)	75%	hard
568	2004-96/388	175	2-4	(female)	61%	hard
569	2004-96/386	177	2-4	(female)	21%	hard
575	2004-96/742	291	8-11	(male)	49%	hard
576	2004-96/397	200	1-2	(male)	61%	hard
577	2004-96/744	303	7-9	indeterm.	14%	hard
582	2004-96/441	86	8-10	indeterm.	17%	hard
621	2004-96/741	277	7-9	(male)	77%	hard
628	2004-96/300	98	1-3	(female)	61%	hard
634	2004-96/400	109	1-2	indeterm.	21%	hard
652	2004-96/353	101	2-4	(female)	39%	hard
656	2004-96/992	656a	0-6 months	(female)	53%	hard
657	2004-96/992	656b	6-12 months	(male)	38%	hard
666	2004-96/764	303	2-4	(female)	37%	hard
675	2004-96/772	291b	4-5	(female)	44%	hard
681	2004-96/717	no No.	1-2	indeterm.	10%	hard

4. Paleodemography

The two fields of demography that mainly deal with past populations are paleodemography as well as historical demography. While historical demography predominantly uses written sources, paleodemography often has no access to such tools. So the definition of paleodemography can be expressed as the reconstruction of biological processes and living conditions of a prehistoric population on the basis of the study of their human remains (Langenscheidt 1985, Grupe et al. 2005). The point of departure for every paleodemographic study is the individual data received from every single skeleton of the studied series. These are mainly the sex and the age at death of every individual. The individual data was collectively summerized to reconstruct the paleodemography of the population (Herrmann et al. 1990, Grupe et al. 2005). Further information like the exact occupation period of the cemetery as well as the complete excavation of the respective graveyard is also prerequisite for demographic reconstructions (Langenscheidt 1985). In this work, different demographic parameters were evaluated. First mortality was calculated then summarized in mortality tables for all individuals under study as well as separated for men and women. Subsequently, the representation of the dead population is examined. The calculated parameters are the probability of death and the life expectancy in the different age classes, the mortality rate, the index of dependence, the estimation of population size and growth rate.

4.1. Calculation of mortality tables

According to Gabler (2009), a mortality table is a tabular presentation of the mortality conditions of a population during a certain time period, in the form of a periodic table. The term population is here referred to as a group of people that lived in a defined geographical region at a given point of time or a specific time range (Herrmann et al 1990, Grupe et al. 2005). In order to take into account the changes in the population structure caused by occupation of a graveyard during different time ranges, some conditions are presupposed for further calculations. It is assumed that the population under study is stationary. That means that the birth rate equals the death rate. It is further assumed that all individuals belong to a so called "cohort". In a cohort all individuals are born at the same vintage (Herrmann et al. 1990). Based on these conditions the calculation of a mortality table is carried out after the guidelines of Acsádi and Nemeskéri (1970). The classification of the individuals' age at death was carried out in categories of five years. In case of overlapping, over two or more age classes, the respective individuals were distributed pro rata over the categories. The respective columns contain the following information:
Age category (x), number of individuals that died in the respective age category (Dx),
the relative number of individuals that died in the respective age category (dx),

the relative number of survivors (lx), the probability of death (qx), the number of lived years in total (Lx), the amount of years left to live (Tx), and the average live expectancy (ex). Mortality tables were calculated for the entire population (tab. 14) as well as separated for adult males and females (tab. 15, tab. 16).

tab. 14. Mortality table including all individuals (n=371)

(x)	(Dx)	(dx)	(lx)	(qx)	(Lx)	(Tx)	(ex)
0-4	51,501	13,882%	100,000%	13,882%	4,653	30,449	30,449
5-9	33,081	8,917%	86,118%	10,354%	4,083	25,796	29,954
10-14	18,002	4,852%	77,202%	6,285%	3,739	21,713	28,125
15-19	11,416	3,007%	72,349%	4,253%	3,541	17,975	24,844
20-24	23,166	6,244%	69,272%	9,014%	3,308	14,434	20,837
25-29	22,167	5,975%	63,028%	9,480%	3,002	11,126	17,653
30-34	40,744	10,982%	57,053%	19,249%	2,578	8,124	14,240
35-39	42,254	11,389%	46,071%	24,721%	2,019	5,546	12,039
40-44	35,836	9,659%	34,682%	27,851%	1,493	3,528	10,171
45-49	36,003	9,704%	25,022%	38,783%	1,009	2,035	8,132
50-54	22,586	6,088%	15,318%	39,743%	0,614	1,026	6,701
55-59	20,744	5,591%	9,230%	60,577%	0,322	0,413	4,471
60+	13,500	3,639%	3,639%	100,000%	0,091	0,091	2,500
	371	100,000%			30,449	142,257	

tab. 15. Mortality table including all adult males (n=129)

(x)	(Dx)	(dx)	(lx)	(qx)	(Lx)	(Tx)	(ex)
20-24	6,250	4,845%	100,000%	4,845%	4,879	23,682	23,682
25-29	5,250	4,070%	95,155%	4,277%	4,656	18,803	19,761
30-34	18,662	14,467%	91,085%	15,883%	4,193	14,147	15,532
35-39	20,669	16,022%	76,619%	20,912%	3,430	9,955	12,993
40-44	19,502	15,118%	60,596%	24,949%	2,652	6,524	10,767
45-49	20,503	15,894%	45,478%	34,948%	1,877	3,872	8,515
50-54	15,252	11,823%	29,584%	39,964%	1,184	1,996	6,746
55-59	13,412	10,397%	17,761%	58,537%	0,628	0,812	4,573
60+	9,500	7,364%	7,364%	100,000%	0,184	0,184	2,500
	129	100,000%			23,682	79,976	

tab. 16. Mortality table including all adult females (n=120)

(x)	(Dx)	(dx)	(lx)	(qx)	(Lx)	(Tx)	(ex)
20-24	14,416	12,013%	100,000%	12,013%	4,700	18,271	18,271
25-29	15,417	12,848%	87,987%	14,602%	4,078	13,571	15,424
30-34	21,082	17,568%	75,139%	23,381%	3,318	9,493	12,634
35-39	20,585	17,154%	57,571%	29,797%	2,450	6,175	10,726
40-44	15,834	13,195%	40,417%	32,647%	1,691	3,726	9,218
45-49	15,000	12,500%	27,222%	45,919%	1,049	2,035	7,474
50-54	6,834	5,695%	14,722%	38,684%	0,594	0,986	6,698
55-59	6,832	5,693%	9,027%	63,072%	0,309	0,392	4,346
60+	4,000	3,333%	3,333%	100,000%	0,083	0,083	2,500
	120	100,000%			18,271	54,732	

4.2. *Representation of the skeletal series*

It is important to note that the data of every individual buried in the Grevenmacher cemetery is not used in this study. As mentioned in chapter 2, only the data of 371 out of a maximum of 1591 individuals are available for further calculations. Only 23,3% of the expected population is used. Therefore, an important parameter is to check to what extend the human remains under study form a representative part of a living population. Another issue is the deficit in non-adults also mentioned above. To check the representation, formulas of two authors were used. Weiss (1973) developed a method modelled after mortality tables of the United Nations for recent populations. He presumes that the 10-14 year old individuals within a population have the lowest death expectancy. Simultaneously the mortality of adolescents or young adults is lower than the mortality of newborns. From these two statements he derived the conditions (Q10 < Q15) and (Q0 > Q15).

$$\text{Mortality rate: } Q_x = 1 - \frac{lx+1}{lx}$$

$$Q_0 = 1 - \frac{l5\text{-}9}{l0\text{-}4} = 0{,}139$$

$$Q_{10} = 1 - \frac{l15-19}{l10-14} = 0{,}063$$

$$Q_{15} = 1 - \frac{l20-24}{l15-19} = 0{,}042$$

Condition Q10 < Q15 : 0,063 < 0,042 not fulfilled
Condition Q0 > Q15 : 0,139 > 0,042 fulfilled

The condition Q10 < Q15 : 0,063 < 0,042 is not fulfilled because in the Grevenmacher collection the 10-14 year old individuals do not have the lowest death expectancy as presumed by Weiss (1973). The juveniles (15-19 years) have the lowest death expectance. There are too few individuals represented in the age class of 15-19 years. A total of 35 individuals in this age class are necessary to fulfil the condition (lx = 74,030; Q15 = 0,041).

However, the formulas of Weiss (1973) are criticised because of the questionable application of recent mortality models on (pre-)historic populations. Furthermore, the impossibility of an absolute chronological age determination results in inaccurate values (Herrmann et al. 1990).
Bocquet and Masset (1977) developed an alternative formula. They summarize all adults in one age category to avoid the inaccuracy of age determination. They also consider a deficit of infants that occur in many skeletal series (Herrmann et al. 1990). In Grevenmacher such a deficit of infants is present by the proportion of just 30,7% of non-adults in the whole population. Bocquet and Masset (1977) state that the number of 5-9 years old individuals is at least twice as high as the number of the 10-14 years old individuals. Furthermore, the relation between the 5-14 years old individuals and the over 20 years old individuals is about ≥ 0,1.

$$\frac{D5-9}{D10-14} = 1{,}84$$

$$\frac{D5-14}{D20+} = 0{,}19$$

Condition (D5-9)/(D10-14) ≥ 2 not fulfilled
Condition (D5-14)/(D20+) ≥ 0,1 fulfilled

To fulfil the condition (D5-9)/(D10-14) ≥ 2 three more individuals in the age from five to nine had to be represented (Dx = 36,080; (D5-9)/(D10-14) = 2,0). The same increase of individuals in the ratio (D5-14)/(D20+) has no effect on this condition.
The results of the formulas according to Weiss (1973) and Bocquet and Masset (1977) show a high deficit of individuals in the juvenile category and a slight deficit of individuals in the category of the 5-9 years old. Both results state that the skeletal series of Grevenmacher is not representative in the case of the non-adult individuals. The rather slight discrepancy of three individuals in the formula of Bocquet and Masset (1977) is the result of the fact that the authors do not take the juveniles into consideration.

4.3. Probability of death

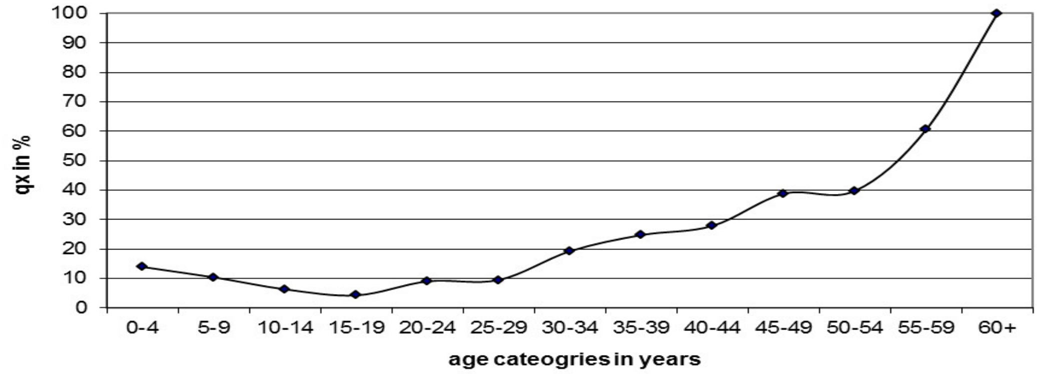


fig. 8. Probability of death for the whole population (n=371)

Figure 8 shows the probability of death for the whole population. The probability of death is relatively high in the first four years of life. After this period it decreases to its minimum in the category juvenis (15-19 years). In a normal represented series probability of death is usually lowest between 10 and 14 years (Strott 2006). In Grevenmacher the low amount of juvenile individuals represented in the series produces a shift to the juvenile category (see "representation of the series"). In the adult and mature age classes the probability of death increases constantly until it reaches its maximum with the age of 60+.

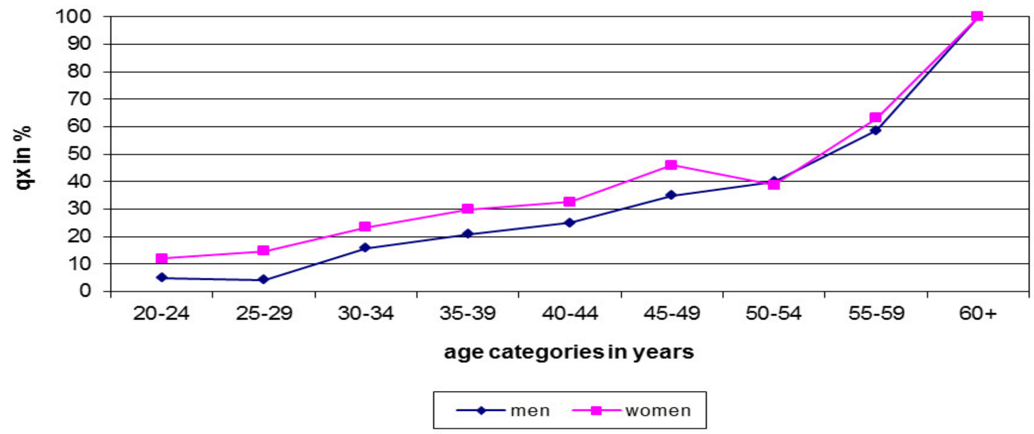


fig. 9. Probability of death separated for males and females

In the age category adultus women show a higher probability of death than men (fig. 9). This continues into the maturus category till the age between 45 and 49. This time period mirrors the reproductive phase of women. So the most probable reason for these higher rates is the vulnerability in giving birth. With the age around 45 the probability of death decreases to almost the same level as the men in the category 50 to 54. This decrease displays most likely the end of the reproductive phase in women and therefore a lower probability of death caused by birth risks. In the late maturus and senilis phases the values of men and women are more or less balanced with still a slight surplus in females.

Bocquet and Masset (1977) developed a formula to calculate the probability of death within the first five years of life.

$$ {}_5q_0 = 1{,}154 \text{ x } \sqrt{\log_{10}\left(200\,\frac{D5\text{-}14}{D20+}\right)} \text{-}1{,}014 \pm 0{,}041 $$

$$ {}_5q_0 = 0{,}445 \pm 0{,}041 $$

44,5% of the children in the age of 0-4 years died. The amount calculated in the mortality table is 13,9%. This means a difference of 30,6%. There is a deficit of children represented between the ages of 0-4 years. To reach the calculated value of 44,5%, 251 individuals are necessary instead of only the 52 excavated infants. So 199 individuals between the age of 0-4 years are "missing". (Dx 256,5, qx 44,531)

For the sake of completeness a new mortality table was calculated including all "missing" children calculated above (tab. 17). This concerns the age categories 0-4 years with 199 individuals, 5-9 years with three individuals and 15-19 with 35 individuals missing. However the increased values in the categories 5-9 and 15-19 years require another increase in the 0-4 years categories to comply the value of 44,5% calculated after Bocquet and Masset (1977) for the probability of death at birth.

tab. 17. Mortality table including all "missing" non-adults

(x)	(Dx)	(dx)	(lx)	(qx)	(Lx)	(Tx)	(ex)
0-4	286,501	44,488%	100,000%	44,488%	3,888	19,440	19,440
5-9	36,081	5,603%	55,512%	10,093%	2,636	15,552	28,015
10-14	18,002	2,795%	49,910%	5,601%	2,426	12,916	25,879
15-19	46,416	7,207%	47,114%	15,298%	2,176	10,491	22,267
20-24	23,166	3,597%	39,907%	9,014%	1,905	8,315	20,837
25-29	22,167	3,442%	36,310%	9,480%	1,729	6,410	17,653
30-34	40,744	6,327%	32,868%	19,249%	1,485	4,680	14,240
35-39	42,254	6,561%	26,541%	24,721%	1,163	3,195	12,039
40-44	35,836	5,565%	19,980%	27,851%	0,860	2,032	10,171
45-49	36,003	5,591%	14,415%	38,783%	0,581	1,172	8,132
50-54	22,586	3,507%	8,825%	39,743%	0,354	0,591	6,701
55-59	20,744	3,221%	5,317%	60,577%	0,185	0,238	4,471
60+	13,500	2,096%	2,096%	100,000%	0,052	0,052	2,500
	644	100,000%			19,44	85,085	

According to the new calculation the total amount of individuals would increase to 644. 387 are now children and adolescents. This would correspond to a percentage of 60,1% of the population. Therefore the deficit in children would be balanced.

4.4. Life expectancy

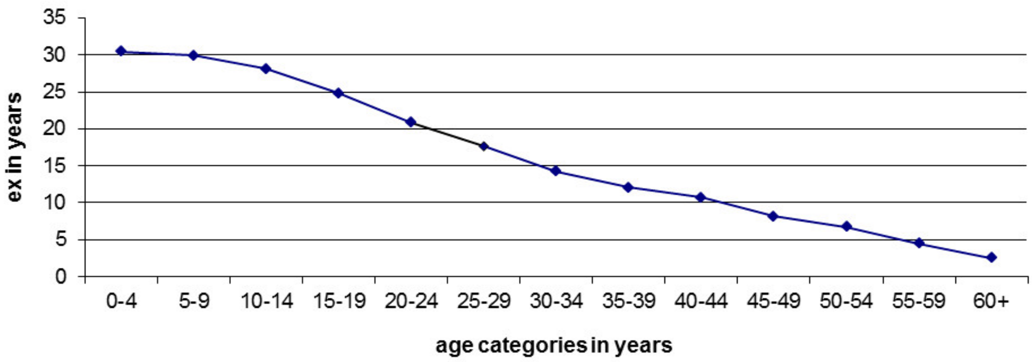


fig. 10. Life expectancy of the entire population (n=371)

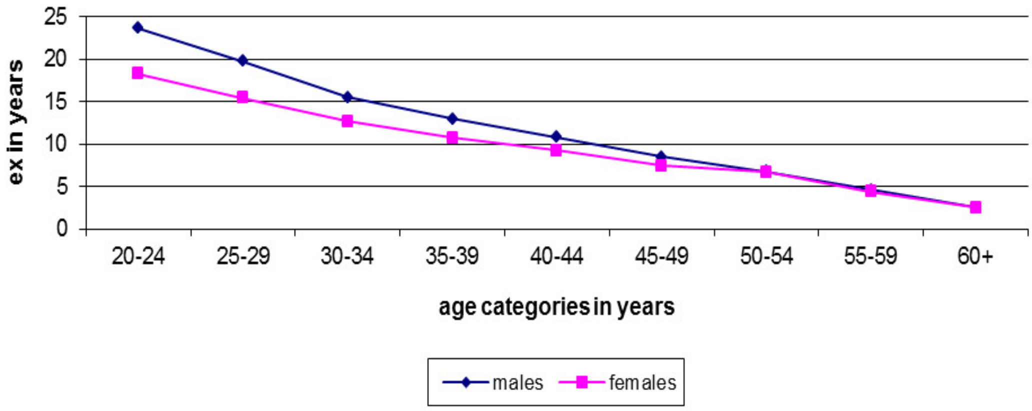


fig. 11. Life expectancy separated for adult males and females

With regard to the whole population the average life expectancy at birth amounts to 30,4 years (tab. 14, fig. 10). Then the curve shape decreases from this point of time till its lowest value in the age class senilis. Entering the age category early adultus (20-24 years) life expectancy is still 20,8 years summarized for both sexes. Comparing the sexes in this age category, males show a higher live expectancy with 23,7 years than females with 18,3 years (tab. 15, tab. 16, fig. 11). This difference of initially 5,4 years decreases slowly till the age category late maturus (50-54 years). In the later stages from late maturus to senilis the life expectancy of males and females is nearly the same.

Bocquet and Masset (1977) developed a formula to calculate of life expectancy at the time of birth.

$$e_0^0 = 78{,}721 \; x \; \log_{10} \sqrt{\frac{D20+}{D5-14}} - 3{,}384 \pm 1{,}503$$

$$e_0^0 = 24{,}2 \pm 1{,}503$$

The mortality table shows a value of ex=30,4 years. That means a discrepancy of 6,2 years to the result gained with the formula of Bocquet and Masset (1977). If all the "missing" individuals are added in the respective categories a result of 19,4 years in life expectancy is reached which approximates the calculated value slightly better.
The deficiency in children requires the difference between the values of the mortality table and the calculation. The higher the amount of neonates and infants in a population the lower is the life expectancy at the time of birth (Strott 2006). The problem with the deficiency of children on (pre-)historic graveyards is a big point of discussion in literature especially in paleodemographic context (Langenscheidt 1985, Dollhopf 2002, Kölbl 2004, Grupe et al. 2005). In particular the age classes neonatus and infans I show very often low rates of preservation. This is the case in Grevenmacher too. The reasons for such a deficiency are various and are frequently discussed in the literature. They range from susceptibility of child bones for taphonomic processes over bias caused by excavation techniques to sociocultural effects on burial rites (Ulrich-Bochsler 1997, Lewis 2007). But what are the most probable reasons in the case of Grevenmacher? Studies of taphonomic processes effecting human remains show that there is a significant difference in the rates of decay between remains of adult and non-adult individuals (Bello et al. 2006, Bello & Andrews 2006, Lewis 2007). Younger individuals in the age classes neonatus and infans I show lower states of representation than older children. Bello & Andrews (2006) state that the rates of decay are inversely proportional to bone size. The relative volume of bones is related to age, so the bones of younger non-adults are more affected than bones of older children or adults. Another point is that bone mineral density is very low

in neonates and increases only in the first years of life. Bello & Andrews (2006) presume that these are important factors that lead to the absence of young non-adults in human bone remains irrespective of the characteristics of the site. As seen in chapter 2, the rates of preserved bones also differ in adults and non-adults in the Grevenmacher remains. So, taphonomic processes affecting adults and non-adults in different ways are one possible explanation for the absence of younger children in the Grevenmacher material. A further reason for a deficiency of children is the burial at special places, for example on special graveyards, at remote areas of the parish cemetery or in the residential buildings. It is apparent that children were buried in special areas in the Grevenmacher cemetery. There are enhanced accumulations of remains of non-adults within the church building as well as outside the church on the northern peripheral area. The burials within the church are separated in two units. 13 children between the ages of one to ten were buried in the choir section including two premature births. A pit located centrically in the nave of the church contained the remains of at least 15 individuals. The age distribution shows a predominance of neonates and infants till the age of four years (Obertová et al. 2009). The burials in the northern peripheral area of the church contained the remains of at least 16 individuals. The first designation as so called "Traufkinder" could not be confirmed due to the age determination that resulted in ages between one and ten years (Obertová et al. 2008). The custom to bury children in special places was therefore common in Grevenmacher. However not all of the children were buried in special places. Some of them are found scattered between the graves of adults. Others were placed in the same burial pit which implies a close connection between the adult and non-adult individual. In addition, more special places may exist around the church or in the peripheral areas of the cemetery. The reasons that they cannot be found are various. Construction measures in and around the church, disturbance of graves and whole areas of the cemetery because of repeated occupancy as well as the fact that parts of the cemetery could not be excavated play an important role. Further reasons for a child deficiency in (pre-)historic contexts are far more difficult to comprehend. Topics like infanticide, lower child mortality due to better health care and economic status or due to socio-biological behaviour as well as the treatment of children in different age categories are also possible causes that contribute to child deficiency (Ulrich-Bochsler 1997). But they all cannot be derived from the bone material and therefore they can not be applied directly on the Grevenmacher remains.

4.5. Mortality rate

The mortality rate means the amount of deaths scaled to the whole population. The higher the life expectancy the lower is the mortality rate.
Formula according to Bocquet and Masset (1977)

$$m = 0{,}127\,\frac{D5-14}{D20+} + 0{,}016 \;= 0{,}041 \pm 0{,}002$$

The mortality rate for Grevenmacher is 4,1%. That means 4,1 deaths per year in 100 individuals.

4.6. Index of dependence

The index of dependence expresses the amount of children (0-14 years) and old people (60+ years), as economically dependent groups in relation to all economically active individuals (15-59 years) (Grupe et al. 2005).

$$AI = \frac{\%\,\Sigma(0-14) + \%\,\Sigma(60+)}{\%\,\Sigma(15-59)} = \frac{42{,}2\%}{60{,}4\%} = 0{,}69$$

In Grevenmacher the index of dependence is 0,69. That means that three economically active individuals had to supply two economically dependents (children and old people).

4.7. Estimation of population size

Acsádi u. Nemeskéri (1970) developed a formula to estimate population size, that means the amount of individuals living at the same time. The individuals under study are just a part of the human remains (see chapter 2). So this rate is calculated with the estimated maximum number of individuals of 1591 and an occupation time of 700 years.

$$P = 1{,}1\frac{D \times e_0^0}{t} = 1{,}1\,\frac{1591 \times 30{,}45}{700} = 76{,}12$$

With regard to the individuals from the cemetery, on average 76 individuals lived at the same time in the village of Grevenmacher. This amount of inhabitants is also confirmed in other publications. Rösener (1987) and Vogt-Lüerssen (2001) state that in the high medieval period a rural village of average size consisted of ten to twelve farmsteads with approximately 70 inhabitants.

4.8. Growth rate

Bocquet and Masset (1977) developed a formula to calculate the growth rate of a population.

$$t = 1{,}484\left[\log_{10}\left(200\,\frac{D5\text{–}14}{D20+}\,\frac{D60+}{D20+}\right)\right] - 1{,}485 \pm 0{,}006$$

$$t = -0{,}051 \pm 0{,}006$$

The result shows a negative growth rate. That means that the population of Grevenmacher decreases constantly over time. With increasing urbanisation in the high medieval period populations in many rural settlements decreased due to migration from rural to urban centres (Fuhrmann 2006). Migrations could lead to the abandonment of whole settlements. In the case of Grevenmacher were a constant settlement is proven over time a more or less balanced rate of migration and immigration guaranteed the preservation of the settlement.

4.9. Summary

The present results of the paleodemographic evaluation show that the individuals from the cemetery of Grevenmacher do not correspond in all aspects to a representative part of a living population. One cause is the child deficiency concerning the age classes of neonatus and infans I. Possible reasons for these deficits are already discussed. How further parameters like the mortality rate, index of dependence, population size and growth rate can be assessed will be shown in comparison with other osteological series. All the results so far are valid just for the data of the 371 individuals under study. To what extend these results will change with regard to the inclusion of the results from the burned bone mixture will be discussed in the respective chapter.

5. Metrical and morphological studies

The recording of metrical data is one of the mainstays in anthropological studies. On the one hand metrical data allow the quantitative description of differences between individuals within a specific population. Therefore it can be used as a tool for sex determination to describe the rate of sexual dimorphism in different parts of the skeleton. On the other hand it enables comparisons with other osteological series on the same standardized level. The quantitative description of shape variation and robustness features are also parameters based on metrical data.
Due to the good preservation of the remains from Grevenmacher a total of 145 measurement sections were taken on cranial and infra-cranial bones. 50 measurements are related to the skull, 20 measurements to the teeth and 75 measurements to bones of the infra-cranial skeleton. 20 special measurements for burned bones were also taken from the bones of the inhumation graves. The goal was to compare the measurements between the bone remains of the burned bone complex and the bones of the inhumation graves. Lists of the recorded measurement sections is given at the end of the chapter (tab. 29-32).
The results presented in this chapter concern only adult individuals. Measurements and further studies carried out on non-adults are presented in chapter 10: The children.

5.1. Metrical and morphological studies of the cranium

In the bone material of Grevenmacher many skulls are intact or barely fragmented. Therefore, it was possible to record several measurements in this skeletal area with relative certainty. Table 18 shows the 50 measurements of the skull with the respective amount of individuals (n), average values (x), ranges and standard deviation (s) for both sexes. To work out a population specific difference between males and females an index was calculated for every specific measurement. The goal was to find out the difference in size between men and women. Significance was estimated with a students t-test at a ≤0,05 level.

tab. 18. Measurement sections of the skull

	♂				♀					
meas.	n	x	range	s	n	x	range	s	f/m%	t-test
M1	61	186,61	168-199	7,21	56	182,12	161-197	9,29	97,59	2,940hs
M5	42	100,81	90-119	5,47	33	97,76	89-106	4,42	96,97	2,563s
M8	59	140,44	126-160	7,14	53	136,41	119-151	6,45	97,13	3,098hs
M9	53	96,64	86-106	4,93	50	96,36	86-106	4,47	99,71	0,301
M10	58	115,60	100-133	7,85	48	113,64	99-129	6,69	98,30	1,395
M11	52	123,50	108-143	6,70	51	118,82	103-128	4,76	96,21	4,097hs
M12	63	111,75	101-125	6,18	55	109,82	97-122	5,81	98,27	1,713
M13	44	104,77	95-118	4,88	50	100,68	91-110	4,18	96,10	4,388hs
M17	43	131,25	119-146	6,67	32	127,62	119-138	4,85	97,23	2,585s
M20	65	113,72	101-132	5,29	56	111,34	99-126	5,55	97,91	2,432s
W1	52	5,61	4,2-8,3	0,84	47	5,59	3,7-8,0	0,93	99,64	0,112
M23	51	527,67	496-556	12,99	50	515,14	472-549	15,70	97,62	4,363hs
M24	47	306,30	231-331	15,77	45	300,31	234-324	15,31	98,04	1,850
M25	48	377,80	327-408	14,80	39	368,33	324-396	13,83	97,49	3,066hs
M26	54	128,81	117-145	5,28	52	126,02	112-146	6,29	97,83	2,486s
M27	62	129,32	114-148	8,42	56	125,36	96-142	8,48	96,94	2,568s
M28	56	119,80	102-136	7,39	46	116,50	93-141	7,97	97,24	2,166s
M29	54	111,44	103-121	4,04	52	109,25	100-125	4,86	98,03	2,538s
M30	62	115,66	103-132	6,93	56	111,68	91-124	6,70	96,56	3,181hs
M31	55	96,53	82-107	4,59	45	95,04	84-110	5,65	98,46	1,455
M38	53	1408,17	1211-1832	108,88	49	1336,04	1147-1586	102,34	94,90	3,436hs
M40	31	96,06	79-108	5,81	21	94,09	84-107	5,87	97,95	1,195
M42	25	108,12	99-120	4,88	17	102,29	91-109	5,25	94,61	3,730hs
M43	49	103,75	92-114	4,51	44	101,79	93-116	4,36	98,11	2,169s
M44	40	99,10	89-109	4,22	30	97,17	90-107	4,27	98,05	1,884
M45	38	125,47	112-135	5,59	31	118,19	109-130	4,83	94,20	5,731hs
M47	30	114,73	95-132	7,77	25	110,84	81-127	9,81	96,61	1,645
M48	38	67,10	58-97	6,99	31	65,74	56-76	4,54	97,97	0,934
M50	44	22,00	15-29	3,31	35	21,57	16-26	2,39	98,04	0,646
M51	42	38,52	35-43	1,95	34	38,35	33-43	2,18	99,56	0,358
M52	43	32,84	29-37	2,25	35	33,43	29-38	2,19	101,79	1,166
M54	43	23,56	21-27	1,71	35	23,46	21-27	1,50	99,57	0,271
M55	41	50,32	45-59	3,35	32	48,72	43-60	3,86	96,82	1,894
M60	42	52,76	44-61	3,97	36	51,17	44-59	3,08	96,99	1,951

(tab. 18. continued)

	♂				♀					
meas.	n	x	range	s	n	x	range	s	f/m%	t-test
M61	45	59,24	49-70	5,35	39	58,08	43-69	5,34	98,04	0,992
M63	41	37,96	30-47	3,06	38	38,20	31-46	3,03	100,63	0,350
W9	43	7,48	5-10	1,07	40	7,41	5-9	0,78	99,06	0,338
W10	43	12,83	10-16	1,54	39	11,60	9-14	1,32	90,41	3,864hs
W11	43	14,85	12-19	2,03	40	13,53	11-16	1,39	91,11	3,431hs
W17	61	20,00	12-24	2,01	56	19,34	16-25	2,02	96,70	1,770
W18	49	8,10	6-10	0,88	44	8,23	6-11	0,96	101,60	0,681
W19	40	2,88	2-5	0,75	38	2,75	2-4	0,45	95,48	0,922
M65	42	122,02	111-137	6,09	38	117,84	108-137	5,83	96,57	3,143hs
M66	53	97,77	84-115	6,17	52	89,40	81-101	4,66	91,44	7,833hs
M68	61	74,82	65-89	5,23	60	72,02	62-89	5,04	96,26	2,998hs
M69	59	30,40	22-38	3,04	61	28,06	19-36	3,87	92,30	3,675hs
M69b	54	14,83	12-20	1,63	49	13,80	10-18	1,63	93,05	3,244hs
M70	60	64,18	54-84	5,01	58	58,31	48-68	4,01	90,85	7,012hs
M71	61	31,02	24-36	2,26	61	29,57	23-35	2,74	95,32	3,188hs
M79	61	123,6°	114-134°	4,77	59	127,4°	115-142°	5,83	103,07	3,914hs

(abbreviations: M=measurement according to Martin 1957 in Bräuer 1988, W=measurements in Wahl 1988, s=significant, hs=highly significant)

On average the values of women reach 98,1% of the male values. Only four measurements show higher values in females. This is the orbital height (M52), the internal palatal breath (M63), the sagittal thickness of the Capitulum mandibulae (W18) and the mandibular angle (M79). Only the difference in the mandibular angle is highly significant. Altogether eight measurements show a statistical significance, 20 measurements show a highly significant difference between males and females. These are 28 out of 50 measurements and this corresponds to a value of 56%. Striking is that these measurements can be pooled in individual groups. The measurements with significant sex difference concern linear and width measures of the skull like the greatest length of the skull (M1), the length of the skull base (M5), the greatest breadth of the skull (M8), the biauricular breadth (M11), the bimastoid breadth (M13) as well as the bizygomatic breadth (M45). Another group forms the measures of height like the basion-bregma height (M17) and the auriculo-bregmatic height (M20). A third group forms the bending and string measures where all measurements except the transversal arc (M24) and the occipital sagittal chord (M31) show a significant or highly significant difference. This is also the case for the skull capacity (M38). In the facial area the gnathion-basion length (M42) and the outer biorbital breadth (M43) show highly significant to respectively significant differences. Noteworthy is also the fact that all measurements of the mandible show highly significant differences.

Degree of heterogeneity

The measurements of the skull show on one hand a high sexual dimorphism between the two sexes. On the other hand the often high standards of deviation indicate that the population itself shows a high range of variation. To express this range of variation in figures, a coefficient was calculated with the formula (standard deviation/mean value)*100. That means the standard deviation is divided by the respective average and multiplied by 100 for every measurement. Then the average of all 50 results is calculated. The coefficient of heterogeneity for all 50 measurements is 7,37 in males and 7,06 in females. These are rather high values. Another series from Luxembourg, Grund/Wenzelsmauer (late 16th – early 18th century) revealed similarly high values with 6,7 in males and 8,0 in females (Trautmann and Trautmann 2011).

Indices of the skull

For a description of morphognostic features of the skull, indices are better suited than just sections of measurements. Indices describe the relation between specific sections of measurements. With their help it is possible to work out shape characters instead of only difference in size. In table 19, the results of 11 indices of the skull are shown with the respective amount of individuals (n), average values (x), ranges and standard of deviation (s) for both sexes. Here again an index shows the difference between males and females, a students t-test calculated the significance of the respective results. All indices calculated for every individual are listed in table at the end of the chapter (tab. 33-34).

tab. 19. Indices calculated from skull measurements

	♂				♀					
Index	n	x	range	s	n	x	range	s	f/m%	t-test
length-width	54	75,45	67,2-88,9	5,61	52	75,41	64,0-88,3	5,6o	99,94	0,037
length-height	43	70,57	63,3-80,2	4,06	30	70,91	63,6-79,5	3,63	100,48	-0,367
width-height	41	93,36	80,0-110,3	6,94	30	93,57	82,7-107,3	5,75	100,22	-0,135
length-earheight	60	61,11	54,3-73,3	3,82	55	61,20	52,1-69,6	4,11	100,15	-0,122
width-earheight	54	81,03	71,6-92,8	4,33	52	81,94	72,4-94,1	4,74	101,12	-1,033
jugofrontal	37	92,32	82,0-103,2	4,98	29	94,61	84,4-106,1	5,60	102,48	-1,755
jugoman-dibular	29	78,18	66,4-90,2	6,06	24	76,06	70,1-87,3	4,37	97,29	1,432
face	28	91,84	80,8-109,1	7,10	21	95,52	83,8-114,4	7,31	104,01	-1,773
upper face	33	53,52	46,1-66,7	4,43	27	55,42	45,5-64,9	4,38	103,55	-1,661
orbital	42	85,46	72,5-97,3	5,65	35	86,42	74,3-100,0	5,62	101,12	-0,744
nasal	39	47,34	35,6-54,1	4,36	31	48,65	40,0-58,1	4,86	102,77	-1,187

It is noticeable that just the jugomandibular index shows a 2,7% higher value in males. Four indices show more or less the same value for males and females. In six indices females show higher values than males. Altogether all the differences mentioned are not significant. These results indicate a high morphological homogeneity between both sexes. This is confirmed by the morphognostic description shown in table 20.

Morphognostic description by means of indices of the skull

tab. 20. Morphognostic description by means of indices sparated for males and females

Index	**males**	**females**	
length-width	mesokran	mesokran	middle long skull
length-height	orthokran	orthokran	middle high neurocranium
width-height	metriokran	metriokran	middle wide neurocranium
length-earheight	orthokran	orthokran	middle high neurocranium
face	leptoprosop	hyperleptoprosop	high/very high face
upper face	mesen	lepten	middle high/high upper face
orbital	hypsikonch	hypsikonch	middle high orbita
nasal	mesorrhin	mesorrhin	middle wide nose

The skull morphology of the Grevenmacher population can be described as follows. The neurocranium of both sexes are middle long, middle high and middle wide. Both sexes have high faces and upper faces whereby the females show higher values in both areas. The middle high orbitae and the middle wide noses are again detectable in both sexes. Noticeable is a very high standard of deviation in all indices (tab. 19).

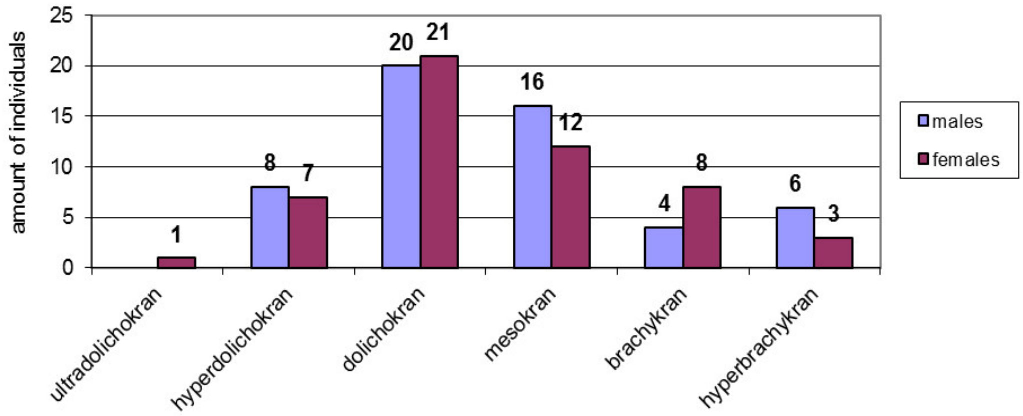


fig. 12. Length-width index of males and females

The length-width index shows an average middle long skull shape in men and women (fig. 12). Figure 12 indicates that a variety of shapes from ultradolichokran to hyper-brachykran are present. Most of the individuals are even classified as narrow long skulled form ultradolichokran to dolichokran.

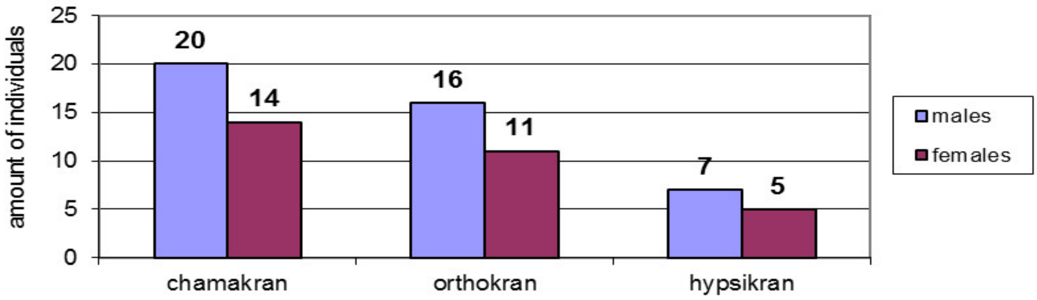


fig. 13. Length-height index of males and females

The length-height index shows a middle high skull shape in both sexes (fig. 13). In this index again all kinds of shapes are present. However most of the individuals (males and females) are classified as flat and low shaped (chamakran)

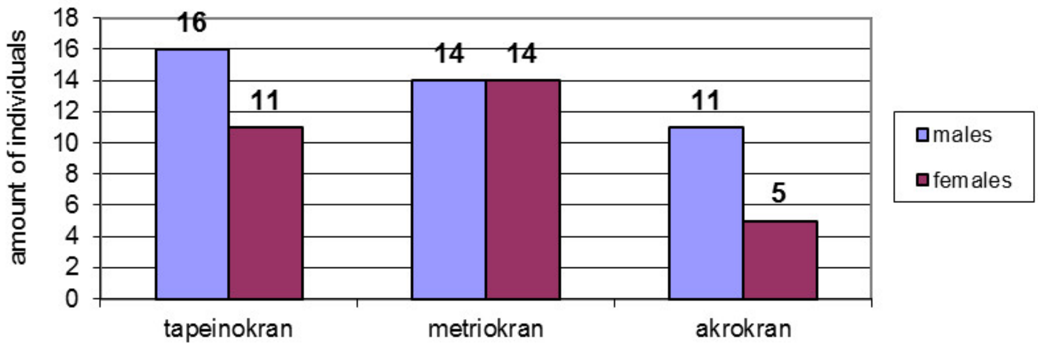


fig. 14. Width-height index of males and females

The width-height index shows the highest range of variation in males of all indices (fig. 14). Most of the male individuals show a low and wide neurocranium (tapeinokran). In females, the middle high and middle wide shape (metriokran) is prevalent.

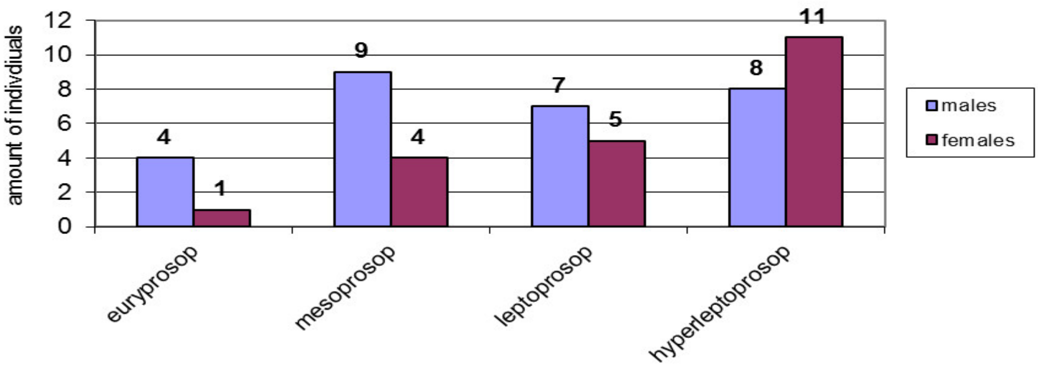


fig. 15. Facial index of males and females

In the facial skull differences between both sexes are visible in the facial (fig. 15) as well as in the upper facial index (fig. 16). In the facial index women show a high to very high facial skull (lepstoprosop to hyperleptoprosop), while men have more middle high to high facial skulls (mesoprosop to leptoprosop). The upper facial area of the females is also higher (lepten) compared to the males (mesen).

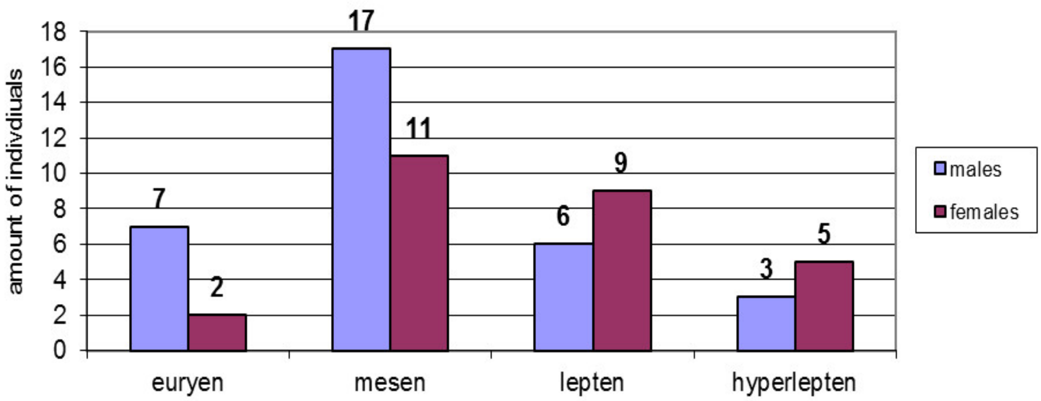


fig. 16. Upper facial index of males and females

The orbital and nasal indices however show no big differences in men and women.
The orbitae of males are almost classified as high (hypsikonch) as well as of the females.
The nasal index shows a middle wide shape (mesorrhin) in both sexes.
Altogether the indices of the skull show relative homogeneity between both sexes. However, within the sexes the state of variability is very high. These results suggest, that there was a high genetic mixing within the population due to active external contacts. The geographical position of Grevenmacher as a junction from east to west as well as from north to south supports this theory.

5.2. Measurements of the teeth

The measuring of teeth can be used for sex determination as studies of Alt et al. (1998) and Teschler-Nicola and Prossinger (2001) have shown. In this work, 20 measurements were taken according to Alt et al. (1998). These are the buco-lingual and the mesio-distal sections of the tooth neck and the tooth crown of the first upper incisors (11, 21), the upper and lower canine teeth (13, 23, 33, 43) as well as the upper and lower first molars (16, 26, 36, 46). Tables 21 and 22 show the values with the amount of individuals (x), average values (x), ranges and standard deviation (s) separated for both sexes.

tab. 21. Measurement sections of the teeth of males

measurement	n	x	range	s
TNBL 11/21	15/17	6,49/6,49	5,6-7,0/5,7-7,2	0,38/0,42
TNMD 11/21	15/17	6,29/6,29	5,2-7,6/4,9-7,7	0,61/0,76
TCBL 11/21	15/16	7,13/7,12	6,3-7,8/6,3-7,9	0,48/0,41
TCMD 11/21	15/16	7,98/7,90	5,8-8,9/5,8-9,1	0,83/0,88
TNBL 13/23	31/34	7,84/8,00	5,6-9,4/5,8-9,1	0,91/0,72
TNMD 13/23	31/34	5,94/5,83	5,1-8,5/4,6-8,8	0,78/0,78
TCBL 13/23	30/32	8,19/8,29	6,7-9,3/6,4-9,4	0,68/0,65
TCMD 13/23	30/31	7,62/7,50	6,3-9,4/6,3-9,1	0,73/0,55
TNBL 16/26	24/24	10,74/10,62	9,0-12,8/7,6-12,0	0,87/0,83
TNMD 16/26	24/24	7,47/7,74	6,4-9,0/6,9-9,9	0,57/0,65
TCBL 16/26	23/23	10,91/11,12	8,7-12,0/9,8-12,3	0,77/0,72
TCMD 16/26	23/24	9,86/9,92	6,6-11,3/8,4-11,3	1,03/0,70
TNBL 43/33	54/51	7,90/7,89	6,9-9,2/6,8-9,8	0,46/0,57
TNMD 43/33	55/52	5,39/5,46	4,4-8,1/4,5-7,8	0,64/0,50
TCBL 43/33	54/50	7,65/7,64	5,0-8,8/5,5-8,6	0,66/0,59
TCMD 43/33	52/47	6,80/6,79	5,5-8,3/5,8-8,5	0,49/0,48
TNBL 46/36	30/26	8,73/8,74	7,0-12,0/6,5-10,8	1,04/1,04
TNMD 46/36	29/26	8,91/8,71	7,2-11,7/5,4-10,2	0,96/0,87
TCBL 46/36	27/26	10,11/10,41	7,7-11,0/9,6-11,5	0,75/0,44
TCMD 46/36	26/24	10,35/10,41	9,2-11,5/7,6-11,9	0,65/0,88

(TNBL=tooth neck bucco-lingual; TNMD=tooth neck mesio-distal;
TCBL=tooth crown bucco-lingual; TCMD=tooth crown mesio-distal)

tab. 22. Measurementsections of the teeth of females

measurement	n	x	range	s
TNBL 11/21	23/27	6,23/6,10	6,5-7,0/5,4-7,0	0,36/0,38
TNMD 11/21	23/27	5,76/5,71	4,9-6,6/5,0-6,5	0,50/0,45
TCBL 11/21	20/24	6,91/6,85	6,5-7,4/6,2-8,1	0,27/0,39
TCMD 11/21	21/25	7,78/7,74	4,5-9,2/6,5-8,5	1,01/0,56
TNBL 13/23	32/30	7,36/7,43	6,2-8,3/6,4-8,2	0,51/0,42
TNMD 13/23	32/31	5,17/5,21	4,5-6,2/4,3-5,9	0,35/0,32
TCBL 13/23	31/30	7,79/7,60	6,8-9,3/6,0-8,3	0,51/0,55
TCMD 13/23	31/30	7,16/7,15	5,9-7,8/6,3-7,8	0,44/0,39
TNBL 16/26	29/30	10,16/10,19	7,9-11,8/6,5-12,0	0,99/1,07
TNMD 16/26	29/30	7,26/7,24	5,8-9,7/4,7-10,3	0,88/0,90
TCBL 16/26	28/29	10,65/10,64	9,9-11,6/7,3-12,0	0,50/0,81
TCMD 16/26	28/28	9,64/9,39	7,0-11,1/6,2-10,9	0,81/0,92
TNBL 43/33	42/42	7,13/7,12	4,3-8,2/4,9-7,9	0,65/0,56
TNMD 43/33	42/40	4,90/4,91	3,5-7,8/3,6-6,7	0,84/0,61
TCBL 43/33	42/41	7,02/7,16	4,4-7,9/6,4-7,9	0,57/0,34
TCMD 43/33	42/39	6,22/6,29	4,9-7,3/5,6-7,0	0,49/0,38
TNBL 46/36	25/21	8,60/8,30	7,0-10,5/5,5-10,4	0,76/1,08
TNMD 46/36	26/21	8,54/8,45	7,6-10,8/7,9-9,8	0,76/0,65
TCBL 46/36	23/20	9,87/9,94	7,0-10,8/7,8-11,0	0,88/0,85
TCMD 46/36	23/21	10,04/10,28	7,5-11,3/8,0-11,1	0,86/0,72

(TNBL=tooth neck bucco-lingual; TNMD=tooth neck mesio-distal;
TCBL=tooth crown bucco-lingual; TCMD=tooth crown mesio-distal)

Measurements of males and females in direct comparison

Table 23 shows the direct comparison of the respective values between males and females. An index was calculated to show the difference between both sexes for every measurement. Statistical significance was tested using students t-test with a level of ≤ 0,05.

tab. 23. Measurement sections of males and females in direct comparison

measurement	x ♂	x ♀	f/m%	t-test
TNBL 11/21	6,49/6,49	6,23/6,10	95,99/93,99	2,192s /3,183hs
TNMD 11/21	6,29/6,29	5,76/5,71	91,57/90,78	2,928hs/3,187hs
TCBL 11/21	7,13/7,12	6,91/6,85	96,91/96,21	1,723 /2,102s
TCMD 11/21	7,98/7,90	7,78/7,74	97,49/97,97	0,629 /0,713
TNBL 13/23	7,84/8,00	7,36/7,43	93,88/92,87	2,593 s /3,801hs
TNMD 13/23	5,94/5,83	5,17/5,21	87,03/89,36	5,082hs/4,119hs
TCBL 13/23	8,19/8,29	7,79/7,60	95,11/91,68	2,605 s /4,497hs
TCMD 13/23	7,62/7,50	7,16/7,15	93,96/95,33	2,992hs/2,858hs
TNBL 16/26	10,74/10,62	10,16/10,19	94,59/95,95	2,241s /1,617
TNMD 16/26	7,47/7,74	7,26/7,24	97,19/93,54	1,006 /2,285s
TCBL 16/26	10,91/11,12	10,65/10,64	97,62/95,68	1,454 /2,228s
TCMD 16/26	9,86/9,92	9,64/9,39	97,77/94,66	0,854 /2,306s
TNBL 43/33	7,90/7,89	7,13/7,12	90,25/90,24	6,793hs/6,535hs
TNMD 43/33	5,39/5,46	4,90/4,91	90,90/89,93	3,262hs/4,752hs
TCBL 43/33	7,65/7,64	7,02/7,16	91,76/93,72	4,920hs/4,616hs
TCMD 43/33	6,80/6,79	6,22/6,29	91,47/92,64	5,706hs/5,275hs
TNBL 46/36	8,73/8,74	8,60/8,30	98,51/94,96	0,520 /1,418
TNMD 46/36	8,91/8,71	8,54/8,45	95,85/97,01	1,572 /1,136
TCBL 46/36	10,11/10,41	9,87/9,94	97,63/95,48	5,381hs/2,433s
TCMD 46/36	10,35/10,41	10,04/10,28	97,00/98,75	1,433 /0,537

(s=significant; hs=highly significant)

Table 23 shows that all average values of men are 1,25% to 12,97% higher than the average values of the women. The average difference is about 5,64%. Statistically significant differences between the both sexes are found in values of the canine teeth. The canine teeth of the mandible (33, 43) as well as the upper jaw (13, 23) show either significant or even highly significant differences in all measures. Neck measures of the upper incisors (11, 21) show significant to highly significant differences. However, the sections of the crowns differ significantly only in the buco-lingual section of the 21. The molars show just a low grade of difference. In the upper jaw the 26 show significant differences in the crown sections and the mesio-distal section of the neck while in the buco-lingual section of the neck the difference is significant in the 16. The molars of the lower jaw differ only in the buco-lingual section of the crown to a significant or highly significant extent. The high sexual dimorphism of the canine teeth and the low grade of dimorphism found in the molars of Grevenmacher individuals confirm the results of former studies on series from medieval times as well as from the Neolithic (Starp 1990, Alt et al. 1998; Teschler-Nichola and Prossinger 2001, Trautmann 2012). One question that is raised is if the sexual dimorphism of the canine teeth is really suitable for sex determination. In order to verify this, a weighted boundary calculation according to Teschler-Nicola and Prossinger (2001) was carried out for all canine teeth as well as the neck sections of the incisors. This value specifies the separation between male and female. Values above this limiting value (WB) indicate a male sex, values below indicate a female sex.

tab. 24. Measurements of teeth separated for males and females including the limiting value

measurement	x♂	WB	x♀
ZHBL 11/21	6,49/6,49	6,35/6,28	6,23/6,10
ZHMD 11/21	6,29/6,29	6,00/5,92	5,76/5,71
ZHBL 13/23	7,84/8,00	7,53/7,64	7,36/7,43
ZHMD 13/23	5,94/5,83	5,41/5,39	5,17/5,21
ZKBL 13/23	8,19/8,29	7,96/7,90	7,79/7,60
ZKMD 13/23	7,62/7,50	7,33/7,29	7,16/7,15
ZHBL 43/33	7,90/7,89	7,58/7,50	7,13/7,12
ZHMD 43/33	5,39/5,46	5,18/5,21	4,90/4,91
ZKBL 43/33	7,65/7,64	7,31/7,33	7,02/7,16
ZKMD 43/33	6,80/6,79	6,51/6,51	6,22/6,29

In some studies sex determination with the help of these weighted boundary calculation was carried out successfully (Menninger 2008). For sex determination in the Grevenmacher material this tool could be used occasionally. Adult individuals that were questionable in their determination did not include teeth. In non-adults two individuals could be determined with the help of the weighted boundary results.

5.3. Metrical and morphological studies of the infra-cranial skeleton

The forthcoming tables show the values from bones of the infra-cranium sorted by body region with the amount of individuals (n), average values (x), ranges and standard deviation (s) separated for both sexes. For the elaboration of sex specific differences an index was calculated and the significance was evaluated by student t-test on a ≤ 0,05 value.

tab. 25. Messurement sections of the shoulder, spine and pelvis

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
Sc1 re	18	161,72	143-179	10,33	24	144,54	117-164	10,38	89,38	5,325hs
li	15	162,40	146-178	7,30	14	143,42	132-158	7,92	88,31	6,723hs
Sc2 re	34	102,15	92-114	6,06	28	95,57	85-108	5,90	93,56	4,273hs
li	37	102,40	90-117	6,35	31	94,58	86-104	4,04	92,36	5,922hs
Sc12 re	55	37,36	25-42	2,57	55	33,62	29-40	2,15	89,99	8,278hs
li	46	37,24	33-42	1,82	53	33,54	29-37	2,04	90,06	9,459hs
Sc13 re	56	28,89	25-34	1,81	55	25,27	22-30	1,66	87,47	10,976hs
li	49	28,53	25-33	1,74	56	24,89	20-29	1,76	87,24	10,629hs
Cl1 re	45	142,93	125-160	8,05	47	135,10	121-151	7,01	94,52	4,962hs
li	47	143,64	127-165	8,88	48	135,29	120-148	6,43	94,19	5,289hs
Cl4 re	54	10,01	9-14	1,34	57	9,44	7-12	1,07	94,30	2,483s
li	57	11,42	9-15	1,31	60	9,63	7-12	1,22	84,35	7,653hs
Cl5 re	54	12,74	9-18	1,48	57	11,26	9-15	1,19	88,38	5,821hs
li	57	12,38	10-16	1,25	60	10,83	9-13	0,82	87,48	7,969hs
Cl6 re	54	38,77	31-52	3,89	57	34,12	22-39	2,79	88,01	7,266hs
li	57	39,38	33-49	3,34	60	34,28	27-40	2,52	87,05	9,353hs
AxW20	44	11,14	9-11	1,57	46	10,61	9-12	0,85	95,24	2,003s
AxW21	44	12,18	11-15	0,89	46	11,50	10-13	0,83	94,42	3,750hs
AxW22	44	34,54	28-44	3,22	45	33,46	30-41	2,64	96,87	1,732
SaW24 re	48	42,85	29-57	6,83	52	44,11	34-55	5,86	102,94	0,992
li	48	42,83	29-57	6,22	52	43,58	27-54	5,44	101,75	0,643
PUM re	27	70,22	61-80	5,98	18	73,22	64-83	4,30	104,27	1,833
li	35	69,54	59-83	5,34	17	71,88	66-78	3,30	103,36	1,655
SPU re	46	29,33	23-35	2,96	49	21,47	17-26	2,02	73,20	15,199hs
li	44	29,48	24-36	2,68	38	22,63	16-27	2,68	76,76	11,542hs
DCOX re	37	215,92	191-233	10,66	38	199,29	181-213	7,03	92,30	7,982hs
li	34	216,85	200-237	10,06	36	201,89	177-215	7,42	93,10	7,127hs

(tab. 25. continued)

♂					♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
IIMT re	47	39,45	28-50	5,14	52	48,67	37-63	5,72	123,37	8,401hs
le	48	40,06	28-49	4,37	52	47,77	37-61	5,81	119,25	7,451hs
ISMM ri	40	114,02	105-123	4,75	38	102,45	92-113	4,43	89,85	11,139hs
le	39	113,61	103-125	5,37	41	101,27	90-109	4,13	89,14	11,611hs
SCOX ri	35	158,97	137-176	8,59	37	156,43	137-186	9,05	98,40	1,201
le	29	160,31	145-177	8,09	44	156,27	135-180	8,56	97,48	1,996s
SS ri	45	73,42	63-81	4,15	51	68,20	57-78	4,65	92,89	5,770hs
le	45	73,55	62-98	5,59	55	67,93	60-76	4,28	92,36	5,693hs
SA ri	46	75,13	66-86	4,41	51	75,69	62-94	6,34	100,74	0,500
le	45	75,13	65-92	5,56	54	76,67	64-89	6,27	102,05	1,280
SIS ri	50	38,84	30-47	3,05	56	35,50	28-42	3,03	91,40	5,648hs
le	49	39,10	33-48	3,26	58	35,31	29-43	3,25	90,31	6,002hs
VEAC ri	50	58,10	53-65	2,76	55	51,43	45-58	2,53	88,52	12,920hs
le	49	57,77	53-63	2,52	59	50,47	46-57	2,37	87,36	15,485hs

(ri=right body side, le=left body side; s=significant hs=highly significant)

In all measures of the shoulder girdle, the males show higher values than the females. The average difference is about 10,2%. Furthermore, all measures show significant or highly significant differences between the sexes. Both sexes in common are the in part large ranges of variation of single measurements. Especially the maximum length and breadth of the scapula (Sc1 und Sc2) as well as the maximum length and the circumference of the mid-shaft of the clavicle (Cl1 und Cl6).
In the second cervical vertebra the transverse and the sagittal diameter (AxW20 und AxW21) of the dens axis differ significantly. The height of the axis (AxW22) shows no significant difference. This is also the case in the transverse breadth of the Pars lateralis of the Os sacrum (SaW24). Here the measurements of the women are up to 2,9% respectively 1,7% larger than the measurements of the men. The ranges of deviation are also relatively high. Compared to the males, the measurements of the pelvis of females are smaller by an average of 4,7%. Just in two measurements the women surpass the men. On one hand the height of the greater sciatic notch (IIMT). Here the values of the females are 23,4% respectively and 19,3% higher than the values of the males. This is not surprising because this area is also used as a relatively secure feature for morphognostic sex determination. On the other hand the difference in the acetabulo-symphyseal pubic length (PUM) between the sexes amounts just 4,3% respectively 3,4% and is not significant. Also the difference in the spino-auricilar length (SA) is not significant. Here the absolute values are almost the same in both sexes. The coxal breadth (SCOX) shows a significant sexual dimorphism just on the left body side. In all other sections of measurement (SPU,

DCOX, ISMM, SS, SIS VEAC) the differences between both sexes are highly significant. This was to be expected. The pelvis shows, due to its role in the birth process, the largest sexual dimorphism in humans. In all measurement sections of the pelvis the ranges of deviation are in part very high. However they all fall within the ranges of deviation according to Murail et al. (2005).

tab. 26. Measurement sections of the upper limbs

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
Hu1 ri	51	328,00	287-361	13,50	50	307,78	276-349	16,99	93,83	6,622hs
le	52	322,00	284-360	15,88	60	301,68	274-336	13,91	93,69	7,212hs
Hu3 ri	42	51,04	48-57	2,00	52	46,71	41-52	2,62	91,51	8,829hs
le	48	49,79	46-58	2,40	54	45,81	40-51	2,46	92,00	9,250hs
Hu4 ri	54	63,46	58-72	3,34	48	58,08	51-67	3,56	91,52	7,872hs
le	57	62,96	56-71	3,79	63	57,35	49-65	3,15	91,09	8,848hs
Hu5 ri	64	23,37	20-29	1,96	67	20,86	17-25	1,67	89,26	7,902hs
le	64	22,67	19-31	2,01	69	20,16	16-23	1,57	88,93	8,057hs
Hu6 ri	59	18,41	15-22	1,53	66	15,91	13-20	1,14	86,42	10,428hs
le	61	18,36	15-23	1,63	68	15,71	13-19	1,06	85,56	11,054hs
Hu7 ri	64	66,62	60-80	4,07	64	58,83	48-68	3,57	88,30	11,511hs
le	61	65,26	58-75	3,82	69	58,00	49-66	3,25	88,87	11,707hs
Hu9 ri	51	45,82	41-53	2,38	57	41,47	36-46	2,41	90,50	9,420hs
le	55	45,31	41-53	2,45	60	40,83	36-46	2,37	90,11	9,964hs
Hu10 ri	51	43,74	40-51	2,19	57	39,30	35-44	2,21	89,85	10,468hs
le	53	42,94	38-49	2,50	63	38,65	35-42	1,96	90,01	10,355hs
HuW28 ri	14	4,11	2,9-5,3	0,65	10	3,43	2,2-4,7	0,72	83,45	2,417s
le	10	4,33	3,1-5,2	0,73	14	3,33	2,0-4,5	0,71	76,90	3,363hs
Ra1 ri	50	243,94	211-274	12,11	49	228,12	204-256	12,20	93,51	6,467hs
le	54	243,61	210-285	13,65	47	226,19	201-263	12,30	92,85	6,689hs
RaW32 ri	57	22,57	20-25	1,15	56	20,46	17-24	1,25	90,65	9,341hs
le	59	22,62	19-25	1,31	54	20,44	18-24	1,24	90,36	9,064hs
Ra4 ri	61	17,03	12-21	1,53	62	15,19	13-18	1,30	89,19	7,192hs
le	59	18,18	14-20	1,42	58	14,76	12-17	1,29	81,19	13,629hs
Ra4a ri	62	16,00	14-20	1,34	61	14,06	11-17	1,34	87,87	8,028hs
le	60	15,08	12-18	1,39	59	13,54	11-18	1,37	89,79	6,086hs
Ra5 ri	61	12,37	11-14	0,83	62	10,92	10-13	0,77	88,28	10,047hs
le	59	12,57	11-15	0,97	58	10,84	9-13	0,82	86,23	10,410hs
Ra5a ri	62	12,25	11-15	0,82	62	10,79	9-13	0,70	88,08	10,663hs
le	60	12,41	11-15	0,88	58	10,64	9-14	0,96	85,74	10,446hs

(tab. 26. continued)

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
Ra5(6) ri	46	33,32	28-40	1,96	44	29,62	24-33	1,84	88,89	9,224hs
le	45	32,91	29-38	2,09	46	29,45	26-34	1,85	89,49	8,367hs
Ra33 ri	14	2,89	2,0-3,8	0,51	14	2,49	1,3-3,5	0,59	86,16	1,919
le	12	2,89	2,1-4,0	0,61	13	2,67	1,4-3,4	0,52	92,39	0,973
Ul1 ri	47	264,87	238-286	11,72	44	248,91	220-276	13,39	93,97	6,075hs
le	47	263,95	230-286	12,92	43	246,95	218-282	13,56	93,56	6,089hs
Ul11 ri	63	17,12	13-20	1,31	63	14,86	12-18	1,39	86,80	9,392hs
le	62	16,95	11-20	1,56	63	14,63	11-20	1,42	86,31	8,698hs
Ul12 ri	62	14,42	11-18	1,34	63	12,47	10-16	1,12	86,48	8,833hs
le	61	13,95	11-19	1,23	63	11,87	10-15	1,07	85,09	10,056hs
UlW35 ri	49	25,60	20-35	2,61	45	23,27	18-27	2,00	90,90	4,826hs
le	49	25,43	21-31	1,93	50	23,08	20-27	1,84	90,76	6,202hs
UlW36 ri	39	20,72	17-25	1,66	36	18,51	16-20	1,17	89,33	6,613hs
le	42	20,27	17-25	1,47	36	18,63	16-25	1,50	91,91	4,866hs

(ri=right body side, le=left body side; s=significant hs=highly significant)

As already seen in the measurements of the shoulder girdle and the pelvis, all but one measurement of the upper limbs shows a significant to highly significant sexual dimorphism. Only the wall thickness of the radius (Ra33) shows no significant difference. The measures of the males show on average 10,9% larger values than the female measures. In most of the sections the ranges of deviation are relatively low, with the exceptions of the linear measures of all three bones (Hu1, Ra1, Ul1).

tab. 27. Measurement sections of the lower limbs

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
Fe1 ri	56	454,16	393-505	24,31	51	425,39	381-473	22,01	93,66	6,379hs
le	51	453,94	391-501	24,32	61	429,74	384-490	21,57	94,67	5,575hs
Fe2 ri	56	450,41	391-501	24,67	51	422,49	379-470	22,18	93,80	6,129hs
le	54	450,74	390-498	24,00	61	425,85	382-487	22,15	94,48	5,785hs
Fe6 ri	75	28,54	23-34	2,21	69	26,14	22-31	1,96	91,59	6,871hs
le	70	28,91	22-35	2,31	69	26,45	23-31	2,00	91,49	6,708hs
Fe7 ri	75	28,44	23-33	1,90	69	25,59	22-30	1,79	89,98	9,245hs
le	70	28,84	22-34	2,42	69	26,43	22-32	1,92	91,64	6,498hs
Fe8 ri	75	90,59	73-99	4,83	69	82,20	70-94	4,44	90,74	10,823hs
le	69	90,84	77-101	5,43	69	83,08	72-95	4,60	91,46	9,058hs

(tab. 27. continued)

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
Fe9 ri	71	32,31	23-39	2,87	65	29,94	24-35	2,50	92,66	5,114hs
le	68	32,75	23-40	2,77	69	30,36	26-35	2,39	92,70	5,410hs
Fe10 ri	71	26,93	20-37	2,37	65	24,27	20-31	1,96	90,12	7,096hs
le	67	26,52	20-38	2,32	69	23,97	21-32	2,12	90,38	6,695hs
Fe13 ri	59	99,96	84-125	6,55	56	91,44	81-108	5,84	91,47	7,349hs
le	55	99,76	87-115	5,14	59	91,35	80-109	5,99	91,57	8,018hs
Fe19 ri	66	48,04	42-55	2,60	60	42,88	38-49	2,36	89,26	11,624hs
le	63	47,81	43-53	2,53	67	42,60	38-49	2,42	89,10	12,000hs
Fe21 ri	58	80,91	70-92	4,26	58	74,62	66-83	3,79	92,22	8,401hs
le	53	80,41	69-91	4,63	57	74,65	67-84	3,48	92,83	7,409hs
FeW43 ri	75	7,07	4,8-11	1,28	68	6,40	4,0-9,6	0,96	90,52	3,512hs
le	70	6,81	4,4-10,2	1,26	70	6,35	3,5-10,0	1,02	93,24	2,374s
FeW44 ri	15	6,01	3,4-8,4	1,32	22	5,40	3,2-9,5	1,33	89,85	1,374
le	14	5,53	2,8-7,4	1,13	15	4,99	3,7-6,0	0,64	90,23	1,598
Ti1 ri	56	368,80	321-412	19,94	58	349,89	308-400	18,41	94,87	5,261hs
le	62	368,24	324-417	20,24	54	348,55	308-399	17,71	94,65	5,540hs
Ti1b ri	59	368,13	321-415	20,08	58	348,62	304-395	18,03	94,70	5,524hs
le	63	367,98	323-420	20,72	55	348,29	303-396	17,62	94,65	5,492hs
Ti3 ri	58	75,83	66-84	3,88	56	69,37	60-76	3,32	91,48	9,536hs
le	65	75,16	67-87	3,77	57	68,91	61-77	3,75	91,68	9,159hs
Ti6 ri	59	51,79	44-61	3,37	55	47,62	41-54	3,17	91,95	6,793hs
le	61	51,44	46-64	3,08	54	47,17	41-56	3,26	91,70	7,219hs
Ti8 ri	72	29,84	23-37	2,41	68	27,34	22-31	1,97	91,62	6,698hs
le	71	30,04	25-38	2,43	68	27,66	23-36	2,24	92,08	5,997hs
Ti8a ri	70	34,53	26-40	2,49	69	31,32	25-35	2,30	90,70	7,892hs
le	72	34,98	29-43	2,63	69	31,46	24-38	2,75	89,94	7,769hs
Ti9 ri	72	23,15	17-28	2,18	68	20,88	18-27	1,87	90,19	6,595hs
le	71	22,80	17-28	2,21	68	20,32	17-25	1,88	89,12	7,112hs
Ti9a ri	70	24,66	18-31	2,59	69	22,06	19-29	1,92	89,45	6,716hs
le	72	24,62	20-30	2,52	69	22,04	18-27	2,11	89,52	6,577hs
Ti10 ri	70	84,23	66-97	5,62	68	76,91	67-87	4,79	91,31	8,224hs
le	70	84,93	72-99	5,64	68	76,98	67-90	4,93	90,64	8,806hs
Ti10a ri	70	96,13	76-112	7,09	69	87,20	67-100	5,92	90,71	8,054hs
le	70	96,40	83-111	6,55	68	86,87	65-102	6,96	90,11	9,286hs
Ti10b ri	68	77,88	63-94	5,47	65	71,11	62-81	4,19	91,31	7,986hs
le	68	77,62	63-91	5,10	66	71,26	61-83	4,82	91,80	7,415hs
Fi1 ri	35	364,60	325-405	18,40	32	338,31	307-366	14,64	92,79	6,434hs
le	36	359,75	318-398	20,89	38	341,16	303-368	15,87	94,83	4,327hs

(tab. 27. continued)

	♂				♀					
measure	n	x	range	s	n	x	range	s	w/m%	t-test
FiW53 ri	43	15,27	12-20	2,11	42	13,45	11-22	1,81	88,08	4,264hs
le	41	14,89	11-20	2,10	45	13,10	10-17	1,45	87,98	4,634hs
FiW54 ri	38	26,77	23-32	1,95	43	23,82	21-28	1,67	88,98	7,334hs
le	34	26,55	23-30	1,86	42	23,86	21-29	1,75	89,87	6,478hs
Pata ri	36	42,52	37-49	3,09	39	39,74	34-47	2,77	93,46	4,108hs
le	37	42,40	36-48	3,10	43	39,46	33-47	2,68	93,06	4,550hs
Patb ri	36	44,11	35-50	3,40	39	41,18	35-47	2,72	93,36	4,136hs
le	37	43,62	38-51	2,84	42	40,76	35-49	2,97	93,44	4,359hs
Patc ri	36	20,55	17-24	1,53	39	19,28	15-22	1,32	93,82	3,857hs
le	37	20,46	18-24	2,48	42	19,28	16-28	2,03	94,23	2,324hs
Ta1 ri	39	56,69	50-66	3,88	47	52,13	46-60	3,94	91,95	5,380hs
le	50	57,02	50-65	3,76	44	52,09	45-61	4,09	91,35	6,088hs
Ca1 ri	46	79,89	70-90	3,66	44	73,79	65-81	3,97	92,36	7,583hs
le	53	80,56	70-90	4,43	48	73,89	63-85	4,72	91,72	7,325hs

(ri=right body side, le=left body side; s=significant hs=highly significant)

Almost all of the measurements of the lower limbs show a significant to highly significant sexual dimorphism. The only exception is the wall thickness of the femur mid-shaft (FeW44). Here no significant difference is visible between the two sexes. All male measurements are larger than the female measurements, on average by 8,3%. The ranges of deviation are high in both sexes whereas males show in most cases slightly higher values. The highest values are visible again in the linear measurements of the femur (Fe1, Fe2), tibia (Ti1, Ti1b) and fibula (Fi1) in both sexes.

Morphognostic description of the infra-cranium by means of indices

Table 28 shows 11 indices calculated from postcranial measurements. Here again differences between the sexes were represented by a index and significance was tested with student t-test on a ≤ 0,05% value. All indices calculated for every individual are listed in table at the end of the chapter (tab. 35-38).

tab. 28. Indices calculated from mesurements of the infra-cranial skeleton

	♂				♀					
Index	n	x	range	s	n	x	range	s	w/m%	t-test
Hu length-thickness ri	46	20,28	17,9-23,3	1,12	48	19,16	14,9-21,4	1,31	94,48	4,447hs
le	49	20,19	18,2-22,9	1,21	55	19,18	16,4-21,7	1,11	95,00	4,439hs
Humero-radial ri	39	75,36	70,1-78,8	1,95	36	74,82	70,0-79,3	2,00	99,28	1,184
le	39	75,57	71,6-79,9	2,18	41	74,58	69,1-78,8	2,24	98,69	2,002s
Femoro-humeral ri	39	71,17	66,2-75,9	2,18	36	71,49	66,0-77,1	2,16	100,45	-0,638
le	37	70,08	67,0-75,2	2,16	43	70,17	65,2-75,6	2,34	100,13	-0,178
Fe length-thickness ri	56	20,24	17,1-24,5	1,28	52	19,65	17,4-22,8	1,25	97,08	2,421s
le	52	20,24	18,0-24,9	1,28	63	19,66	17,2-22,4	1,14	97,13	2,569s
Fe robust-ness ri	56	12,73	10,8-15,6	0,82	52	12,46	10,9-17,9	1,06	97,88	1,487
le	54	12,86	11,6-15,9	0,78	63	12,49	10,9-14,3	0,78	97,12	2,558s
Fe platyme-ricus ri	69	83,18	66,7-100,0	7,88	65	81,32	65,6-112,5	10,04	97,77	1,197
le	70	81,01	65,7-96,7	7,01	71	79,14	61,8-100,0	8,30	97,69	1,444
Fe pilastri-cus ri	74	100,55	74,2-122,2	9,94	67	102,04	79,3-120,0	10,16	101,48	-0,885
le	73	100,16	74,3-122,7	11,18	71	99,97	71,9-125,0	9,51	99,81	0,133
femoro-tibial ri	41	82,44	77,2-88,0	2,26	45	83,00	79,0-90,0	2,41	100,68	-1,109
le	44	82,14	76,9-88,7	2,18	52	82,55	78,3-86,3	2,17	100,50	-0,920
Ti cnemicus ri	68	71,34	55,3-87,5	7,22	66	70,53	55,9-90,6	6,55	98,86	0,680
le	68	71,22	53,8-90,6	7,69	65	69,73	54,3-87,5	6,58	97,91	1,198
intermemb-ral ri	24	67,27	64,2-69,9	1,34	23	67,23	62,8-71,4	1,81	99,94	0,086
le	24	67,03	64,6-69,7	1,30	24	66,00	61,6-68,6	1,74	98,46	2,323s
Sacro-clavicular ri	31	28,86	15,3-39,7	5,42	27	31,93	25,7-40,2	3,67	110,64	-2,487s
le	30	29,90	17,2-40,1	5,24	29	31,63	20,3-40,0	4,56	105,78	-1,351

(Hu=Humerus, Fe=Femur, Ti=Tibia; ri=right body side, le=left body side; s=significant hs=highly significant)

The length-thickness index of the humerus and the femur as well as the index of robustness of the femur are features that describe the robustness of an individual. In all three indices the male values surpass the female values. In the humerus the difference between the sexes is highly significant, in the femur the difference is still significant. The index of robustness shows a significant difference only on the left body side. The difference of robustness of the humerus and femur support the results of the measurements shown in tables 26 and 27. These measurements already show highly significant differences. The difference of robustness of the right and left body side of the femur could be evidence for preferred use of one body side. This option is discussed in detail in the chapter 8 about physical adaptations. The humero-radial, femoro-humeral and femoro-tibial indices describe the relation of the mentioned bones to each other. The femoro-humeral and the femoro-tibial indices show almost the same values in males and females. There is a slight surplus in the female values but the difference is not significant. The humero-radial index shows a slight surplus of the male values in comparison to the females. There is also a significant difference between men and women in the left body side. Here again this fact will be discussed in the chapter about physical adaptations. The intermembral index describes the ratio between the upper and lower limbs. The results show almost the same values with a slight surplus of the male relations. Here again a significant difference between males and females is visible in the left body side. The indices platymericus and pilastricus of the femur and cnemicus of the tibia describe the shape of the cross-section of the respective bone. Changes in the cross-section shape of a bone are mostly caused by physical stress and an adaptation of the bone to increased load. Therefore, the discussion of the results of the mentioned indices is also in the chapter about physical adaptations. The sacro-clavicular index is a ratio that describes the relation between the shoulder and pelvis girdle. As expected the women show higher values, that means larger dimensions in the pelvis girdle in comparison to the shoulder girdle than men do. However, the differences are not that clear as expected. Only the right body side shows a significant difference while the difference in the left body side is not significant.

The recorded measurement sections divided by skeletal segments.
The respective measurement sections are listed with their abbreviation, an English and German definition and citation.

tab. 29. Measurement sections of the skull

abbr.	definition english	definition german	author
M1	maximum cranial length	größte Schädellänge	Bräuer 1988
M5	basion-nasion length	Schädelbasislänge	Bräuer 1988
M8	maximum cranial breadth	größte Schädelbreite	Bräuer 1988
M9	least frontal breadth	kleinste Stirnbreite	Bräuer 1988
M10	maximum frontal breadth	größte Stirnbreite	Bräuer 1988
M11	biauricular breadth	Biauricularbreite	Bräuer 1988
M12	biasterionic breadth	größte Hinterhauptsbreite	Bräuer 1988
M13	bimastoid breadth	Mastoidealbreite	Bräuer 1988
M17	basion-bregma height	Basion-Bregma-Höhe	Bräuer 1988
M20	auriculo-bregmatic height	Ohr-Bregma-Höhe	Bräuer 1988
W1	thickness of the skullcap	Kalottendicke	Gejvall 1963
M23	horizontal circumference	Horizontalumfang	Bräuer 1988
M24	transversal arc	Transversalbogen	Bräuer 1988
M25	total sagittal arc	Mediansagittalbogen	Bräuer 1988
M26	frontal sagittal arc	Mediansagittaler. Frontalbogen	Bräuer 1988
M27	parietal sagittal arc	Mediansagittaler Parietalbogen	Bräuer 1988
M28	occipital sagittal arc	Mediansagittaler Occipitalbogen	Bräuer 1988
M29	frontal sagittal chord	Mediansagittale Frontalsehne	Bräuer 1988
M30	parietal sagittal chord	Mediansagittale Parietalsehne	Bräuer 1988
M31	occipital sagittal chord	Mediansagittale Occipitalsehne	Bräuer 1988
M38	cranial capacity (Lee-Pearson 1901)	Schädelkapazität (Lee-Pearson 1901)	Bräuer 1988
M40	basion-prosthion length	Gesichtslänge	Bräuer 1988
M42	gnathion-basion length	untere Gesichtslänge	Bräuer 1988
M43	outer biorbital breadth	Obergesichtsbreite	Bräuer 1988
M44	biorbital breadth	Biorbitalbreite	Bräuer 1988
M45	bizygomatic breadth	Jochbogenbreite	Bräuer 1988
M47	total facial height	Gesichtshöhe	Bräuer 1988
M48	upper facial height	Obergesichtshöhe	Bräuer 1988
M50	anterior interorbital breadth	vord. Interorbitalbreite	Bräuer 1988
M51	orbital breadth	Orbitalbreite	Bräuer 1988
M52	orbital height	Orbitalhöhe	Bräuer 1988

(tab. 29. continued)

abbr.	definition english	definition german	author
M54	nasal breadth	Nasenbreite	Bräuer 1988
M55	nasal height	Nasenhöhe	Bräuer 1988
M60	maxillo-alveolar length	Maxilloalveolarlänge	Bräuer 1988
M61	maxillo-alveolar breadth	Maxilloalveolarbreite	Bräuer 1988
M63	internal palatal breadth	Gaumenbreite	Bräuer 1988
W9	Frontal process of the Zygomatic bone: distance between fmt and fmo	Processus frontalis des Os zygomaticum: Breite zwischen fmt und fmo	Wahl 1988
W10	Frontal process of the Zygomatic bone: least distance between the Marginal tubercle and the inner orbital margin	Processus frontalis des Os zygomaticum: kleinster Abstand zwischen Processus marginalis und innerem Orbitarand	Wahl 1998
W11	Frontal process of the Zygomatic bone: Distance between inner lateral orbital margin and the jugale (j)	Processus frontalis des Os zygomaticum: Abstand zwischen innerem lateralen Orbitarand und Jugale	Wahl 1988
W17	transverse breadth of Capitulum mandibulae	transversale Breite des Caput mandibulae	van Vark 1974
W18	sagittal thickness of Capitulum mandibulae	sagittale Dicke des Caput mandibulae	van Vark 1974
W19	Coronoid process: thickness 2mm below the apex	Processus coronoideus: Dicke 2mm unterhalb des Apex	Wahl 1988
M65	bicondylar breadth	Kondylenbreite de Unterkiefers	Bräuer 1988
M66	bigonial breadth	Winkelbreite des Unterkiefers	Bräuer 1988
M68	projective length of the Corpus mandibulae	Unterkieferlänge	Bräuer 1988
M69	height of the mandibular symphysis	Kinnhöhe	Bräuer 1988
M69b	breadth of the Corpus mandibulae at the M2	Corpusdicke am M2	Bräuer 1988
M70	condyloid height	Asthöhe	Bräuer 1988
M71	condyloid breadth	Astbreite	Bräuer 1988
M79	mandibular angle	Astwinkel des Unterkiefers	Bräuer 1988

(M=measurement number according to Bräuer (1988), W= measurement according to Wahl (1988)) tab. 30. Measurement sections of the shoulder, pelvis and spine

abbr.	definition english	definition german	author
Sc1	maximum length of the scapula	morphologische Breite der Scapula	Bräuer 1988
Sc2	maximum breadth of the scapula	morphologische Länge der Scapula	Bräuer 1988
Sc12	height of the glenoid cavity	Länge der Cavital glenoidalis	Bräuer 1988
Sc13	breadth of the glenoid cavity	Breite der Cavitas glenoidalis	Bräuer 1988
Cl1	maximum length of the clavicle	größte Länge der Clavicula	Bräuer 1988
Cl4	vertical mid-shaft diameter	vertikaler Durchmesser der Mitte	Bräuer 1988
Cl5	sagittal mid-shaft diameter	sagittaler Durchmesser der Mitte	Bräuer 1988
Cl6	circumference of the mid-shaft	Umfang der Mitte	Bräuer 1988
AxW20	transverse diameter of the dens axis	transversaler Durchmesser des Dens axis	Helmuth u. Rempe 1968
AxW21	sagittal diameter of the dens axis	sagittaler Durchmesser des Dens axis	Helmuth u. Rempe 1968
AxW22	height of the axis	Höhe des Axis	Wahl 1988
SaW24	Os sacrum: transverse breadth of the Pars lateralis	Os sacrum: transversale Breite der Pars lateralis im Bereich der Basis	Wahl 1988
PUM	Acetabulo-symphyseal pubic length	Acetabular-Symphysenbreite	Bräuer 1988
SPU	Cotylo-pubic width	Hintere Schambeinbreite	Gaillard 1960
DCOX	Innominate or coxal length	Beckenhöhe	Bräuer 1988
IIMT	Greater sciatic notch height	Höhe der Incisura ischiadica major	Bräuer 1988
ISMM	Ischium post-acetabular length	Ischium-obere Acetabularlänge	Schulter-Ellis et al. 1983
SCOX	Iliac or coxal breadth	Darmbeinbreite	Bräuer 1988
SS	Spino-sciatic length	Spino-incisuralänge	Gaillard 1960
SA	Spino-auricular length	Spino-auricularlänge	Gaillard 1960
SIS	Cotylo-sciatic breadth	hintere Sitzbeinbreite	Bräuer 1988
VEAC	Vertical acetabular diameter	größter Durchmesser der Gelenkpfanne	Bräuer 1988

(Sc=Scapula, Cl=Clavicle, Ax=Axis, Sa=Sacrum. PUM, SPU, DCOX, IIMT, ISMM, SCOX, SS, SA, SIS, VEAC are abbreviations used by Murail et al. (2005))

tab. 31. Measurement sections of the upper limbs

abbr.	definition english	definition german	author
Hu1	maximum length of the humerus	Größte Länge des Humerus	Bräuer 1988
Hu3	breadth of the proximal epiphysis	obere Epiphysenbreite	Bräuer 1988
Hu4	bi-epicondylar width	Epicondylenbreite	Bräuer 1988
Hu5	maximum mid-shaft diameter	Größter Durchmesser Diaphysenmitte	Bräuer 1988
Hu6	minimum mid-shaft diameter	kleinster Durchmesser Diaphysenmitte	Bräuer 1988
Hu7	least circumference of the shaft	kleinster Umfang der Diaphyse	Bräuer 1988
Hu9	transverse head diameter	größter transverslaer Durchmesser des Caput	Bräuer 1988
Hu10	longitudinal head diameter	größter sagittaler Durchmesser des Caput	Bräuer 1988
HuW28	wall thickness of the mid-shaft	Wanddicke in der Diaphysenmitte	Gejvall 1963
Ra1	maximum length of the radius	größte Länge des Radius	Bräuer 1988
RaW32	average head diameter	mittlerer Durchmesser des Caput radii	Wahl 1988
Ra4	maximum transverse shaft diameter	transversaler Durchmesser des Schaf-tes	Bräuer 1988
Ra4a	transverse mid-shaft diameter	transversaler Durchmesser der Schaft-mitte	Bräuer 1988
Ra5	minimum sagittal shaft diameter	sagittaler Durchmesser des Schaftes	Brauer 1988
Ra5a	sagittal mid-shaft diameter	sagittaler Durchmesser der Schaftmitte	Bräuer 1988
Ra5(6)	distal maximum breadth	untere Epiphysenbreite	Bräuer 1988
RaW33	wall thickness of mid-shaft	Wanddicke in der Diyphysenmitte	Gejvall 1963
Ul1	maximum length of the ulna	Größte Länge der Ulna	Bräuer 1988
Ul11	dorso-ventral shaft diameter	dorso-volarer Durchmesser der Schaft-mitte	Bräuer 1988
Ul12	transverse shaft diameter	transversaler Durchmesser des Schaf-tes	Bräuer 1988
UlW35	width of the trochlear notch	Weite der Incisura trochlearis	Wahl 1988
UlW36	average diameter of the Caput ulnae including the styloid process	mittlerer Durchmesser des Caput ulnae inclusive des Processus styloideus	Wahl 1988

(Hu=Humerus, Ra=Radius, Ul=Ulna)

tab. 32. Measurement sections of the lower limbs

abbr.	definition english	definition german	author
Fe1	maximum length of the femur	größte Länge des Femur	Bräuer 1988
Fe2	physiological length of the femur	natürliche Länge des Femur	Bräuer 1988
Fe6	sagittal mid-shaft diameter	sagittaler Durchmesser der Diaphysen-mitte	Bräuer 1988
Fe7	transverse mid-shaft diameter	Transversaler Durchmesser Diaphysen-mitte	Bräuer 1988
Fe8	circumference of the mid-shaft	Umfang der Diaphysenmitte	Bräuer 1988
Fe9	subtrochanteric transverse diameter	oberer transversaler Diaphysendurch-messer	Bräuer 1988
Fe10	subtrochanteric sagittal diameter	oberer sagittaler Diaphysendurchmes-ser	Bräuer 1988
Fe13	upper epiphyseal length	obere Epiphysenlänge	Bräuer 1988
Fe19	transverse diameter of the head	transverslaer Durchmesser des Caput	Bräuer 1988
Fe21	bicondylar width	Epicondylenbreite	Bräuer 1988
FeW43	breath of the Linea aspera	Breite der Linea aspera	Gejvall 1963
FeW44	wall thickness of the mid-shaft	Wanddicke im mittleren Diaphysenbe-reich	Wahl 1988
Ti1	lateral condylo-malleolar length	Länge der Tibia	Bräuer 1988
Ti1b	medial condylo-malleolar length	Ganze Länge der Tibia	Bräuer 1988
Ti3	bicondylar breadth	größte proximale Epiphysenbreite	Bräuer 1988
Ti6	transverse diameter of distal epiphy-sis	größte distale Epiphysenbreite	Bräuer 1988
Ti8	sagittal midshaft diameter	größter Durchmesser der Schaftmitte	Bräuer 1988
Ti8a	sagittal diameter at nutrient foramen	Sagittaler Durchmesser auf Höhe des Foramen nutritium	Bräuer 1988
Ti9	transverse midshaft diameter	transversaler Durchmesser der Schaft-mitte	Bräuer 1988
Ti9a	transverse diameter at nutrient foramen	transversaler Durchmesser auf Höhe des Foramen nutritium	Bräuer 1988
Ti10	circumference of the mid-shaft	Umfang der Diaphyse	Bräuer 1988
Ti10a	circumference at nutrient foramen	Umfang der Diaphyse auf Höhe des Foramen nutritium	Bräuer 1988
Ti10b	minimum circumference of the shaft	kleinster Unfang der Diaphyse	Bräuer 1988
Fi1	maximum length of the fibula	größte Länge der Fibula	Bräuer 1988
FiW53	transverse midshaft diameter	transversaler Schaftdurchmesser im mittleren Bereich	Wahl 1988
FiW54	distal maximum breadth	Breite der distalen Epiphyse	Mollison 1938
Pat1	maximum height of the patella	Höhe der Patella	Bräuer 1988
Pat2	maximum breadth of the patella	transversale Breite der Patella	Bräuer 1988
Pat3	maximum thickness of the patella	maximale Dicke der Patella	Bräuer 1988
Ta1	talar length	Länge des Talus	Bräuer 1988
Ca1	maximum length of the calcaneus	größte Länge des Calcaneus	Bräuer 1988

(Fe=Femur, Ti=Tibia, Fi=Fibula, Pat=Patella, Ta=Talus, Ca=Calcaneus) tab. 33. Indices of the skull of males

ID	age	l-w	l-h	w-h	l-earh.	w-earh.	jugo-front.	jugo-mand.	face	upper face	orbital	nasal	cap.
1	50-60	76,4	69,6	91,1	59,7	78,1	84,8	73,5	87,1		81,6		1832
3	30-40	75,0	72,9	97,2	63,5	84,7	97,6	82,1	96,7	57,7	92,5	40,7	1535
4	55-65	69,7	66,1	94,8	56,4	80,9	100,0	78,8	89,4	54,5	91,7	41,8	1211
5	35-45	77,5	80,2	103,5	68,1	87,9	95,3	82,8	95,3	54,7	86,8	46,9	1472
8	30-40		77,4		66,6								
10	40-50	70,4			59,1	84,0							1305
11	50-60	86,1	68,7	82,5	65,4	78,5	96,1	71,5	86,1	53,8	89,2	47,2	1451
14	40-50	78,7			64,9	82,4					82,5		1542
17	50-60	79,1	75,3	95,1	65,4	82,6					89,2	49,0	1451
22	60+	81,6	70,9	87,0	60,9	74,6							1361
26	60+	74,3			60,0	80,7							1514
32	30-40	73,5	74,0	100,7	57,3	77,9	103,2	76,4	105,7	66,7	87,5	35,6	1301
35	30-40	68,5	69,1	100,7	61,3	89,5	96,0	72,8	92,0	56,8	86,5	51,0	1435
38	50-60	79,7	69,2	86,9	59,9	75,2							1370
39	50-60	70,4	65,0	92,4	56,4	80,1	82,0	76,2	94,3	53,3	94,6	46,2	1265
41	50-60	79,4	68,1	85,7	60,0	75,5	96,5	89,6	99,1	58,3	94,3	52,1	1417
50	40-50	69,6	76,8	110,3	64,6	92,8	92,7	82,1	92,7	52,8	72,5	52,1	1301
51	35-45	75,7	72,4	95,7	61,6	81,4	96,0	81,6	80,8	48	77,5	48,9	1396
54	30-40				64,4								
57	60+	76,5	70,5	92,1	61,7	80,7	88,5	71,0	87,8	51,9	91,9	50,0	1376
62	30-40	76,3			65,1	85,2	89,7	77,0	82,5	47,6	81,6	53,3	1476
63	60+	68,1			57,1	83,8	86,2	75,6	95,9	61,0	91,9	41,1	1314
68	50-60					79,7							
71	50-60	69,1	71,1	103,0	59,7	86,6	85,1	80,2	109,1	63,6	83,3	42,6	1416
75	40-50	83,6	76,0	90,9	63,5	77,6	88,4						1282
79	40-55	69,2			56,4	84,4						39,3	1412
89	30-40	70,2	66,5	94,7	68,1	81,1	88,8	88,0	86,4	48,8	86,8	46,0	1297
94	20-30	71,9	70,8	98,5	66,6	84,2	93,9	73,0	106,1	53,9	83,8	46,7	1330
99	30-40				59,1								
103	60+	69,1	69,2	103,0	65,4	83,4	84,4	78,1		46,1	75,0	44,9	1386
110	45-50	83,6			64,9	76,4							1456
112	30-40	69,2	72,2	87,7	65,4	77,9	98,5	79,2	88,9	48,1	79,5	49,0	1563
114	40-50	70,2	77,2	86,9	60,9	82,5	94,5	66,9	92,1	54,3	80,5	54,0	1677
115	60+	71,9			60,0	83,3							1437
117	20-25	69,1	71,2	101,5	57,3	89,1							1321

(tab. 33. continued)

ID	age	l-w	l-h	w-h	l-earh.	w-earh.	jugo-front.	jugo-mand.	face	upper face	orbital	nasal	cap.
120	45-55	83,6	68,2	80,0	61,3	72,7	96,1	75,0	100,0	53,1	86,8	49,0	1371
122	20-30	69,2	68,2	92,1	59,9	79,3	92,2	75,8	90,6	51,8	82,9	48,9	1390
128	50-60	70,2	69,8	80,1	56,4	77,6	93,3		87,4		88,1	45,4	1537
131	50-60	71,9	71,9	91,7	60,0	80,0	90,3	66,4		48,5			1448
132	40-50	69,1	66,8	81,7	64,6	75,2	97,8	72,4	82,8		86,0	54,1	1508
207	30-40	83,6			61,6	77,3				55,3	94,9		1369
209	40-50	69,2	70,1	95,5	64,4	81,5	89,3	90,2		51,6	86,8	49,1	1322
215	40-50	70,2	74,4	96,5	61,7	81,0	93,0				81,6	42,0	1413
217	30-50	71,9	63,3	90,3	65,1	86,6				54,8	82,0	45,6	1401
221	40-50	69,1	71,7	100,8	57,1	81,2	89,6			51,3	97,3	45,8	1211
224	50-60				59,7		91,6				86,1	48,0	
227	30-40	75,8	64,0	84,4	63,5	71,6				53,3	82,8		1295
228	50-60	86,3	79,2	91,7	56,4	76,5	100,0	86,1	91,8			53,3	1313
309	40-50	74,7			68,1	78,9							1418
312	30-40	70,6	66,0	93,4	66,6	78,1				52,4			1359
315	40-50	76,7	71,3	92,9	59,1	83,8	92,8	81,7	89,7	49,2	80,5	42,8	1453
339	30-40				65,4		98,4	84,9	82,5		78,9	54,0	
361	20-40				64,9						80,0		
364	50-60	87,6			65,4	74,5							1349
511	30-40	69,1	66,0	99,2	60,9	83,6				56,2	85,4	45,1	1382
512	40-50	73,8	71,3	96,5	60,0	78,5	85,9	78,5	91,7	50,4	80,5	48,0	1469
526	30-40	73,0	66,0	93,6	57,3	83,7	89,5		87,2	55,2	80,0	53,2	1481
537	50-60	71,9	71,3	100,7	61,3	86,5	88,8				83,8	48,9	1535
546	60+		66,0		59,9								
615	50-60	87,6											
631	60+	69,1			59,7	84,1				51,2	91,7	45,6	1320
639	40-50	73,8	64,3	85,0	61,1	80,7	89,1			53,1	92,5	49,0	1387

(Abbreviations of indices: l-w=length-thickness; l-h=length-height; w-h=width-height; l-earh.=length-earheight; w-earh.=width-earheight; jugofront.=jugofrontal; jugomand.=jugomandibularis; cap.=skull capacity) tab. 34. Incdices of the skull of females

ID	age	l-w	l-h	w-h	l-earh.	w-earh.	jugo-front.	jugo-mand.	face	upper face	orbital	nasal	cap.
2	30-40	71,2			57,1	80,2							1385
7	20-25	68,7			60,0	87,3	104,3	77,8	107,7	64,9	100,0	40,0	1586
12	30-40	79,1			63,8	80,7							1345
13	50-60	73,6	67,5	91,8	54,4	73,8							1167
16	30-40	66,5	71,3	107,3	59,4	89,4	92,8	75,7	114,4	62,2	80,0		1246
29	30-40	72,3	67,5	93,4	58,5	80,9	91,5	71,2	95,8	57,6	86,5	43,1	1319
30	60+	82,4	760	92,2	69,6	84,4	95,9	76,4	87,0	53,6	88,1	51,1	1341
31	20-25	76,1	71,1	93,4	61,1	80,3	84,4	71,3	88,5	52,4	86,1	50,0	1281
44	40-50	83,3			66,7	80,0	87,1	75,9	101,7	60,3		45,8	1147
45	25-30	88,3			65,5	74,2							1350
55	50-60	72,5	70,3	97,0	60,4	83,3	86,2	73,2	99,2	56,9	83,7	49,1	1254
61	20-30	75,4	69,1	91,7	60,6	80,3	88,2	87,3	96,4	56,4	74,3	55,8	1228
70	40-50				54,4								
80	40-50	72,9			61,7	84,7							1386
87	50-60	67,7	66,1	97,6	57,1	84,4	89,6			52,8	80,5	57,4	1243
90	40-50	68,1			55,5	81,5	93,0	78,1			100,0	42,6	1250
91	50-60	74,2	71,4	96,3	58,8	79,2					86,8	58,1	1288
93	20-25	83,3	73,0	87,6	62,2	73,8	94,6	70,8	83,8	50,8	87,5	55,6	1395
95	50-60	82,9			69,6	84,0							
96	35-45	71,8			55,3	77,0							1426
98	20-30	82,9	73,5	88,6	62,3	75,2	92,7	72,6	91,1	53,2	82,5	48,9	1215
104	50-60	79,6			65,7	82,5							1435
105	30-40	70,8			54,3	76,8	97,5			49,6	81,1	54,2	1508
106	30-40	71,0	75,4	106,1	66,1	93,1	94,9	76,9	103,4	62,4	82,9	40,3	1345
108	25-30	88,2	79,5	90,1	67,1	76,1	93,0	72,8	87,7	50,0	82,5	47,7	1189
109	50-60	64,0			60,2	94,1	90,8	81,6					1238
118	25-30	72,3	73,4	101,5	62,5	86,5	96,6	75,2	94,9	55,6	86,5	46,7	1320
121	20-25	77,5	77,5	100,0	69,2	89,3					89,5	49,0	1234
124	50-60	71,9	69,3	96,4	59,9	83,3	104,5	86,5			75,6		1409
125	30-40	81,5	67,4	82,7	59,0	72,4	106,1	73,9			89,5		1280
135	50-60		67,5		57,9			81,0	99,2	57,8	86,5	52,1	
136	50-60	75,0			62,0	82,6	101,7	70,1	96,6	55,6	85,4	45,1	1502
137	60+	72,7	69,4	95,5	63,4	87,2	96,7			50,8	91,7	47,9	1353
139	30-40	74,3	67,0	90,2	57,5	77,4							1181
142	30-40	76,2			64,1	84,1							1352

(tab. 34. continued)

ID	age	l-w	l-h	w-h	l-earh.	w-earh.	jugo-front.	jugo-mand.	face	upper face	orbital	nasal	cap.
201	40-50	82,3	71,2	86,4	67,6	82,1	90,1	76,8	92,6	45,5	81,1	46,0	1290
204	40-50	74,5			61,4	82,5							1483
210	30-40	70,7			60,1	85,0							1324
213	30-50	72,6	68,0	93,7	61,1	84,2				54,8	86,5	44,7	1153
214	25-30	69,5			58,3	83,8					97,3	46,7	1257
218	30-40	82,4											
223	40-50			87,9		80,1	100,9			54,8	86,5	47,9	
226	40-50	78,8			61,4	78,0					92,1		1297
229	40-50	87,3	73,4	84,1	68,2	78,1	97,5		90,2	55,7	89,5	50,0	1413
305	60+	68,4			59,3	86,7	90,1	76,8	90,1	52,9	86,8	57,8	1260
307	25-30	78,6			58,2	74,1	95,8	74,8	88,2	52,1	92,1	46,9	1299
313	30-40	73,5	68,2	92,8	61,4	83,4				59,8	89,5	41,5	1465
316	30-40	74,0	71,9	97,1	64,3	86,9	100,8	76,1	96,6	57,3	86,1	51,0	1397
345	30-40	78,0	72,3	92,7	64,4	82,6					85,4	46,1	1309
352	40-50										82,0		
355	25-35				52,1								
359	30-40	73,8	63,6	86,2	60,4	81,9	98,3	72,6	100,8	60,7	82,5	49,0	1359
508	50-60	75,7	69,7	92,1	62,2	82,1	88,1						1383
548	20-30				61,0								
567	40-50	74,7			57,9	77,4							1421
633	40-50	77,0	77,0	100,0	67,2	87,3							1460
648	20-30	68,6			58,0	84,5							1428
654	40-50	72,6	68,9	94,9	58,4	80,4							1530

(Abbreviations of indices: l-w=length-thickness; l-h=length-height; w-h=width-height; l-earh.=length-earheight; w-earh.=width-earheight; jugofront.=jugofrontal; jugomand.=jugomandibularis; cap.=skull capacity) tab. 35. Indices of the infra-cranium of males

ID	age	Hu leng-thick		humero-radial		femoro-humeral		Fe leng-thick		Fe rob.		Fe platy.	
		ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le
1	50-60							20,5	19,4	12,5	12,1	75,0	78,1
3	30-40	19,8	19,4		72,2	75,2	75,2	20,1	20,5	12,5	12,6	93,3	90,3
4	55-65	19,7	20,1	75,1	77,1	69,6	67,6	19,5	19,4	12,4	12,5	84,8	75,7
5	35-45	19,7	20,6	71,6	73,0	74,3	73,4	21,2	21,6	12,8	13,0	87,1	84,4
8	30-40	20,5	20,7	77,2		70,2	69,7	20,6	20,2	12,5	12,8	84,4	80,0
9	30-40							17,6		11,4		74,3	75,7
10	40-50	19,3	19,2										
11	50-60	19,0	19,3	76,4	76,7	68,2	68,1	19,1	19,3	11,9	12,5	80,6	78,8
17	50-60	20,7	20,7	76,5	76,8	73,2	72,9					73,5	78,8
21	20-40								19,5		12,3		83,3
22	60+	18,7	18,5	73,4	73,9	75,9	74,4		19,9		12,4	78,8	78,1
23	ad.o.o.												93,3
26	60+	20,0	19,6	76,4	76,8	69,9	68,9	19,9	19,1	12,3	12,6	93,5	90,6
32	30-40	19,2	19,7	71,4	73,0	69,6	67,7	19,6	18,9	12,1	12,1	96,6	84,4
35	30-40		18,6										
36	20-30							19,6	18,8	12,5	12,1	74,2	77,4
37	30-40		22,3		76,7		69,7		20,1		12,9		78,1
38	50-60	19,5	19,4	77,2	77,9	69,6		20,1		12,9		87,1	90,0
39	50-60		21,9		78,1		67,2	20,2	18,6	13,1	11,6	86,2	92,3
41	50-60	20,2	21,4	75,0		69,8	69,4	20,0	19,9	12,2	12,9	82,8	84,8
43	50-60							20,9	21,4	13,4	13,5	96,0	77,1
46	30-40	18,3	18,4			71,0	68,0	21,3	20,8	13,0	13,2	83,3	77,4
51	35-45	20,2	20,9	74,4	76,9							74,3	71,1
53	20-30	19,8		74,9		71,6		19,4	19,3	12,2	12,1	86,7	83,9
54	30-40	20,0	19,8	77,7	79,9	69,4	68,6	20,1	20,4	12,7	12,9	68,6	65,7
57	60+		19,3		73,6							90,0	93,1
63	60+	23,3	22,9	77,0	77,5	70,3	68,5	21,2	21,4	13,0	13,7	96,4	93,1
65	ad.o.o.											71,9	71,9
66	30-40		18,7		71,9		72,8		19,2		12,3	74,2	75,0
68	50-60											82,3	75,0
69	50-60							20,0	21,1	13,1	13,3	96,5	87,9
71	50-60			74,9									
72	20-30	20,0	19,0	75,7	74,3	68,6	69,1	18,8	19,3	11,8	12,5	84,4	84,4
73	35-45	21,1				72,1		21,7	22,2	13,3	14,4	87,5	87,5

(tab. 35. continued)

ID	age	Hu leng-thick ri	/ le	humero-radial ri	/ le	femoro-humeral ri	/ le	Fe leng-thick ri	/ le	Fe rob. ri	/ le	Fe platy. ri	/ le
74	30-40	19,7		74,9		69,8		18,8		12,3		84,8	
75	40-50											90,3	87,1
78	45-55							24,5	24,9	15,6	15,9	88,2	85,7
79	40-55	22,2	20,1	77,5	77,3								
82	40-50							19,9	19,4	11,8	12,3	79,4	81,2
83	40-50							19,7	19,6	12,5	12,1	84,4	84,4
86	30-40		18,7		74,6								
88	50-60		20,2										71,4
89	50-60	21,4	20,8	72,7	71,6	72,9	73,8	20,7	21,3	13,2	13,6	100,0	92,8
92	60+	21,2	21,4	78,4	77,7	70,9	71,1	21,6	21,7	13,5	14,1	85,3	85,3
94	20-30							17,1	18,2	10,8	11,6	88,9	85,2
97	40-50											66,7	76,7
99	30-40		20,9		72,4		70,9				12,7		81,8
103	60+	21,2	22,5	77,8		74,0	70,9	22,2	21,6	13,7	13,5	81,8	90,0
110	40-50	20,2	20,5										90,3
112	30-40	22,4	22,9	74,3	75,3	71,7	70,4	20,4	20,5	12,8	13,3	86,1	86,1
113	40-50		18,6		75,6		69,2	18,5	18,0	11,7	11,8	86,7	80,6
114	40-50	20,1	19,6	75,5	76,2	72,1	70,7	21,0	20,6	12,9	13,2	87,1	81,3
115	60+	20,5	19,9	77,6	78,5	74,0	68,2	20,1	20,8	13,3	13,5	81,8	74,3
116	30-50							21,2	20,7	13,4	13,2	90,9	87,9
117	20-25	18,6	18,2	76,7	76,5	68,3	67,3	18,7	18,7	11,3	11,8	87,1	84,4
120	45-55	22,3	22,3	73,7	74,3	69,4	67,7	20,5	20,0	12,9	12,8	74,3	75,7
122	20-30	21,6	20,6			66,2		20,8		13,0		100,0	
123	40-50	20,6	20,5	75,5	75,5	71,0	69,7	20,8	21,3	13,0	13,8	77,1	73,0
126	45-55	20,6	19,9	76,3	77,3	68,7	67,6	20,4	20,7	12,7	13,3	76,3	70,0
127	30-40											76,5	69,4
128	50-60	20,3	20,8	75,7	77,1	70,8	70,3	20,5	21,4	13,1	12,7	90,6	96,7
131	50-60	19,8	20,4	70,1	72								
132	40-50	19,1	19,7	74,8	75,7	73,3	70,8	19,2	19,2	12,4	12,8	69,7	75,7
133	45-55	19,7	19,4	77,9	77,6	72,7	73,3	20,8	20,6	13	13,3	79,4	84,8
134	20-30	20,0	19,1	75,4	76,9	72,3	70,7	18,5	18,5	11,4	11,8	78,8	75,7
143	30-40	17,9		73,9		75,2		20,3	20,7	13,0	13,2	74,3	72,2
144	30-60							23,2	22,8	14,8	14,1	86,1	85,7
145	50-60							19,6		12,4		69,2	

(tab. 35. continued)

ID	age	Hu leng-thick		humero-radial		femoro-humeral		Fe leng-thick		Fe rob.		Fe platy.	
		ri	le	ri	le	ri	le	ri	le	ri	le	ri	le
203	40-50	20,5	20,4	73,6	74,2	70,0	71,6	19,2	21,4	12,1	13,0	89,6	66,7
207	30-40	20,0		78,8								76,7	
209	40-50	21,6				72,6		19,2		12,2		81,8	
212	30-60								19,8		12,7		75,7
217	30-50										12,8		75,0
221	40-50	20,6		75,0		68,5		20,6		12,8		84,4	
228	50-60	18,7	18,4	73,3	71,9	70,6	69,3	18,5	18,7	11,7	11,9	71,4	75,0
303	30-50								19,1		12,0		74,3
309	40-50							20,0		12,8		89,3	86,2
339	30-40	21,3	20,6	74,9	74,4	72,3	71,3	22,7	22,0	14,4	14,2	81,8	79,4
342	30-50							21,4		13,5		96,7	
369	40-60	21,8	21,4		78,6								
374	40-50							20,4		13,0		80,0	
506	ad.o.o.											82,8	85,3
523	40-60											75,7	75,0
557	20-40							21,8		13,5		86,7	
610	30-50		21,1				67,0		20,0		12,3		82,3
644	ad.o.o.							19,6	20,2	12,6	12,8	76,5	73,5

(Abbreviations of the indices: Hu leng-thick= Humerus length-thickness; Fe leng-thick=Femur length-thickness; Fe rob= Femur robustness; Fe platy= Femur platymericus) tab. 36. Indices of the infra-cranium of males

ID	age	Femur pilastricus ri	/ le	femoro-tibial ri	/ le	Tibia cnemicus ri	/ le	inter-membral ri	/ le	Scaro-clavicular ri	/ le
1	50-60	89,6	89,6	87,0	85	70,6	70,6				
3	30-40	107,1	110,7	82,5	82,2	75,0	72,2		69,4	26,0	25,8
4	55-65	114,8	110,7				69,4			35,5	32,9
5	35-45	96,5	93,3	85,5	84,0	84,8	84,8		67,4	26,1	26,7
8	30-40	100,0	100,0			75,7	78,7			21,5	24,8
9	30-40	96,4	100,0								
11	50-60	107,4	103,4	78,2	77,5	80,6	75,0	66,4	66,7		
14	40-50									22,7	
17	50-60	103,6	103,4			78,8	77,1				
18	ad.o.o.					69,4	67,6				
20	30-40		74,3				71,8				
21	20-40		103,8			70,6					
22	60+	79,3	75,9			66,7	64,7				
23	ad.o.o.		107,1								
26	60+	100,0	106,9	81,8	83,2	72,2	69,4	66,7	66,4	29,4	
32	30-40	93,3	100,0							28,6	29,0
36	20-30	100,0	100,0	83,1	81,6	72,7	69,7				
37	30-40		112,0		83,2	65,6	58,8		66,3	34,4	31,1
38	50-60			82,6		76,5	90,6	66,7		20,1	24,0
39	50-60	100,0	122,7	80,8	79,9	68,7	79,4		65,5		28,8
41	50-60	107,1	110,0	82,7	81,5	64,1	69,4	66,2			34,0
43	50-60	117,8	113,8								
46	30-40	107,1	90,3		83,4	64,7	68,7			29,0	28,9
47	ad.o.o.	96,5	78,1			75,7	74,3				
51	35-45	93,5	85,3							28,3	31,7
53	20-30	107,7	107,7	85,6	84,0	71,9	71,9	66,7		31,4	33,6
54	30-40	89,6	89,6		82,0	61,8	62,8		66,9		
57	60+	100,0	103,7			61,1	72,7				
63	60+	100,0	107,4	80,8	79,4	68,6	71,4	67,9	66,6	27,7	35,1
65	ad.o.o.	93,1	96,3			75,0	75,9				
66	30-40	107,7	103,7								
68	50-60	93,3	87,1								
69	50-60	110,7	106,0	84,4	83,6	73,0	64,9				
71	50-60					75,0	78,4				

(tab. 36. continued)

ID	age	Femur pilastricus ri	/ le	femoro-tibial ri	/ le	Tibia cnemicus ri	/ le	inter-membral ri	/ le	Scaro-clavicular ri	/ le
72	20-30	100,0	118,5	83,9	84,1	67,5	61,5	65,0	65,2	36,4	38,0
73	35-45	96,6	110,3	81,2	80,9	77,1	71,4				
74	30-40	100,0		81,0		72,2		67,1			
75	40-50	110,7	110,7			75,7	77,8				
78	45-55	96,8	93,7	88,0	88,7	55,3	53,8				
82	40-50	74,2	90,0	77,2	76,9	65,6	66,7				
83	40-50	83,3	82,7	83,2	83,6	80,6	80,6				
85	30-40	90,9	100,0			77,8	87,5				
88	50-60	87,1	100,0				60,5				
89	50-60	100,0	96,4	81,7	80,4	60,6	60,6	67,9	69,7	26,0	24,1
92	60+	87,5	90,9	80,8	81,2	79,4	77,1	68,8	66,0	23,8	21,5
94	20-30	100,0	113,0	83,8	86,1	80,8	65,6				
97	40-50	103,8	103,0								
99	30-40		96,7		79,5		85,7		67,2		
103	60+	100,0	120,0	82,9	82,1	64,7	71,9	69,9		20,0	24,3
110	40-50		84,8							24,1	24,3
112	30-40	103,4	110,3	81,7	82,1	74,4	76,3	68,3	67,3	15,3	17,2
113	40-50	107,7	103,7	84,0	83,1	66,7	64,7		66,0		
114	40-50	115,4	119,2	83,0	83,4	71,4	70,6	68,8	67,8	30,6	31,2
115	60+	96,7	93,5	81,7	81,5	69,7	64,7	67,3	66,7		
116	30-50	106,7	106,7		84,2						
117	20-25	107,4	103,4	83,5	82,9	70,6	70,6	65,3	64,6	30,9	32,4
120	45-55	103,7	103,7	80,2	80,5	67,6	70,6	66,6	65,3	34,3	34,9
122	20-30	106,7									
123	40-50	90,3	90,9	84,5	83,7	73,5	69,4	67,1	66,1	36,1	37,3
126	45-55	90,6	88,2		80,9	67,5	67,5	66,5			31,8
127	30-40	96,4	93,3								
128	50-60	114,3	107,1	79,1	81,0	84,4	87,1	68,5	68,3	31,3	30,7
131	50-60									30,6	
132	40-50	96,4	93,3	82,3	81,4	68,7	57,1	68,4	67,5		32,6
133	45-55	93,3	106,9	85,2	86,0	76,5	76,5	68,7	69,0		
134	20-30	108,0	92,8	81,5	81,5	68,7	75,0	68,8	68,0	34,2	35,1
143	30-40	87,1	84,4	83,4	83,0	58,8	54,0			39,7	40,1
144	30-60	91,4	90,9								
145	50-60	93,7		82,8		71,8	71,0				

(tab. 36. continued)

ID	age	Femur pilastricus		femoro-tibial		Tibia cnemicus		inter-membral		Scaro-clavicular	
		ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le
203	40-50	96,4	83,9	77,7	79,4	78,1	80,6	66,8	68,2	27,1	23,8
207	30-40	111,1				74,3					
209	40-50	100,0									
212	30-60		96,4			65,7					
217	30-50	89,6	82,3		80,6	70,3	76,5				
221	40-50	96,7				62,2	63,1			29,3	
228	50-60	83,9	87,1	82,9	82,7	87,5	73,5	64,2		32,2	31,2
303	30-50	114,8	119,2			67,6	75,7				
309	40-50	103,8	112,5	81,9		65,6	68,7				
333	30-40					71,4	71,0				
339	30-40	106,7	106,7		80,0	63,9	60,5			32,2	
342	30-50	122,2		79,9		75,7	76,5				
343	30-60					57,9	60,5				
364	50-60	116,0	121,4			87,5	75				
369	40-60										
374	40-50	114,3		84,8		87,1	78,8				
505	ad.o.o.					58,1	67,7				
506	ad.o.o.	110,3	106,9								
523	40-60	100,0	103,6			66,7	65,8				
557	20-40	107,7									
610	30-50		96,7		81,4	78,4	76,3				
644	ad.o.o.	114,8	103,4	81,3	81,1	66,7	66,7				

tab. 37. Indices of the infra-cranium of females

ID	age	Hu leng-thick		humero-radial		femoro-humeral		Fe leng-thick		Fe rob.		Fe platy.	
		ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le
2	30-40	20,5	19,9	75,5		69,5			20,2		12,4		89,3
6	30-40		18,8		75,6			17,9		17,9		66,6	61,8
7	20-25	18,4	19,4			71,3	68,1	18,2	18,7	11,1	11,7	112,5	100,0
12	30-40	20,4	20,1	75,5	73,6	66,0	65,8	19,3	20,0	12,1	12,8	85,7	82,7
15	30-50							21,1	20,4	13,2	13,1	76,7	71,0
16	30-40	19,4	19,5		75,6								
24	30-40		20,0				67,1		20,7		13,4	100,0	96,5
25	20-30		18,3		77,7		68,4	18,7	19,7	11,8	12,1	92,0	88,9
27	30-40											86,7	76,7
29	30-40	18,8	19,5	76,0	76,5								
30	60+								20,1		12,8	72,7	78,1
31	20-25	17,9	17,8	73,8	73,1		68,9		17,5		11,1	69,7	73,3
34	40-50	18,3	18,4										
40	20-30								19,3		12,3		96,1
42	30-40	18,3	18,9	72,0	70,3	73,4	72,4	20,9	21,4	13,3	13,9	92,6	79,3
44	40-50							19,1	19,3	11,7	11,9	86,2	80,6
45	25-30	18,7	18,7	78,9								85,7	
48	30-40	18,8		73,9								70,6	72,7
49	30-40	18,0	18,1		72,3		74,2		19,5		12,2		71,0
52	20-30											92,3	88,9
55	50-60	18,5	19,4	72,3	71,0	73,3	70,8	18,3	19,4	11,2	12,0	77,4	80,6
59												74,1	81,5
60	30-45	18,2		73,5								75,8	
61	20-30	19,2	19,3	74,3	75,5								
64	40-50							19,4	19,3	12,6	12,2	76,7	73,3
67	20-30	21,4	21,3			71,7	69,6	20,0	20,2	12,4	12,6	75,0	77,4
76	40-50	20,7	20,5	73,9	72,5	71,0	72,1	21,0	21,6	13,8	14,3	80,6	83,9
77	20-30		18,7		75,7		72,8	19,0	18,9	12,1	12,0	90,0	82,7
80	40-50	19,6		72,8		71,8		19,8	20,3	11,9	12,8	100,0	89,3
81	20-30											80,8	84,6
84	20-25								20,4		12,3	76,7	79,3
87	50-60	19,5	19,4	74,4		73,5	70,3	22,4	22,1	13,6	14,3	103,3	90,3
90	40-50	20,1	20,2	77,2	78,8	75,2	65,5	22,8	22,4	13,8	13,2	103,8	92,9
91	50-60	16,9	18,0	73,8	75,7	71,7	69,3	19,3	19,3	12,1	12,2	71,9	70,6

(tab. 37. continued)

ID	age	Hu leng-thick		humero-radial		femoro-humeral		Fe leng-thick		Fe rob.		Fe platy.	
		ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le
93	20-25	19,6	19,8		76,9	70,8	70,3	19,5	19,6	11,7	12,1	72,7	84,4
95	50-60	20,1	19,5	75,8	74,7	72,9	71,4	20,4	20,3	12,4	13,2	92,6	92,8
96	35-45	20,0	19,1	76,8	76,4	76,1	75,6	21,5	21,6	13,0	13,7	100,0	93,1
98	20-30	18,2	17,8	73,5	72,9	69,6	70,1	19,9	18,8	12,2	11,8	75,0	68,7
100	20-30	19,6	18,5	71,2		72,6	72,3	19,1	18,8	11,8	12,1	88,5	75,0
101	50-60		21,1				68,1		20,9		13,1		81,2
104	50-60		20,1		76,3		66,7	19,1	20,2	12,1	12,9	74,2	66,7
105	30-40	21,1	20,5	74,1	70,6	73,0	70,8	20,3	19,8	12,5	12,2	92,6	96,3
106	30-40	20,1	20,4	74,2	75,5	73,4	72,4	22,0	21,0	12,8	12,8	79,3	75,9
107	20-30	17,5	17,4	74,4	73,2	77,1	74,4	19,6	18,7	12,7	12,3	75,9	81,5
108	25-30	17,0	17,1	74,5	74,9	69,7		18,4		11,9		84,0	69,0
111	ad.o.o.							19,6		12,1		82,7	
118	25-30	19,3	19,3		75,7	70,3	70,2	19,0	19,3	12,1	12,4	77,4	74,2
119	40-50	20,9	20,1	75,1	74,1	71,4	71,4	19,1	20,0	12,2	12,8	74,2	68,8
121	20-25	17,5	17,1	79,3	77,5	71,2	71,8	18,4	18,2	11,5	11,3	75,9	73,3
124	50-60	20,3	19,3	76,8	75,2	70,6	70,8	20,6	20,1	13,4	13,2	90,3	78,1
125	30-40	20,8	20,3	76,4	73,8	71,3		20,1		12,8		74,2	74,2
129	30-50	18,7							18,8		12,2	69,7	72,7
130	30-50	18,1		70,0		72,8		18,3	18,4	11,7	11,9	68,6	68,6
135	50-60		20,5		75,0		71,1	20,3	19,8	12,9	12,8	77,4	74,2
136	50-60	19,6	20,1	75,6	76,8	67,9	65,9	19,2	19,8	12,3	12,8	74,2	83,3
137	60+	19,9	19,9		75,9	72,2	71,5	20,4	20,2	12,7	13,2	78,8	71,4
138	30-50	20,0	20,1	75,7	75,8	70,1	68,6	19,2	19,2	12,3	11,9	74,2	71,0
140	20-30	20,1		77,8		70,3		19,3	19,4	12,4	12,5	65,6	67,7
141	40-50		18,6				65,2	18,0	18,1	11,3	11,7	96,4	85,7
142	30-40	17,8	18,1		69,7	71,4	69,6	19,4	18,9	12,0	12,1	75,0	70,6
146	30-40		18,4		69,1		68,7	19,8	18,4	12,7	11,5	71,0	73,3
201	40-50	17,0	17,3	76,0	75,0	71,2	70,1	17,4	17,2	10,9	10,9	80,8	77,8
205	30-60								18,8		12,3		85,7
211	30-50		18,8			67,8		17,4	17,9	11,0	11,4	83,9	83,9
214	25-30	14,9	17,9										
220	ad.o.o.												
222	30-40												
223	40-50							19,6	19,2	12,6	12,8	78,1	69,7

(tab. 37. continued)

ID	age	Hu leng-thick ri	/ le	humero-radial ri	/ le	femoro-humeral ri	/ le	Fe leng-thick ri	/ le	Fe rob. ri	/ le	Fe platy. ri	/ le
301	30-40							19,2	19,9	12,1	12,6	81,8	74,3
305	60+	19,8	19,7	77,4	76,9	69,5	71,8	19,2	19,3	12,0	12,4	82,1	77,8
307	25-35	20,3	19,9	75,1	75,3	70,2	71,6	21,3	20,7	13,3	12,5	82,7	88,9
328	30-50								19,3		12,0		78,6
335	40-50	21,1	21,7	72,8	73,2	72,0	70,0	22,0	22,0	14,1	14,2	89,6	76,7
340	30-50	19,5		73,4					18,1		11,5		79,4
352	40-50		18,5				70,3		18,6		11,4		77,4
357	30-50							19,0	19,0	13,0	13,0	75,7	74,3
359	30-40		18,8		77,2		72,1		19,6		12,7		92,6
376	40-50		19,7		73,2		71,1		19,8		12,5	74,2	71,0
514	20-30							20,2	21	12,5	13,6	73,3	75,9
519	20-30		16,4		73,0		68,1	17,5	17,6	11,0	11,1	68,7	71,0
529	30-40	19,3	19,2										
612	30-50							21,4	21,8	13,2	14,0	78,8	79,4

(Abbreviations of the indices: Hu leng-thick= Humerus length-thickness; Fe leng-thick=Femur length-thickness; Fe rob= Femur robustness; Fe platy= Femur platymericus) tab. 38. Indices of the infra-cranium of females

ID	age	Femur pilastricus		femoro-tibial		Tibia cnemicus		inter-membral		Scaro-clavicular	
		ri	/ le	ri	/ le	ri	/ le	ri	/ le	ri	/ le
2	30-40		108,0							29,2	29,3
6	30-40	81,5									40
7	20-25	108,3	108,8	83,1	82,8	78,1	83,3			30,5	30,8
12	30-40	100,0	96,4	81,4	82,3	67,7	62,5	62,8	61,6	32,6	35,7
15	30-50	85,2	85,2	87,1	85,9	75,0	75,9				
16	30-40										
24	30-40	83,3	83,9		78,3	68,7	71,9				
25	20-30	112,5	108,0	81,5	82,1	79,3	67,7		65,8		32
27	30-40	104,0	100,0			66,7					
29	30-40									35,4	36,1
30	60+	111,5	107,4		85,6	65,6	64,7				
31	20-25	104,0	96,0		82,5	68,7	73,3		64,3	38,3	37,1
34	40-50										
40	20-30		104,1		83,4	70,0	65,5				
42	30-40	112,5	107,7	80,1	79,6	75,0	71,0	69,3	67,9	31,3	34,5
44	40-50	88,9	85,7	83,0	80,6	66,7	69,0				
45	25-30	108,7				72,4	75,0				36,8
48	30-40									32,6	30,4
49	30-40		100,0			70,6	70,6				
52	20-30	104,2	104,0								
55	50-60	108,0	100,0	84,3	83,7	70,6	72,7	67,3		26,6	24,8
59	ad.o.o.	118,2	104,0			70,4	64,3				
60	30-45	116,7				79,4					
61	20-30										
64	40-50	103,8	100,0	83,4	81,9	74,2	64,7				
67	20-30	103,8	100,0	83,4	82,2	77,4	80,6			32,3	31,8
76	40-50	111,1	103,4	83,6	84,7	77,4	72,7	66,7	66,7	34,7	33,6
77	20-30	103,8	108,0	83,9	85,9	63,6	65,6		68,6		
80	40-50	108,3	112,0	83,5	83,7	64,7	60,0	66,6		28,5	
81	20-30	100,0	100,0			84,0	87,5				
84	20-25	96,3	96,3		82,4	77,4	74,2				
87	50-60	103,6	103,3	87,1	85,9	57,6	58,8	66,2		29,4	28,2
90	40-50	100,0	100,0	90,0	81,3	78,1	75	68,8	68,2	27	30
91	50-60	80,0	77,4	82,5	83,3	62,5	61,3	67,5	65,8		

(tab. 38. continued)

ID	age	Femur pilastricus ri	/ le	femoro-tibial ri	/ le	Tibia cnemicus ri	/ le	inter-membral ri	/ le	Scaro-clavicular ri	/ le
93	20-25	86,2	92,1	82,2	81,6	72,7	78,1		67,4		
95	50-60	117,4	92,8	85,8	84,8	68,7	68,7		66,3	28,2	
96	35-45	108,0	103,7	84,8		60,6	54,3	71,4		25,7	26,4
98	20-30	79,3	85,2	81,5	81,6	65,5	65,5	65,0	65,3	30,6	35,4
100	20-30	92,0	96,0	81,0	81,7	78,6	77,8	67,2			32,6
101	50-60		125,0			75,0					
104	50-60	85,2	82,7	80,7	83,0	73,3	70,0		63,4	34,5	
105	30-40	112,5	108,3	81,9	80,4	77,4	79,3	67,8	66,5		
106	30-40	112,5	112,5	88,0	86,2	68,7	63,6			30,5	33,6
107	20-30	96,3	104,0		86,3	67,7	68,7				27,8
108	25-30	95,8	71,9	81,1		84,6	75,0	70,7		37,5	32,2
111	ad.o.o.	104,3					69,4				
118	25-30	104,0	100,0	82,7	82,8	61,3	63,3		67,4	34,3	36,8
119	40-50	100,0	92,6	82,4	82,3	71,9	72,7	67,6	66,7		
121	20-25	92,3	96,0	83,4	85,9	75,9	73,3	68,5	68,4		32,6
124	50-60	111,1	111,1	86,6		68,6	65,7	66,4	66,4	33,6	31,2
125	30-40	104,0	108,0	86,4	78,3	70,0	66,7	66,7		37,1	29,5
129	30-50	92,6	96,3		82,1	66,7					
130	30-50	96,4	93,1	79,6		75,7	72,7	68,0		40,2	
135	50-60	104,0	104,0	85,3		64,5	63,3		66,2		
136	50-60	100,0	107,7	80,5	85,6	78,6	82,1	64,7	63,3		38,2
137	60+	103,7	103,6	82,6	82,5	60,0	61,1				
138	30-50	92,6	85,0	81,2		71,9	71,9	66,7	65,2		
140	20-30	85,2	82,1	83,4	83,4	70,0	73,3	66,8		31,3	
141	40-50	104,0	112,0	80,2	79,6	61,8	67,7				
142	30-40	108,0	96,3	80,8	80,6	63,6	67,7		64,4		
146	30-40	120,0	108,3	79,0		55,9	62,5				
201	40-50	113,6	113,6	84,2		74,0	74,0			28	26
205	30-60		104,0			62,5	63,9				
211	30-50	112,5	112,0								
214	25-30				83,7						
220	ad.o.o.	117,4	104,1			65,6	71,9				
222	30-40	107,7	96,3								
223	40-50	100,0	89,6								

(tab. 38. continued)

ID	age	Femur pilastricus ri	/ le	femoro-tibial ri	/ le	Tibia cnemicus ri	/ le	inter-membral ri	/ le	Scaro-clavicular ri	/ le
301	30-40	96,3	96,4	80,5	81,9	73,5	68,4				
305	60+	104,2	108,3		82,2	71,0	73,3			29,1	20,3
307	25-35	89,3	92,3	81,7	84,7	63,3	74,1	65,9	67,9	33,1	23,8
328	30-50	104,2	104,0		85,9	65,7	68,6				
335	40-50	107,7	96,4	80,4	83,7	66,7	70,0	67,5	65,8		
340	30-50		100,0			90,6	81,8				
352	40-50		108,0		82,4		75,7				
357	30-50	114,8	96,7		85,9		73,0				
359	30-40		108,0		81,3		67,7				
376	40-50	100,0	104,0		83,3	71,0					
514	20-30	117,4	111,5	85,7	81,6	68,7	61,8				
519	20-30	96,0	92,3	81,1	84,8	69,7	57,1		64,3		
529	30-40					71,0	68,7				
612	30-50	90,0	90,6	81,9	81,6	70,6	60,5				

6. Reconstruction of body height

The reconstruction of body height of (pre-)historic individuals is based on calculations of different regression formulas using linear measurements of several long bones. In the literature the discussion about methodological approaches as well as the right applications of specific formulas has been debated for many years (Rösing 1988, Siegmund 2010). In this work, seven formulas from six different authors were used. It should be tested to what extend different formulas lead to different results in one series. In addition the the comparability between different series evaluated with different formulas is increased. The formulas used are developed by Breitinger (1938) for male and Bach (1965) for female individuals. Furthermore, the formulas developed by Pearson (1899) and Olivier et al. (1978) were used. Frank Siegmund (2010) established in his study, about body height reconstructions of pre- and early historic series in central Europe, a combination of three formulas. This combined formula includes the arithmetic means of the estimations by Pearson (1899) as well as Trotter and Gleser (1952) 'American White' and 'American Negro'. This combined formula was used for the Grevenmacher individuals as well. The necessary results by Pearson (1988) as well as Trotter and Gleser (1952) are also listed. Table 39 shows the results for the respective formulas separated for adult males and females with the amount of individuals (n), mean value (x), range and standard deviation (s). The difference in body height between men and women is listed in centimetres and expressed as index with t-test check on a ≤0,05 value. The results for all adult individuals are listed in tables 41 and 42 at the end of the chapter.

tab. 39. Body heights of males and females according to different authors

	♂				♀						
formula	n	x	range	s	n	x	range	s	f/m%	diff. m-f	t-test
Breitinger (1938)	92	169,3	161,9-179,9	3,97							
Bach (1965)					91	161,1	152,1-169,6	3,49	95,16	8,2	14,833hs
Olivier (1978)	106	168,4	154,5-186,4	5,92	91	159,4	148,4-174,5	5,24	94,65	9,0	11,213hs
Pearson (1899)	100	166,2	154,8-179,1	4,65	92	156,4	147,9-168,3	4,09	94,10	9,8	15,450hs
TG-AW (1952)	106	170,8	158,1-184,4	5,68	94	160,9	149,7-176,3	5,58	94,20	9,9	12,404hs
TG-AN (1952)	106	166,1	153,5-179,4	5,12	94	157,4	147,2-171,3	4,83	94,76	8,7	12,316hs
Sieg. Kombi. (2010)	100	167,7	156,1-179,7	5,10	92	158,3	148,5-172,0	4,69	94,39	9,4	13,258hs

(TG-AW=Trotter and Gleser 'American White'; TG-AN=Trotter and Gleser 'American Negro'; Sieg.Kombi.=Siegmund Kombinierte Methode; hs=highly significant)

As shown in table 39, male individuals from Grevenmacher are on average 9,2 cm taller than the females. Within the sexes, the differences according to the respective formulas is 4,7 cm in males as well as females. As mentioned above, the calculation of body height according to seven different formulas was carried out to increase the comparability with other series. However, the question that remains is which formula is the most suitable for the Grevenmacher individuals. One fact we have to take into consideration is that all of the used estimations were developed with the help of anatomical series from the 19th and beginning 20th century. Thereby formulas were derived with the help of regression calculations from linear measurements including either all available bones or just the best bone available (Siegmund 2010). Siegmund (2010) points in his work to the fact, that the formulas of Bach (1965) and Breitinger (1938) were rather inaccurate. Their regression formulas were developed with the help of male and female athletes. This kind of selection leads to excessive values and therefore, does not mirror an average part of a population. In addition, the formulas are also rather inaccurate. Nevertheless both formulas were included in the study due to the fact that they were still used in many studies, especially in the German-speaking world. Siegmund (2010) offers calculations to correct the Bach (1965) and Breitinger (1938) formulas in relation to Pearson (1899) as well as his own combined method. However, this kind of correction was not used in this work because it would limit the comparability with other studies because this kind of correction is not widely used. The formula of Olivier et al. (1978) is also commonly used in different European series. Rösing (1988) states in general good results. In his comprehensive examination of different calculations Siegmund (2010) confirms that the formula used by Pearson (1899) is still one of the estimations that reveal very exact results for (pre-)historic populations. The formula used by Trotter and Gleser (1952) for the classification 'Negro' shows similar good outcomes. The combined method by Siegmund (2010) including the arithmetic means of the formulas by Trotter and Gleser for 'White' and 'Negro' as well as Pearson (1899), is an attempt to compensate for the slightly over- and underestimations of body height in the respective estimations. However, the fact that this method was established recently is the reason why it is not yet used to a greater extent. Following the arguments of Siegmund (2010), the method of Pearson (1899) delivers the most accurate results in the Grevenmacher series. However, results according to the combined method of Siegmund (2010) reveal slightly higher values in males as well as in females.

To compare the body height of males and females from different populations from the medieval period, Siegmund (2010) created a table with sites from all over Europe. For every series body height was calculated by the formula of Pearson (1899). The results from Grevenmacher were included by the author.

tab. 40. Comparison of body height of different sites from medieval Europe (11th-15th century) sorted by body heights of males ascending

Site	Reference	BH men (cm)	BH women (cm)
Tomils (CH)	Papageorgopoulou (2008)	163,6	152,8
Zürich Münsterhof (CH)	Etter (1982)	163,8	155,2
Kérpuszta (HU)	Nemeskéri et al. (1954)	164,7	153,5
Békés Povádzug (HU)	Lipták & Farkas (1967)	164,9	152,6
Unterregenbach II (D)	Preuschoft & Schneider (1972)	164,9	158,1
Twann-Fiedhof (CH)	Ulrich-Bochsler (1988a)	165,0	155,0
Ungarn 11th-12th (HU)	Éry (1998)	165,4	153,5
Csátalja (HU)	Lipták (1957)	165,6	152,7
Ungarn 13th-15th (HU)	Éry (1998)	165,9	153,9
Fonyod (HU)	Nemeskéri (1963)	165,9	154,2
Ostrow Lednicki (PL)	Godycki (1956)	166,0	154,9
Grevenmacher (L)		**166,2**	**156,4**
Sandau (D)	Gregor (2003)	166,4	159,0
Ptuj (SLO)	Ivaniček (1951)	166,7	156,7
Samborzek (PL)	Sarama (1956)	166,9	153,7
Kirchlindach II-IV (CH)	Ulrich-Bochsler (1983)	167,0	155,8
Schwyz (CH)	Cueni (1995)	167,4	153,5
Zwentendorf (A)	Heinrich (2001)	167,7	156,2
Westerhus (S)	Gejvall (1960)	169,0	156,0
Walkringen 3-4 (CH)	Ulrich-Bochsler & Meyer (1992)	169,5	152,3
Rohrbach (CH)	Ulrich-Bochsler (1988b)	171,4	157,9

The average value of all 21 series is 166,3 cm for males and 156,4 cm for females. The average height of a Grevenmacher male fits perfectly with the overall range. The result for the women is just 1,7 cm higher than the average. So the average statures of the Grevenmacher population comply with the European average in the medieval period.

tab. 41. Body height of males

ID. No.	Age	Breitinger (1938)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
1	50-60	170,4	168,7	168,2	172,2	167,3	169,2
3	30-40	173,9	171,4	171,4	174,8	169,6	171,9
4	55-65	170,8	171,6	166,9	173,6	169,8	170,1
5	35-45	169,8	168,1	166,2	170,0	165,5	167,2
8	30-40	173,9	173,7	171,1	176,1	172,0	173,1
9	30-40		175,0	170,2	178,4	171,2	173,3
10	40-50	171,4	171,4	166,9	174,7	168,0	169,9
11	50-60	173,6	172,0	171,2	172,9	168,0	170,7
14	40-50		167,9	164,7	170,1	164,0	166,3
17	50-60	167,9	164,9	165,2	167,2	162,9	165,1
18	ad.o.o.		174,0		174,7	169,7	
19	ad.o.o.		170,5		171,2	166,9	
20	30-40	179,1	180,9	176,7	184,4	178,0	179,7
21	20-40	168,1	166,6	165,4	170,6	165,9	167,3
22	60+	164,4	160,8	160,7	161,7	158,1	160,2
23	ad.o.o.	162,4	159,1	158,5	163,3	159,6	160,5
26	60+	172,1	173,3	169,4	175,1	169,9	171,5
32	30-40	173,1	172,5	168,2	177,1	172,9	172,7
33	40-50		175,5		175,8	168,9	
35	30-40	178,9	179,0	174,8	181,3	179,4	178,5
36	20-30	166,0	163,3	163,4	166,2	162,1	163,9
37	30-40	161,9	157,1	157,5	161,1	157,6	158,7
38	50-60	172,0	171,8	169,3	175,1	167,0	170,5
39	50-60	162,1	158,2	157,9	161,6	158,0	159,2
41	50-60	172,2	170,6	169,3	175,2	170,0	171,5
43	50-60		162,7	167,7	173,1	168,4	169,7
46	30-50	169,2	167,8	166,4	171,1	166,4	168,0
47	ad.o.o.	168,3	168,2	165,6	168,9	165,0	166,5
51	35-45	169,1	168,0	165,0	173,0	166,5	168,2
53	20-30	169,0	167,4	165,4	170,3	165,7	167,1
54	30-40	164,4	160,9	160,7	164,8	160,8	162,1
56	30-60		170,0	166,4	171,4	165,0	167,6
57	60+	154,9	161,3	160,4	165,6	161,6	162,5
58	40-50		175,9	171,0	179,1	171,9	174,0
62	30-40	170,2	168,8	165,6	171,5	169,0	168,7

(tab. 41. continued)

ID. No.	Age	Breitinger (1938)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
63	60+	159,9	154,5	155,3	158,1	154,9	156,1
65	ad.o.o.	169,8	167,9	167,4	168,2	164,5	166,7
66	30-40	171,0	168,1	165,6	172,5	166,0	168,0
69	50-60	170,0	168,9	167,4	171,7	166,9	168,7
71	50-60	170,6	170,2	166,0	175,6	170,3	170,6
72	20-30	172,2	172,1	169,1	176	170,7	171,9
73	35-45	164,8	161,3	160,2	163,4	159,6	161,1
74	30-40	171,8	164,8	169,0	174,2	169,2	170,8
75	40-50	167,3	165,6	164,4	169,6	165,1	166,4
78	45-55	160,8	155,4	156,5	158,2	155,0	156,6
79	40-55	169,5	169,8	166,2	174,3	166,6	169,0
82	40-50	168,1	166,7	165,6	169,2	164,8	166,5
83	40-50	167,8	165,9	165,1	168,5	164,1	165,9
85	30-40		186,4	179,1	178	170,9	176,0
86	30-40	171,0	169,8	166,6	173,2	166,6	168,8
87	50-60		167,0		167,7	164,0	
88	50-60	164,3	161,3	160,0	167,0	162,9	163,3
89	30-40	162,3	156,9	158,0	159,8	156,4	158,1
92	60+	169,1	166,9	166,0	170,8	166,1	167,6
94	20-30	166,8	164,0	163,7	166,8	162,6	164,4
97	40-50	170,7	163,8	161,4	166,2	160,4	162,7
99	30-40		168,1	167,5	172,1	167,3	169,0
102	30-40	169,6	167,4	166,3	159,4	157,2	161,0
103	60+	162,4	157,1	158,3	160,1	156,7	158,4
110	45-55	171,7	167,3	167,1	164,5	159,0	163,5
112	30-40	170,1	169,1	167,2	171,3	166,6	168,4
113	40-50	170,5	170,3	167,4	172,8	167,9	169,4
114	40-50	166,0	162,9	162,5	165,7	161,6	163,3
115	60+	166,1	163,5	162,7	167,0	162,7	164,1
116	30-50	171,3	168,6	165,7	174,6	169,4	169,9
117	20-25	175,4	177,2	173,0	180,7	174,9	176,2
120	45-55	162,9	158,1	159,1	162,3	158,6	160,0
122	20-30	168,0	166,3	163,2	169,0	166,4	166,2
123	40-50	169,4	167,1	166,1	171,1	166,4	167,9
126	45-55	172,2	181,7	169,7	175,8	170,6	172,0

(tab. 41. continued)

ID. No.	Age	Breitinger (1938)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
127	30-40		181,8	175,5	182,6	175,3	177,8
128	50-60	169,5	167,6	166,8	170,7	166,1	167,9
131	50-60	168,3	163,8	162,2	167,3	161,4	163,6
132	40-50	168,5	166,5	165,4	169,2	164,8	166,5
133	45-55	170,6	169,3	167,9	171,8	167,0	168,9
134	20-30	170,1	169,8	167,3	171,2	166,5	168,3
143	30-40	170,6	169,5	167,8	170,2	165,6	167,9
145	50-60	177,5	178,7	177,0	182,6	176,5	178,7
203	40-50	167,3	163,3	163,8	167,5	163,2	164,8
207	30-40	174,5	167,5	174,9	158,6	153,5	158,8
209	40-50	177,4	176,9	168,2	179,0	174,5	176,1
215	40-50	170,5	169,8	172,3	173,6	168,6	170,1
217	30-50	173,6	173,3	164,8	177,1	171,7	173,7
221	40-50	169,2	174,2	172,1	171,6	168,0	168,1
228	50-60	175,0	176,2	159,2	179,0	173,4	174,8
309	40-50	162,9	159,9	161,5	161,6	158,0	159,6
315	40-50	166,4	164,4	161,7	167,2	164,5	164,4
324	30-60		171,6		172,3	167,8	
339	30-40	165,9	162,1	164,9	165,1	161,1	162,6
342	30-50	167,5	165,4	168,7	168,3	163,9	165,7
343	30-60	170,9	171,2	169,9	171,9	167,4	169,3
346	30-60	174,2	173,6	154,8	176,1	173,9	173,3
361	20-40	160,2	157,0	166,0	160,0	157,0	157,3
366	30-60	168,6	167,3	168,4	171,2	166,5	167,9
369	40-60	171,0	172,8	170,4	178,8	171,5	172,9
374	40-50	172,1	173,8	164,4	174,6	169,5	171,5
503	ad.o.o.	167,3	165,6	168,3	168,0	164,3	165,6
505	ad.o.o.	170,6	169,9	168,7	172,3	167,8	169,5
523	40-60	170,9	170,3	168,7	172,0	167,5	169,4
537	50-60	173,2	172,3	166,3	174,9	172,6	172,1
543	ad.o.o.	168,6	166,0	166,8	169,0	165,7	167,0
557	20-40	169,2	168,7	166,7	170,5	165,9	167,7
590	30-50	169,2	168,1	173,0	172,0	167,1	168,6
610	30-50	174,4	175,8	167,9	179,6	174,0	175,5
644	ad.o.o.	170,0	169,2		171,9	167,1	169,0

(TG-AW=Trotter and Gleser American White; TG-AM=Trotter and Gleser American Negro) tab. 42. Body height of females

ID. No.	Age	Bach (1965)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
2	30-40	162,0	158,4	154,8	159,0	156,7	156,8
6	30-40	159,9	156,1	152,2	155,4	153,2	153,6
7	20-25	164,7	160,1	161,8	168,6	164,3	164,9
12	30-40	160,0	157,9	154,6	162,0	158,4	158,3
15	30-50	154,8	150,1	149,1	151,7	149,0	149,9
16	30-40	164,2	162,1	157,8	165,3	157,8	160,3
24	30-40	159,0	158,0	153,7	150,0	155,7	153,1
25	20-30	161,0	158,9	156,7	162,4	158,7	159,3
28	40-50	161,4	154,0	153,3	157,8	156,1	155,7
29	30-40	164,1	155,0	158,3	153,0	149,2	153,5
30	60+	161,2	167,3	158,7	163,8	159,9	160,8
31	20-25	162,9	160,2	158,8	165,5	161,5	161,9
34	40-50	168,7	164,7	162,7	169,3	166,8	166,3
40	20-30	156,9	160,3	152,4	155,7	152,6	153,6
42	30-40	155,4	148,7	148,5	149,7	147,2	148,5
44	40-50	161,1	162,4	158,4	163,6	159,8	160,6
45	25-30	160,5	163,7	158,0	164,3	159,9	160,7
48	30-40	164,9	163,1	158,4	166,2	159,4	161,3
49	30-40	162,9	162,5	159,0	162,9	159,1	160,3
52	20-30		164,8		163,2	157,1	
55	50-60	167,8	170,1	165,4	173,0	168,3	168,9
60	30-45	169,6	170,1	164,2	166,8	162,0	164,3
61	20-30	156,7	151,2	148,2	156,0	151,5	151,9
64	40-50	159,9	159,6	156,8	161,3	157,7	158,6
67	20-30	158,6	154,6	153,0	156,8	153,6	154,5
70	40-50	156,9	166,6	158,1	161,5	157,5	159,0
76	40-50	159,7	156,2	154,6	158,8	155,5	156,3
77	20-30	163,7	162,8	160,3	165,5	161,5	162,4
80	40-50	160,6	157,5	155,7	159,9	156,5	157,4
84	20-50	163,7	160,7	157,2	161,0	157,0	158,4
87	50-60	162,4	161,3	158,0	164,0	160,1	160,7
90	40-50	159,4	154,9	154,3	158,4	155,1	155,9
91	50-60	164,0	163,9	160,7	166,7	162,6	163,3
93	20-25	166,0	167,2	163,8	170,4	165,9	166,7
95	50-60	159,4	156,0	154,1	158,1	154,8	155,7

(tab. 42. continued)

ID. No.	Age	Bach (1965)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
96	35-45	159,7	155,9	155,2	156,8	153,6	155,2
98	20-30	160,8	158,7	155,9	161,4	157,8	158,4
100	20-30	158,4	154,1	152,6	155,6	152,5	153,6
101	50-60	160,3	151,2	152,4	157,6	155,3	155,1
104	50-60	157,4	153,4	151,5	156,8	153,6	154,0
105	30-40	158,9	154,6	153,5	157,1	153,9	154,8
106	30-40	158,8	157,0	154,4	162,3	157,8	158,2
107	20-30	162,1	159,8	158,0	161,0	157,4	158,8
108	25-30	155,4	151,7	150,8	151,0	148,6	150,1
109	50-60	165,4	159,9	158,5	164,1	162,0	161,5
111	ad.o.o.	158,0	151,3	148,9	150,7	148,9	149,5
118	25-30	159,8	156,6	155,0	159,0	155,6	156,5
119	40-50	158,6	154,6	153,2	156,7	153,6	154,5
121	20-25	162,8	161,5	159,5	164,4	160,5	161,5
124	50-60	162,1	160,7	157,9	163,4	159,6	160,3
125	30-40	157,9	157,1	152,0	155,8	152,7	153,5
129	30-50	164,7	159,9	158,2	162,0	159,4	159,9
130	30-50	167,4	168,8	165,2	170,9	166,4	167,5
135	50-60	158,2	153,2	152,4	156,8	153,6	154,3
136	50-60	159,1	156,1	153,7	159,6	156,2	156,5
137	60+	162,3	160,8	158,4	163,0	159,2	160,2
138	30-50	159,9	157,0	155,0	160,1	156,6	157,2
140	20-30	158,2	154,1	152,7	156,7	153,5	157,2
141	40-50	162,6	162,4	159,5	166,8	162,7	163,0
142	30-40	161,9	160,3	157,1	152,6	158,9	156,2
146	30-50	161,1	159,0	156,8	162,0	153,4	157,4
147	30-40	165,4	162,7	158,5	164,9	158,4	160,6
201	40-50	162,4	160,9	158,3	164,2	160,4	161,0
205	30-60	159,8	158,6	156,5	161,0	157,5	158,3
210	30-40	163,5	160,3	156,0	163,2	157,1	158,8
211	30-50	167,0	171,1	161,9	169,4	166,2	165,8
214	25-30	161,7	154,5	153,7	158,3	156,6	156,2
220	ad.o.o.	158,7		159,4	165,9	160,8	162,0
223	40-50	163,6	160,3	157,1	161,2	158,6	159,0

(tab. 42. continued)

ID. No.	Age	Bach (1965)	Olivier (1978)	Pearson (1899)	TG-AW (1952)	TG-AN (1952)	Siegmund (2010)
301	30-40	157,2	161,8	157,4	160,7	156,8	158,3
305	60+	160,4	159,0	153,1	155,5	153,3	154,0
307	25-35	157,4	152,7	151,5	154,6	151,6	152,6
325	ad.o.o.				153,9	151,1	
328	30-50	159,5	163,4	156,0	160,6	157,1	157,9
335	40-50	154,9	148,4	147,9	150,1	147,5	148,5
336	40-50	162,0		163,9	171,4	165,5	166,9
340	30-50	169,4	174,5	168,3	176,3	171,3	172,0
352	40-50	167,1	162,4	161,8	167,7	164,6	164,7
355	25-35	165,2	167,8	160,4	174,3	165,7	166,8
357	30-50	164,5	168,7	162,6	170,0	165,6	166,1
359	30-40	162,6	155,9	154,9	159,8	158,0	157,6
362	20-40	158,6	163,1	159,3	165,8	160,7	161,9
376	40-50	160,8	156,3	152,9	155,6	153,5	154,0
510	20-30	163,3	166,2	158,1	160,5	158,0	158,9
514	20-30	157,7	155,5	153,0	157,0	153,8	154,6
519	20-30	162,9	162,2	159,0	165,7	161,7	162,1
521	20-40	154,3	157,3	153,4	156,7	151,2	153,8
529	30-40	161,1	153,7	152,9	158,4	155,8	155,7
533	20-40	156,1	166,9	157,8	158,0	154,5	156,8
542	20-40	165,2	159,6	158,2	163,8	161,7	161,2
556	30-40		160,4	154,7	156,7	152,8	154,7
598	20-40	152,1	154,5	150,5	154,9	151,5	152,3
605	20-40	157,3	153,4	150,2	158,9	153,8	154,3
612	30-50	160,2	160,9	157,1	162,0	158,3	159,1

(TG-AW=Trotter and Gleser American White; TG-AM=Trotter and Gleser American Negro)

7. Non-metric traits

The evaluation of non-metric traits is a common feature in modern anthropological studies. Non-metric traits are small variations of phenotypic expression which can be found in all human tissues but cannot be recorded metrically. For anthropological studies, traits expressed in the skeleton are the most suitable for evaluation (Tyrell 2000). The fact that a lot of these traits occur more frequently within families or populations, lead to the assumption that these traits have a genetic background (Hauser and De Stefano 1989, Tyrell 2000, Grupe et al. 2005). Based on the genetic determination as well as their independence from age and sex, these traits are often used for reconstructions of family relations within a specific population as well as for comparison between different populations (Czarnetzki 1971, 1972, Herrmann et al. 1990, Alt 1997). However authors like Tyrell (2000) also state that kinship studies are limited by the insufficient knowledge about heritability and therefore, genetic determination of some traits. Furthermore. it is still unclear to what extend external factors influence trait development. The evaluation of non-metric traits cannot be considered as a substitute for kinship analysis based on nuclear DNA. However, it can be used as a first measure to examine possible relations between induviduals.

In this work, a total of 31 different traits were recorded, 24 at the skull and seven at the infra-cranial skeleton. A complete list of all traits with their respective variations is given at the end of the chapter (tab. 45). The aim of this recording was at first to establish a reference list of different traits for an average rural population from medieval Luxembourg, which does not currently exist today. Frequency distributions of the traits can help to examine the homogeneity of the population. In addition, this study focuses on kinship relations in the cemetery. An attempt was made to reconstruct possible family relations based on specific traits as well as the location of specific individuals in the cemetery relative to one another.

7.1. Non-metric traits of the skull

tab. 43. Frequency of the recorded traits of the skull for males and females as well as summarized for both sexes.

		Males			Females			Total		
trait	var.	region present	trait present	%	region present	trait ptesent	%	region present	trait present	%
Sut. frontalis (metopica)	pres.	70	8	11,4	64	8	12,5	134	16	11,9
Sut. mendosa pers.	pres.	71	1	1,4	65	0	0,0	136	1	0,7
For. (Inc.) supraorb. ri.	pres.	62	32	51,6	56	28	50,0	118	60	50,8
le.	pres.	61	39	63,9	57	26	45,6	118	65	55,1
For. frontale ri.	pres.	62	35	56,4	57	22	38,6	119	57	47,9
le.	pres.	60	25	41,7	58	20	34,5	118	45	38,1
Oss. coronalia ri.	pres.	68	1	1,5	60	1	1,7	128	2	1,6
le.	pres.	69	0	0,0	59	1	1,7	128	1	0,8
Oss. sagittalia	pres.	68	2	2,9	61	3	4,9	129	5	3,9
Oss. apicis lambdae	pres.	68	0	0,0	61	3	4,9	129	3	2,3
Oss. lambdoidea ri.	pres.	68	14	20,6	62	10	16,1	130	24	18,5
le.	pres.	68	20	29,4	61	13	21,3	129	33	25,6
Oss. astericum ri.	pres.	67	1	1,5	62	0	0,0	129	1	0,8
le.	pres.	68	1	1,5	61	1	1,6	129	2	1,5
Os epiptericum ri.	pres.	65	4	6,1	59	0	0,0	124	4	3,2
le.	pres.	66	3	4,5	58	0	0,0	124	3	2,4
For. parietale ri.	pres.	65	40	61,5	61	35	57,4	126	75	59,5
le.	pres.	66	36	54,5	61	30	49,2	127	66	52,0
For. Huschke ri.	pres.	57	15	26,3	55	12	21,8	112	27	24,1
le.	pres.	61	14	22,9	55	15	27,3	116	29	25,0
For. ovale ri.	doub.	47	0	0,0	36	3	8,3	83	3	3,6
le.	doub.	46	0	0,0	41	1	2,4	87	1	1,1
For. ovale ri.	open	47	3	6,3	37	2	5,4	84	5	5,9
le.	open	46	0	0,0	41	1	2,4	87	1	1,1
Fac. condyl. ri.	doub.	60	2	3,3	57	1	1,7	117	3	2,6
le.	doub.	60	1	1,7	57	0	0,0	117	1	0 8
For. zygomaticof. ri.	doub.	52	25	48,1	54	25	46,3	106	50	47,2
le.	doub.	52	16	30,7	51	22	43,1	103	38	36,9
For. zygomaticof. ri.	miss.	52	7	13,5	54	6	11,1	106	13	12,2
le.	miss.	52	2	3,8	51	5	9,8	103	7	6,8

(tab. 43. continued)

		Males			Females			Total		
trait	var.	region present	trait present	%	region present	trait present	%	region present	trait present	%
Torus palatinus	pres.	55	1	1,8	52	10	19,2	107	11	10,2
For. palat. minor ri.	pres.	41	19	46,3	35	10	28,6	76	29	38,1
le.	pres.	41	18	43,9	36	11	30,6	77	29	37,7
Torus mandibularis ri.	pres.	57	9	15,8	55	11	20,0	112	20	17,8
le.	pres.	56	9	16,1	51	10	19,6	107	19	17,7
For. mentale ri.	doub.	57	7	12,2	53	3	5,6	110	10	9,1
le.	doub.	56	10	17,8	52	5	9,6	108	15	13,9
Oss. incis.parietale ri.	pres.	58	7	12,1	57	1	1,7	115	8	6,9
le.	pres.	58	9	15,5	53	1	1,9	111	10	9,0
Can. hypoglossi ri.	doub.	55	6	10,9	48	3	6,2	103	9	8,7
le.	doub.	52	3	5,8	49	8	16,3	101	11	10,9
Torus maxilaris ri.	pres.	59	11	18,6	50	8	16,0	109	19	17,4
le.	pres.	59	10	16,9	51	8	15,7	110	18	16,4

(Sut.=Sutura, For.=Foramen, Inc.=Incisura, Oss.=Ossiculum, Can.=Canalis; ri.=right body side, le.=left body side; pres.= trait present; doub.= trait is double; miss.= trait missing)

The following traits are present in high frequency for both sexes: For example the Foramen respectively the Incisura supraorbitale and frontale; the Ossicula lambdoidea; the Foramina parietale and Huschke; the doubled Foramen zygomaticofaciale; as well as, the Foramen palatinum minor. Some traits are hardly found and are only present in one individual like the Sutura mendosa persistens and the Ossicula coronalia and astericum. Some traits show high discrepancies in their frequencies between males and females, whereas, in five traits these differences are significant on a ≤0,05 value. This includes the left Foramen supraorbitalia; the right Foramen ovale partitum; the Torus palatinus, as well as, both Ossicula incisura parietale.

7.2. Non-metric traits of the infra-cranial skeleton

Table 44 shows the frequencies of the seven examined traits at the infra-cranial skeleton. The values are separated for males and females as well as summarized for both sexes.

tab. 44. Frequency of the recorded traits of the infra-cranial skeleton for males and females as well as summarized for both sexes

		Males			Females			Total		
trait	var.	region present	trait present	%	region present	trait present	%	region present	trait present	%
For. transversvers. ri. (cervival vertebr.) le.	doub.	60	5	8,3	60	6	10,0	120	11	9,2
	doub.	60	5	8,3	60	5	8,3	120	10	8,3
Fenestratio sternalis	pres.	55	0	0,0	62	3	4,8	117	3	2,5
For. suprascap. ri.	pres.	53	0	0,0	53	3	5,6	106	3	2,8
le.	pres.	51	0	0,0	49	3	6,1	100	3	3,0
For. supratroch. ri.	pres.	59	3	5,1	62	10	16,1	121	13	10,7
le.	pres.	61	4	6,5	65	18	27,7	126	22	17,5
Proc. supracond. ri.	pres.	61	0	0,0	72	0	0,0	133	0	0,0
le.	pres.	65	1	1,5	70	1	1,4	135	2	1,4
Fac. art. talaris ri. (Calcaneus) le.	doub.	51	20	39,2	55	22	40,0	106	42	39,6
	doub.	52	22	42,3	54	19	35,2	106	41	38,7
Trochanter tertius ri.	pres.	65	14	21,5	62	17	27,4	127	31	24,4
le.	pres.	62	12	19,3	59	19	32,2	121	31	25,6

From the traits of the infra-cranial skeleton only the divided Facies articularis talaris of the calcaneus and the appearance of a Trochanter tertius at the femur show higher frequencies in both sexes. In general, women show slightly higher frequencies than men, but only the differences in the Foramen supratrochleare are statistically significant. The Fenestratio sternalis and the Foramen suprascapulare are two traits that are only present in women whereas, these traits show a relatively low frequency. The very rare trait of the Processus supracondylaris at the humerus is present in one male and one female individual.

7.3. Discussion

To what extent frequencies and distributions of recorded traits are characteristic for a population can only be determined with the help of a comparable series. Certain problems persist due to the lack of comprehensive recordings of non-metric traits for series of specific time ranges and geographic areas are. In addition, there is a great disunity in literature about the designation, as well as, the recording method of specific traits. Furthermore, every researcher creates his own selection out of the numerous amount of traits. Therefore, the comparison of the own results with listings of traits that are already published cannot always be carried out without difficulties (Tyrell 2000).
The fact that there are so many non-metric traits present in the Grevenmacher sample points to a more heterogenous population. On the other hand high frequencies in a few, as well as, absence or low frequencies in other traits indicate a homogenous basic population. These two facts do not contradict each other at all, if we assume a basic or founding population that is basicly stationary, but has lively exchange with other populations. The geographic location of Grevenmacher at main trading routes supports this theory.
Using non-metric traits for kinship analysis, one question that needs to be solved is what kinds of traits are useful for these studies. Alt and Vach (1998) postulate requirements for traits used for this kind of evaluation. They state that traits must be determined mainly by genetic factors and not exogenous influences. Only rare traits can contribute to kinship analysis and those traits must be genetically independent from each other. Tyrell (2000) explains that cranial traits are preferable to infra-cranial traits because they are highly canalized during the early part of an individuals development. In contrast infra-cranial traits are more dependent to external factors and more susceptible to remodelling and functional modification. Based on the list of recorded traits an attempt was made to reconstruct possible kinship relations between individuals from the Grevenmacher cemetery. Therefore, traits were selected, that fit the requirements mentioned above as well as possible. Individuals were checked for single traits, as well as, a combination of traits. The selected individuals were mapped on the cemetery plan to check their spatial distribution. If these individuals are located close together, this would support a possible kinship based on the assumption that family members were buried close to each other.
To expand the number of traits rarely found in the Grevenmacher individuals some more features were included in the evaluation that are also associated with heredity. These traits are discussed in detail in chapter 9 about pathological changes and include the Os acromiale, Spodylolysis, Sacralization of the LW5, unfused neural arches as well as incomplete fusion of the median sacral crest. In literature some of these traits are also assigned to as non-metric traits and are included in the respective lists.
The evaluation of kinship within the Grevenmacher sample was carried out in separate steps. At first all individuals that show rare cranial traits were separated. Within that group it was examined to what extent individuals show combinations of these rare traits.

It was assumed that, the higher the number of shared features the higher the possibility that individuals are related to each other. Unfortunately, individuals did not share more than two of these rare features. However, this low rate of combinations is too low to state a relationship between any individuals. Although, the inclusion of cranial traits with higher frequencies within the population increases the amount of shared features, but on the other hand this approach dilutes the results. In a second step infra-cranial traits were included although these kinds of traits are more limited in their significance (Alt and Vach 1998). This approach led at least to an accordance in traits in two female individuals (ID 142; 119/38, 30-40 years old and ID 55; 117/47, 50-60 years of age). They share three cranial traits (Sutura frontalis, doubled Foramen zygomaticofaciale on the right side, Ossicula lambdoidea) as well as two infra-cranial traits (Sacralization of the fifth lumbar vertebra and Foramen supratrochleare on the left side) and moreover their graves are located close together. In this case, the possibility that these two individuals are related to each other is quite high. Unfortunately, this couple is the only one that shares a larger amount of features that supports a possible relationship. Comparisons of other individuals just resulted in uncertain combinations of mostly very common traits.

Another attempt to reconstruct relationships is based on the assumption that individuals that are buried close to each other are possibly related to each other. With the help of the cemetery plan, groups of individuals were selected that were located close to each other. Individuals of these groups were tested on the same combination of traits. In these cases the results showed also the same distributions found on the rest of the cemetery and were too uncertain to state possible relationships of any individuals.

Altogether kinship analysis within the cemetery of Grevenmacher did not work out well. One possible reason for this is the in general heterogenous population. As mentioned above the great amount of non-metric traits, as well as, the geographical position of the town supports a genetic admixture from outside with a rather homogeneous founding population over time. The assumption that members of a specific family are in general buried close to each other could not be maintained with regard to the long occupation time, as well as, the related amount of individuals buried on the limited cemetery area. The available space for burials was extensively used and led to a massive mixture of individuals. Places originally occupied by members of specific families could be used in later times also for persons not related to that former family.

The detection of possible kinship relations within a cemetery is an important feature in the evaluation of population structures within a cemetery. Unfortunately, the examination of non-metric traits is the only method feasible in dry bone without major efforts and in some cases this method does not produce clear results. With the evaluation of variations of the frontal sinus or analysis of nuclear DNA, two further methods are available to prove kinship relations between individuals. However, both methods have to face the problem that they are complex and therefore, costly and time consuming. Nevertheless, both methods are options in further studies of the Grevenmacher population.

tab. 45. List of the 31 recorded non-metric traits and their variations

trait	variation
Sutura frontalis (metopica)	present
Sutura mendosa persistens	present
Foramen respectively Incisura supraorbitale	present
Foramen frontale	present
Ossiculum coronalia	present
Ossiculum sagittalia	present
Ossiculum apicis lambdae	present
Ossiculum lambdoidea	present
Ossiculum astericum	present
Os epiptericum	present
Foramen parietale	present
Foramen Huschke	present
Foramen ovale	double
Foramen ovale	open
Facies condylaris (Condylus occipitalis)	double
Foramen zygomaticofaciale	double
Foramen zygomaticofaciale	missing
Torus palatinus	present
Foramen palatinum minor	present
Torus mandibularis	present
Foramen mentale	double
Ossiculum incisura parietale	present
Canalis hypoglossi	double
Torus maxilaris	present
Foramen transversarium (Cervical vertebrae)	double
Fenestratio sternalis (Sternum)	present
Foramen suprascapulare (Scapula)	present
Foramen supratrochleare (Humerus)	present
Foramen supracondylaris (Humerus)	present
Facies articularis talaris (Calcaneus)	double
Trochanter tertius (Femur)	present

8. Physical adaptations

Biomechanical stresses over a long period, often leave traces on the bones. The examination of these traits, together with different pathological changes, can help to reconstruct the living conditions of individuals and populations. In this work, five different basic approaches were tested to reconstruct the physical activity and habits of the Grevenmacher individuals.

1) With the help of indices of infra-cranial bones, an attempt was made to evaluate the scope of robustness and changes of bone shape due to physical load.

2) The surface structure of the attachment sites of the great muscles was examined macroscopically to work out specific movement patterns.

3) Attachment sites of tendons and ligaments on bones leave special traces on the bone surface due to mechanical stress. The evaluation of these traces can reveal information about the degree of physical stress in different skeletal elements (Villotte 2006).

4) The degree of asymmetry in different parts of the body can reflect biomechanical stress (Özener 2010) as well as stress related features on specific body sides for example a preferred use of the right or left hand (Kujanová et al. 2008).

5) Features on the skeleton that can be assigned to specific body postures were also evaluated.

8.1. Indices of the infra-cranial skeleton

Table 46 shows the indices that are applicable for physical adaptation separated for males and females with the number of individuals (n), the average value (x) as well as the respective standard deviation (s). Differences between the sexes were calculated with the help of an index, significance was estimated with a students t-test at a ≤0,05 level. Only individuals where both right and left limbs were preserved entered this study.

tab. 46. Indices significant for physical adaptation

	♂			♀				
Index	n	x	s	n	x	s	f/m%	t-test
Hu length-thickness ri.	39	20,3	1,12	41	19,2	1,43	94,58	3,817hs
le	39	20,2	1,16	41	19,2	1,16	95,05	3,923hs
Fe length-thickness ri	45	20,3	1,31	48	19,7	1,32	97,04	2,199s
le	45	20,3	1,35	48	19,7	1,25	97,04	2,225s
Fe robustness ri	45	12,7	0,86	48	12,4	0,77	97,64	1,775
le	45	12,9	0,84	48	12,6	0,81	97,67	1,753
Fe platymericus ri	60	83,0	7,76	62	81,3	10,28	97,95	1,028
le	60	81,8	7,13	62	78,5	8,35	95,97	2,344s

(tab. 46. continued)

	♂			♀				
Index	n	x	s	n	x	s	f/m%	t-test
Fe pilastricus ri	65	99,8	9,40	63	102,0	9,95	102,20	-1,281
le	65	100,6	11,07	63	99,1	9,47	98,51	0,823
Ti cnemicus ri	64	71,4	7,44	61	70,4	6,66	98,60	0,790
le	64	71,2	7,67	61	69,6	6,73	97,75	1,237

(Hu=Humerus; Fe=Femur; Ti= Tibia; ri= right body side; le= left body side; s=significant; hs=highly significant)

The values of the length-thickness index of the humeri as well as of the femora show an expected higher robustness in males. In the humeri this difference is highly significant, in the femora it is still significant. However, differences between body sides show no significant results in both sexes.

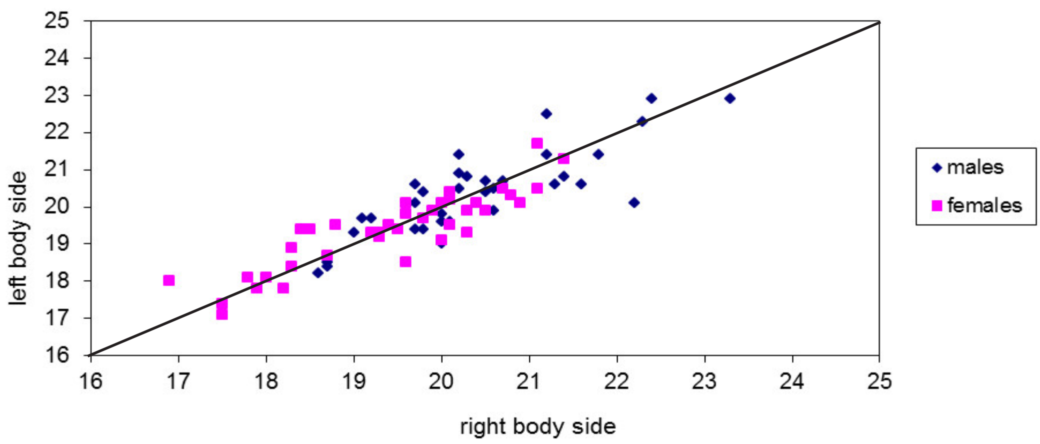


fig. 17. Humerus length-thickness index

Figure 17 shows exemplarily the single values of 39 males and 39 females for the length-thickness index of the humerus. Values from both body sides for were available for all individuals. The balanced values for right and left body sidea were confirmed again.

A general preference of one specific arm is not apparent. Only a few individuals show strong preference of one body side. In general, the values distribute around the mean value, this is also apparent by the low standard deviation. The frequency of right handed persons within populations varies between 74% and 95% (Uomini 2009, Blackburn 2011). This frequency is not visible in the values of the Grevenmacher sample. A possible reason for the balanced outcome is that in the Grevenmacher population work was

carried out concerning the upper extremities more or less the same way. On the other hand, it is possible that indices are not suitable tools to represent handedness. To verify this statement, handedness should be checked again in the section about activity related asymmetry.
The femur index of robustness shows slightly higher values in males than in females. However, no significant difference is visible between the sexes. The comparison between the body sides result in slightly higher values in the left side but in both sexes they are not significant.
The index platymericus of the femora, as well as, the index cnemicus of the tibiae are indicators for the shaping of the cross-section in the proximal shaft area of the respective bone. Whereas the index pilastricus displays the cross-section of the mid-shaft of the femur. In all these areas muscles that are attached to the bone are responsible for locomotion. The flatter the cross-section in this area, the higher the muscle tension. This in turn explains the mechanical load of the respective bone. The values for the index platymericus of the femora, fall on average, in the platymer range, that means they are more flat than round. This applies to both sexes. Thereby males show higher values than females, on the left side the difference is even significant. The differences between the body sides are relatively high, with higher values for the right side in both sexes but they are not significant. Striking are the high ranges of deviation in both sexes whereas the females show even higher values than males.
The values for the index cnemicus of the tibiae show the same tendency as the index platymericus. They range on average in the euryknem area, that means they are more broad than round. Again, both sexes are affected the same way. Men show slightly higher values than women and the difference between the body sides are not significant. Also the high ranges of deviation are similar.
The index pilastricus illustrates the cross-section of the femur mid-shaft, as well as, the characteristic of the Linea aspera. Males show very balanced values around 100 for both body sides. However, the women show a higher scattering up to 102. Values around 100 and higher mean that a pilaster is developed and thereby an increased load of the adductor muscles of the femora can be assumed (Bräuer 1988). In females the difference between the body sides are higher than in men but not significant. The values of the index pilastricus show the highest ranges of deviations in all indices.
Altogether all three indices discussed in this section show very homogeneous characteristics. The mean values show, in general, middle to high physical load of the legs in both sexes. An unbalanced stress to one body side is not visible. The very high ranges of deviation indicate a variety of physical characteristics possibly linked to a vast number of activities.

8.2. Muscle attachment sites

The term muscle attachment site, used in this work, refers to the position where muscles are attached at the shaft of a bone. It is assumed that physical load of a respective muscle leads to hypertrophy of bone tissue and therefore,changes in size and shape of the related attachment sites (Weiss 2007). Until now, only a few studies were carried out dealing with the physical process of muscle load and changes in bone, therefore, no standardized recording system is established. However, in some studies (Weiss 2004, Trautmann 2012, Weiss 2010) authors evaluated the degree of deformity using their own recording system. In this work, muscle attachment sites were not evaluated separately for every bone, but as summarization of bones forming a respective joint. The four major joints were evaluated. The shoulder joint consisting of proximal humerus/clavicle and scapula, the elbow joint consisting of distal humerus/proximal radius and ulna, the hip joint consisting of proximal femur/pelvis and the knee joint consisting of distal femur/proximal tibia and fibula as well as the patella. The classification follows the work of Trautmann (2012). The data was separated by body side, age and sex.

Grading of the muscle attachment sites:
0= no elevation
1= weak (slight elevations) a= smooth
2= middle (protrusions) b= rough
3= strong (clear protrusions)

tab. 47. Mean values for the respective joints of males

age	n	Shoulder joint		Elbow joint		Hip joint		Knee joint	
		right	left	right	left	right	left	right	left
20-30	6	1,8b	1,4b	1,5b	1,5b	1,4b	1,5b	1,3b	1,3b
30-40	16	1,6b	1,6b	1,7b	1,6b	1,8b	1,8b	1,5b	1,5b
40-50	18	1,5b	1,3b	1,7b	1,7b	1,8b	1,8b	1,6b	1,6b
50+	21	1,9b	1,8b	1,9b	1,9b	2,0b	1,9b	1,8b	1,8b
total	61	1,7b	1,6b	1,8b	1,8b	1,8b	1,8b	1,6b	1,6b

tab. 48. Mean values for the respective joints of females

age	n	Shoulder joint		Elbow joint		Hip joint		Knee joint	
		right	left	right	left	right	left	right	left
20-30	16	1,1a	1,1a	1,1b	1,1b	1,1b	1,1b	1,1b	1,1b
30-40	21	1,1b	1,1b	1,2b	1,1b	1,4b	1,2b	1,2b	1,2b
40-50	14	1,1b	1,0b	1,2b	1,2b	1,8b	1,7b	1,2b	1,2b
50+	12	1,5b	1,4b	1,4b	1,5b	1,8b	1,8b	1,6b	1,5b
total	63	1,2b	1,1b	1,2b	1,2b	1,5b	1,4b	1,2b	1,2b

Tables 47 and 48 show the results separated for males and females graded by age. 61 male and 63 female individuals were included in this study. As expected the male individuals show a more pronounced topography of the muscle attachment sites than the females in all joints. This corroborates the greater robustness emphasized in several evaluations before (raw measurements, indices). On average the women reach 68,2% of the male values in the upper limbs and 77,8% in the lower limbs. Almost all individuals show a rough surface of the attachment sites except the youngest age class in the females. An increase in the degree of manifestation with age is visible in all joints. The only exception is the class of the 40-50 years old male individuals. In this age class the values decrease before they reach their top in the class over 50 years. A comparison between body sides of the upper joints shows slightly higher values in the right side. However, a preference of this side within the population cannot be derived for certain because it concerns not all age classes and in total the values are again more or less balanced. The results gained from the Grevenmacher sample corroborate with previously published research. Weiss (2004, 2007) states in her studies that the characteristics of muscle attachment sites correlate with age and that differences in males and females are visible. She also supports a correlation between shaping of muscle attachment sites and bone size. This relationship could not be completely confirmed in the Grevenmacher sample. Furthermore, the differences in males and females are present, but they do not allow statements about the kind of activity carried out nor about a possible sexual division of labor.

8.3. Entheseal changes

An entheses characterizes the region where a tendon, ligament or joint capsule is attached to the bone. It means its attachment or insertion site. The term enthesopathy refers to any pathological change of this region occurring due to increasing age, spondyloarthropathies, overuse or traumatic injuries (Benjamin et al. 2002, Villotte et al. 2010a, Villotte et al 2010b). A lot of previously published studies use entheseal changes to reconstruct activity patterns of past populations (Hawkey and Merbs 1995, Robb 1998). However, only in recent years the methodological gaps were filled by the studies of Villotte (2006) and Villotte et al. (2010). In this work, the methods of recording entheseal changes follow these studies.

tab. 49. Attachment sites evaluated

Entheses	Location	Code
Insertion of the M. subscapularis	Lesser tubercle of the humerus	HSC
Common insertion of the MM. supraspinatus and infraspinatus	Greater tubercle of the humerus	HSI
Common origin of wrist extensors	Lateral epicondyle of the humerus	HEL
Common origin of wrist flexors	Medial epicondyle of the humerus	HEM
Insertion of the M. biceps brachii	Radial tuberosity	RBB
Common origin of the MM. biceps femoris, semitendinosus and semimembranosus	Ischial tuberosity of the coxal bone	CSB
Insertion of the M. gluteus minimus	Greater trochanter of the femur	FPF
Insertion of the M. gluteus medius	Greater trochanter of the femur	FMF
Insertion of the M. iliopsoas	Lesser trochanter of the femur	FIP

Evaluated are the surface as well as the contour of the respective entheses. Stages of 0, 1or 2 are assigned to each of the evaluations. The sum of the partial evaluations (surface + contour) result in the stages A=0, B=1-2, C=3-4 (Villotte 2010, Havelková et al. 2011).
In this stuy only individuals were included where both, left and right, extremeties were present.

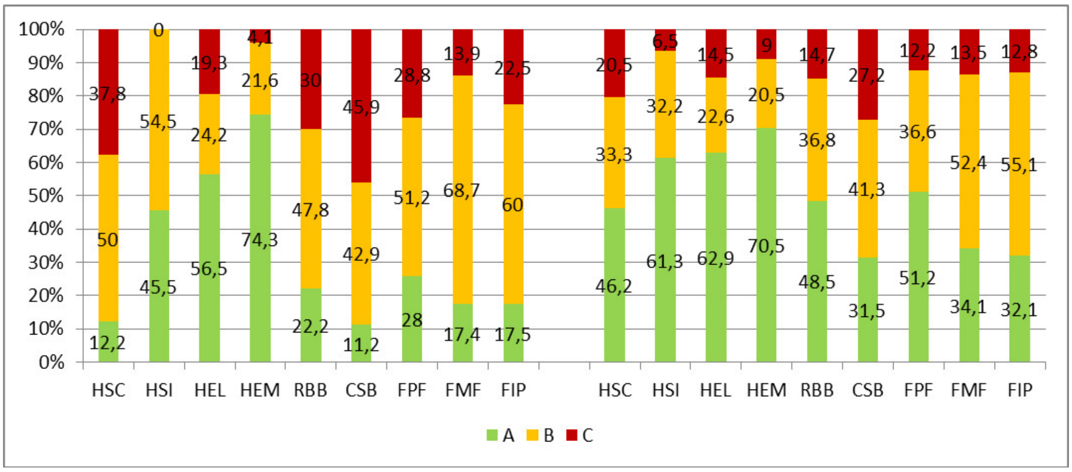


fig. 18. Severity code of entheseal changes for males (left) and females (right)

Figure 18 shows the severity code of entheseal changes in percentage differenced for both sexes. Although males show in general higher values in the upper, as well, as in the lower limbs. The curve shape is very similar in both sexes. Noticeable are the higher differences in the upper limbs and the lower differences in the lower limbs. This kind of distribution is noted in previous studies and Havelková et al. (2011) generalize this fact as typical for "agriculturally based activities in flat terrain". This means higher load of the upper extremities whereby differences between males and females can be interpreted as division of labor and, in general lower load in the lower extremities.

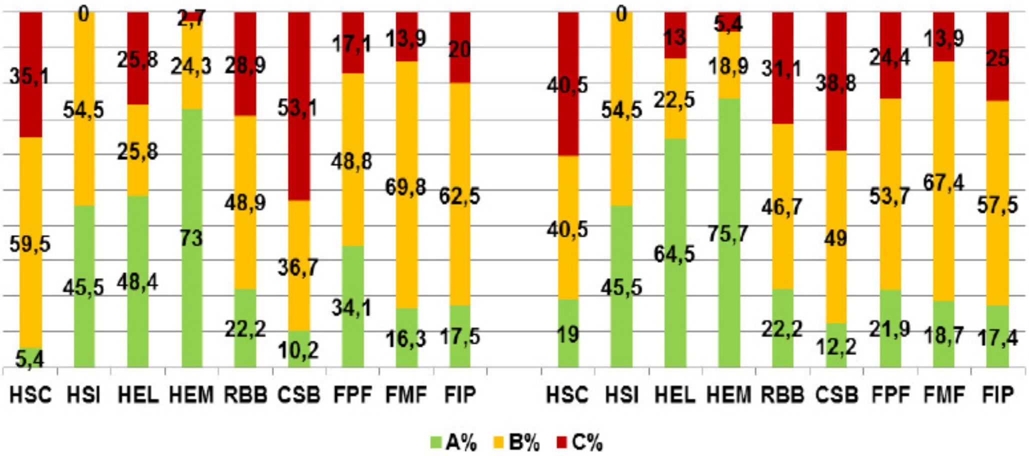


fig. 19. Severity code of entheseal changes for males right and left body side

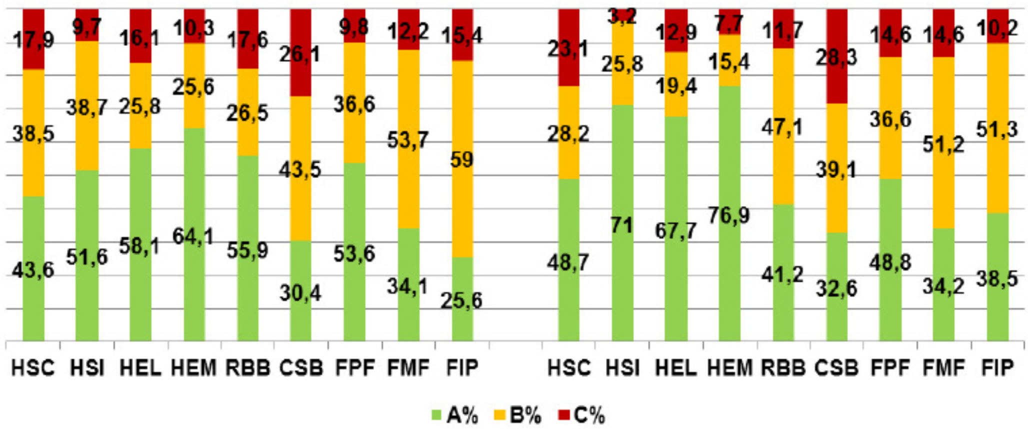


fig. 20. Severity code of entheseal changes for females right and left body side

A comparison of body sides of males and females (fig. 19, fig. 20) show again very similar curve shapes. In males values of the shoulder area (HSC, HSI) show slightly higher values at the right side. The same is visible for the elbow joint (HEL, HEM), except the radial tuberosity (RBB). Values of the lower limbs show more or less the same values. The same distribution is visible in the females. This distribution confirms the results from the study of the indices, as well as, the muscle attachment sites in this chapter. Slightly higher values in the right body side of the upper limbs are visible in both sexes. But they are not significant enough to derive a preference of the right body side for activity.

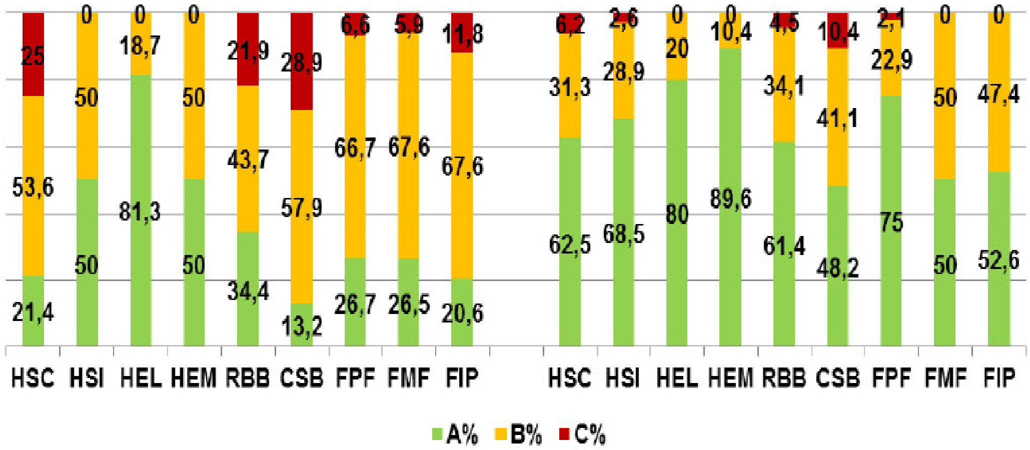


fig. 21. Severity code of entheseal changes for males (left) and females (right) age 20-40

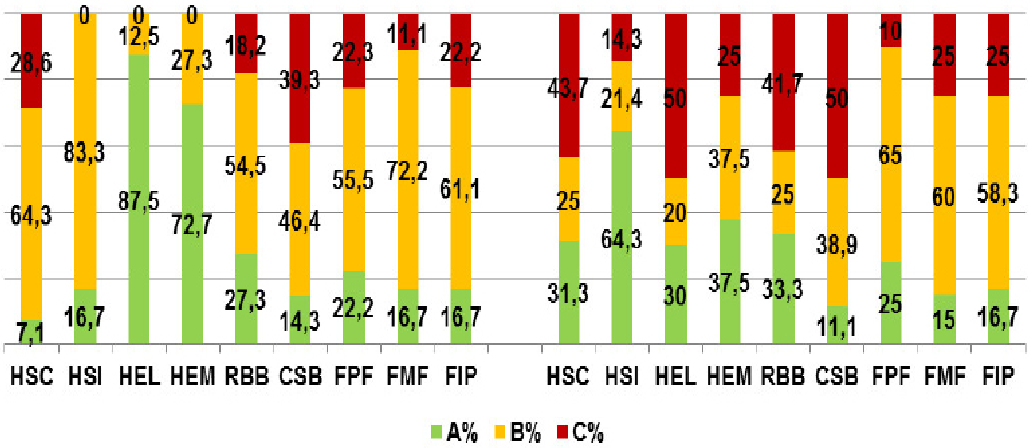


fig. 22. Severity code of entheaseal changes for males (left) and females (right) age 40-50

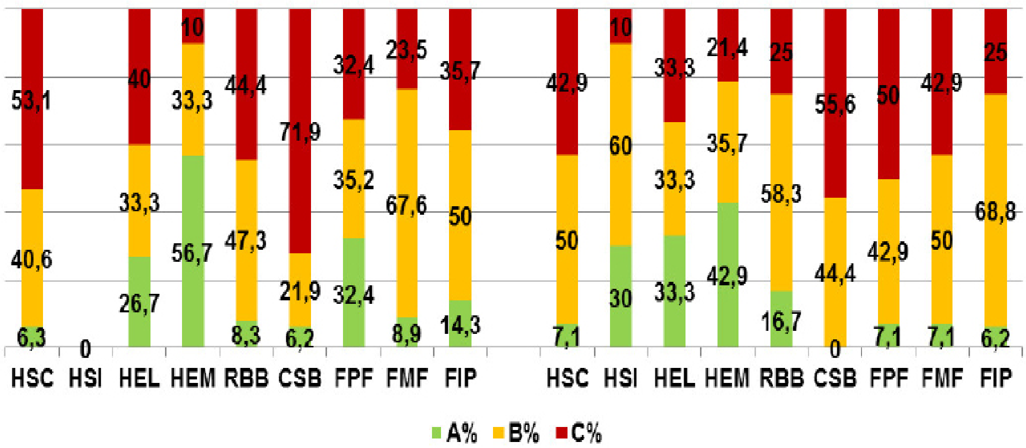


fig. 23. Severity code of entheaseal changes for males (left) and females (right) age 50+

The increase in severity of entheseal changes with age in the Grevenmacher sample corroborates with previous studies (Robb 1998, Villotte et al. 2010b, Cardoso and Henderson 2010, Havelková et al. 2011). Therefore, it can be assumed that the development of entheseal changes is caused by degenerative changes associated with age apart from mechanical stress. In the Grevenmacher sample a generally increase in the prevalence of entheseal changes and age is visible in both sexes. However, some differences between males and females in the single age groups are present. In the youngest age class (20-40 years) the prevalence of entheseal changes is significantly higher in males than in females. In the next age category (40-50 years) this unequal distribution has already leveled off. Niinimäki (2011) found the same results in his study and he explains this fact that males in younger ages have larger muscles and are involved in labors that requires more physical load. This effect is leveled off by age related changes in higher age categories. He also states that advancing age and muscle size affects entheses to a higher degree than labor activity.

8.4. Limb bone asymmetry

Asymmetry is a common feature in living organisms also in the human body. Diverse factors influence asymmetry. They can be intrinsic, dealing with genetic or hormonal factors. On the other hand environmental factors like malnutrition, exposure to excessive noise, heat or cold, or biomechanical causes like specific physiological stress can lead to pronounced asymmetry. To what extent age and sex of an individual influences asymmerty is still under discussion (Kujanová 2008, Özener 2010, Blackburn 2011). In this work, an attempt was made to evaluate to what extent physical load can be derived from asymmetry of bones in the Grevenmacher sample. Questions that will be posed are how pronounced is asymmetry in the bones of the Grevenmacher individuals and to what extent it can be inferred to physical stress. Can this method help to point out the preferred use of a specific body side (handedness)? For this purpose, directional asymmetry of bones of the upper and lower limbs were evaluated according to the studies of Kujanová et al. (2008), Čuk et al. (2001) and Steele and Mays (1995). 48 metric dimensions on bones from the shoulder, upper and lower limbs were measured. Only individuals with both left and right bones preserved were used in this study. Results were presented in tables 50 and 51 with the number of individuals (n), the mean values (n) standard deviation (s) and a total standart deviation (sd) differenced for males and females. The degree of directional asymmetry was determined by paired t-test. Standardized asymmetry was calculated with the formula:

st. asym. = $((R-L))/(((R+L))/2) \times 1000$
(R=values of right body side; L=values of left body side)

tab. 50. Measurement sections used for limb bone asymmetry of males

	right body side			left body side					
measure	n	x	s	n	x	s	t-test	st. asym.	sd
Sc1	10	158,4	11,86	10	161,5	10,26	-0,625	20,2	33,17
Sc2	26	101,0	6,37	26	103,3	6,47	-0,786	13,8	28,03
Sc12	37	37,0	2,07	37	37,2	1,88	-0,435	4,7	44,64
Sc13	40	28,5	1,84	40	28,2	1,77	0,743	8,6	37,59
Cl1	38	142,4	8,52	38	144,0	8,23	-0,937	12,6	33,85
Cl4	49	10,9	1,31	49	11,3	1,21	-1,570	34,3	91,21
Cl5	49	12,8	1,43	49	12,4	1,24	1,479	29,8	91,71
Cl6	49	38,9	3,86	49	39,2	3,19	-0,419	9,3	51,62
Hu1	40	326,7	13,02	40	322,6	13,89	1,329	12,3	14,23
Hu3	31	51,2	2,03	31	50,0	1,91	2,377 s	23,5	25,76
Hu4	42	63,5	3,30	42	62,9	3,66	0,842	20,5	27,52
Hu5	56	23,1	1,78	56	22,6	2,07	1,179	19,8	71,00
Hu6	52	18,4	1,56	52	18,3	1,60	0,226	4,3	42,64
Hu7	53	66,4	3,81	53	65,2	3,80	1,160	18,2	33,12
Hu9	43	45,5	2,18	43	45,4	2,36	0,286	3,3	24,82
Hu10	40	43,5	1,86	40	43,0	2,05	1,188	12,3	29,56
Ra1	40	242,3	11,64	40	241,1	11,70	0,460	4,9	11,44
Ra	44	22,6	1,16	44	22,4	1,37	0,517	6,7	36,88
Ra4	48	17,1	1,36	48	16,1	1,46	3,194 hs	55,9	58,58
Ra4a	50	16,1	1,31	50	15,1	1,38	3,939 hs	68,7	68,11
Ra5	48	12,3	0,87	48	12,4	0,93	-0,707	9,9	57,16
Ra5a	50	12,2	0,84	50	12,3	0,86	-0,471	6,4	53,00
Ul1	37	262,8	11,99	37	262,8	12,68	0,383	4,1	13,51
Ul11	52	17,1	1,33	52	16,9	1,59	0,557	10,7	78,79
Ul12	51	14,7	1,27	51	14,0	1,26	2,355 s	41,3	47,00
Fe1	44	451,3	23,64	44	452,9	23,90	-0,316	-3,5	12,14
Fe2	44	448,5	22,95	44	450,3	23,21	-0,366	-4,0	12,31
Fe6	63	28,4	2,23	63	28,9	2,40	-1,405	-19,6	53,04
Fe7	64	28,4	1,92	64	28,9	2,42	-1,373	-17,2	54,14
Fe8	64	90,3	4,92	64	91,0	5,36	-0,825	-8,0	30,25
Fe9	59	32,1	2,80	59	32,7	2,86	-1,036	-16,6	58,17
Fe10	58	26,9	2,50	58	26,6	2,45	0,674	11,4	39,56
Fe13	48	99,0	5,09	48	99,2	4,59	-0,182	-3,0	21,70
Fe19	54	47,8	2,46	54	47,7	2,32	0,217	1,8	14,74
Fe21	46	80,8	4,52	46	80,3	4,25	0,547	6,0	34,32

(tab. 50. continued)

	right body side			left body side					
measure	n	x	s	n	x	s	t-test	st. asym.	sd
Fea	64	7,1	1,34	64	6,8	1,22	1,104	33,5	130,90
Ti1	50	367,7	20,69	50	368,7	20,68	-0,242	-2,8	16,61
Ti1b	51	367,9	20,71	51	369,0	20,60	-0,269	-3,0	17,25
Ti3	53	75,6	3,90	53	75,6	3,77	-0,027	-0,3	26,13
Ti6	49	51,5	3,34	49	51,6	3,19	-0,152	-2,2	45,73
Ti8	66	29,8	2,48	66	30,0	2,40	-0,330	-4,8	53,45
Ti8a	66	34,5	2,56	66	35,0	2,63	-1,018	-13,1	57,67
Ti9	66	23,1	2,17	66	22,7	2,21	1,075	18,1	65,19
Ti9a	66	24,6	2,60	66	24,6	2,46	-0,045	-1,3	54,79
Ti10	64	84,2	5,78	64	84,7	5,48	-0,452	-5,7	33,47
Ti10a	64	96,0	7,18	64	96,1	6,34	-0,058	-1,5	30,35
Ti10b	62	77,5	5,55	62	77,6	5,17	-0,125	-2,0	32,43
Fi1	24	363,7	20,41	24	364,7	19,67	-0,173	-2,9	11,37

(For complete description of measurement sections see tab. 30-32)

tab. 51. Measurement sections used for limb bone asymmetry of females

	right body side			left body side					
measure	n	x	s	n	x	s	t-test	st. asym.	sd
Sc1	8	142,9	8,49	8	144,0	8,15	-0,264	7,8	30,57
Sc2	17	93,8	5,28	17	94,2	4,38	-0,240	4,3	18,65
Sc12	40	33,5	2,06	40	33,3	2,01	0,439	5,9	40,23
Sc13	44	25,1	1,48	44	24,7	1,71	1,173	13,4	44,57
Cl1	37	134,2	6,49	37	134,4	6,42	-0,133	1,6	28,63
Cl4	50	9,4	1,05	50	9,6	1,22	-0,879	19,5	94,25
Cl5	50	11,3	1,16	50	10,8	0,83	2,380 s	41,0	94,88
Cl6	50	34,2	2,79	50	34,1	2,53	0,113	0,8	71,03
Hu1	41	304,9	15,14	41	310,0	13,94	0,902	9,4	16,24
Hu3	40	46,7	2,90	40	45,8	2,56	1,439	18,6	28,10
Hu4	40	58,0	3,41	40	57,3	3,2	0,947	11,9	37,96
Hu5	58	20,7	1,55	58	20,1	1,58	2,168 s	31,5	48,34
Hu6	57	15,8	0,94	57	15,7	1,03	0,541	7,1	39,16
Hu7	56	58,3	3,24	56	58,1	3,16	0,413	4,2	30,22
Hu9	44	41,1	2,45	44	40,9	2,42	0,405	4,9	33,31
Hu10	47	39,0	2,13	47	38,5	2,09	0,988	11,0	32,72
Ra1	34	228,1	12,78	34	225,9	12,75	0,711	9,8	18,19
Ra	40	20,4	1,30	40	20,3	1,27	0,522	7,4	42,44

(tab. 51. continued)

	right body side			left body side					
measure	n	x	s	n	x	s	t-test	st. asym.	sd
Ra4	44	15,1	1,26	44	14,6	1,37	1,675	33,0	51,59
Ra4a	44	14,0	1,27	44	13,4	1,47	1,946	43,1	92,04
Ra5	44	10,9	0,80	44	10,8	0,81	0,932	14,9	47,89
Ra5a	44	10,7	0,74	44	10,5	0,87	1,452	24,6	60,47
Ul1	29	247,6	14,31	29	245,3	14,4	0,610	9,4	23,93
Ul11	50	15,1	1,32	50	14,6	1,51	1,551	30,9	58,32
Ul12	50	12,5	1,14	50	11,7	1,02	3,513 hs	62,3	73,38
Fe1	47	427,0	21,92	47	428,4	21,63	-0,312	-3,3	11,41
Fe2	47	423,5	22,06	47	424,6	22,33	-0,240	-2,6	7,33
Fe6	61	26,2	1,92	61	26,4	1,99	-0,480	6,1	43,64
Fe7	61	25,7	1,79	61	26,6	1,92	-2,737 hs	-34,6	51,88
Fe8	61	82,4	4,21	61	83,2	4,55	-0,983	-9,3	26,55
Fe9	60	30,0	2,54	60	30,4	2,38	-1,001	-15,5	41,16
Fe10	60	24,2	2,04	60	23,9	2,14	0,838	13,5	67,33
Fe13	50	91,7	5,99	50	91,8	6,03	-0,150	-1,9	16,92
Fe19	56	42,9	2,39	56	42,5	2,4	0,906	9,7	19,76
Fe21	46	75,1	3,42	46	74,9	3,55	0,330	37,3	22,70
Fea	61	6,5	0,95	61	6,4	1,01	0,394	13,8	126,59
Ti1	49	348,5	18,30	49	347,7	17,38	0,222	2,3	11,45
Ti1b	49	347,5	18,19	49	347,5	17,51	0,000	-0,04	10,34
Ti3	48	69,1	3,44	48	68,7	3,58	0,544	5,8	20,70
Ti6	45	47,6	3,03	45	46,8	2,89	1,346	17,7	35,60
Ti8	62	27,3	1,96	62	27,5	1,94	-0,400	-5,4	45,13
Ti8a	63	31,2	2,36	63	31,4	2,68	-0,489	-6,4	49,23
Ti9	62	20,9	1,90	62	20,2	1,79	2,051 s	32,9	49,14
Ti9a	63	22,0	1,91	63	21,8	1,93	0,380	6,0	46,27
Ti10	68	76,9	4,79	68	77,0	4,93	-0-084	3,2	28,77
Ti10a	62	87,1	6,02	62	86,3	6,49	0,703	9,6	31,03
Ti10b	59	70,9	4,24	59	71,0	4,45	-0,125	-1,2	26,61
Fi1	23	339,2	15,67	23	339,8	16,38	-0,127	-1,8	6,76

(For complete description of measurement sections see tab. 30-32)

In males 12 (25,0%) out of 51 measurement sections show higher values on the right side. Four of the 12 measurements are significantly different. Also 12 (25,0%) measurements show higher values on the left side, 24 (50,0%) measurements show equal values. In females 18 (37,5%) measurements show higher values on the right side whereas four are significantly different. Nine (18,8%) measurements show higher values on the left side with one of them significantly different, 21 (43,7%) measurements show equal values. In males only four measurements (8,3%), in females only five (10,4%) measurementss show a significant directional asymmetry. All of these asymmetries except one are found on the right side whereas males and females show manifestations on different measurements. In males asymmetries are just visible on the upper limbs. It concerns the width of the upper epiphysis of the humerus (Hu3), the maximum width as well as the width of the middle of the radius diaphysis (Ra4, Ra4a) and the width of the ulna diaphysis (Ul12), all on the right side. Females show asymmetry in the sagittal diameter of the clavicle (Cl5), the maximum diameter of the middle of the humerus diaphysis (Hu5) and the width of the ulna diaphysis (Ul12). All of the asymmetries of the upper limbs were found on the right side. However the transverse diameter in the middle of the femur diaphysis (Fe7) is manifest on the left side. Asymmetry in the transverse diameter in the middle of the tibia diaphysis (Ti9) is visible again on the right side. In general, asymmetry is more dominant in the upper than in the lower limbs. Striking is that all significant differences concerning measurements of the width of the diaphysis are mostly in the transverse direction. No significant differences are visible in the length dimensions. This corroborates with previous studies (Kujanová et al. 2008, Auerbach and Ruff 2006, Čuk et al. 2001) and is explained with the fact that longitudinal bone growth completes between 18 and 25 years of age. However, width growth of bones continues throughout life and is dependent to physical stress. In the lower limbs the distribution is reversed. In males as well as females the femora show higher values on the left side, in females the transverse diameter in the middle of the diaphysis is even significantly different. This corroborates also with outcomes of the study by Kujanová et al. (2008) and Čuk et al. (2001). This phenomenon is explained by transverse asymmetry. This means individuals with preference of the right hand show a pronounced development of the left femur and vice versa. It is also assumed that the left leg is supportive without regard to handedness (Čuk et al. 2001). As mentioned in the Grevenmacher sample, the femur supports the thesis of transverse asymmetry. In the case of the tibia things are less clear. In males only the length dimensions are dominant in the right side. The transverse diameter is more developed in the left side, the rest of the measurements show equal values. In females even five measurements are dominant in the right side, the transverse diameter of the middle of the diaphysis show even a significant difference. Only one measurement is more developed on the left side. Čuk et al. (2001) found the same phenomena in their study. They state that the supportive leg with a more developed femur lies opposite the dominant arm, whereas the dominant leg shows transverse symmetry with the femur and induce a more developed tibia. However, this thesis must be strengthened by further studies in particular where both dominant and supportive extremity is known.

The evaluation of direct asymmetry in the Grevenmacher sample and the comparison with other studies supports the initial examination that a majority of the individuals were right handed. To substantiate these assumption, a further study was applied were Steele and Mays (1995) analyzed directional asymmetry and handedness based on long bone measurements of the upper limbs. The authors measured the maximum length of the humerus, radius and ulna. Furthermore, they used a combination of humerus and ulna length to estimate arm length. The same evaluation was carried out for the Grevenmacher sample to figure out if it is possible to support the assumption with concrete values. Length dimensions of humerus radius and ulna were measured. An estimate of arm length was obtained from the sum of the humerus and the radius length. A mean asymmetry was calculated as mentioned in the previous section. Differences between body sides were tested using students t-test.

tab. 52. Directional asymmetry evaluated for humerus, radius, ulna and combined arm length

	humerus (n=81)	**radius (n=74)**	**ulna (n=66)**	**arm length (Hu1+Ra1) (n=56)**
right	60 (74,1%)	48 (64,9%)	38 (57,5%)	43 (76,8%)
equal	2 (2,5%)	6 (8,1%)	4 (6,1%)	3 (5,4%)
left	19 (23,4%)	20 (27,0%)	24 (36,4%)	10 (17,8%)
mean asymm.	11,00	7,23	6,77	8,60
t-test	1,266	0,727	0,586	0,537

Table 52 shows the results for the Grevenmacher sample combined for both sexes. In all skeletal elements measured, individuals show a significant direct asymmetry favoring the right side. The humerus and the arm length provide the highest values. Steele and Mays (1995) present very similar results in their studied sample from Wharram Percy, North Yorkshire, England dated from 10th to 19th century. 77% of all individuals show significant directional asymmetry in length of the right humerus. 15% show higher values in the left humerus, in 8% values of both sides are equal. Mays (1991) also published values of 77% for the right humerus 12% for the left humerus and 11% with equal values for both sides in his study of medieval burials from the Blackfriars Friary, Ipswich, England.

tab. 53. Directional asymmetry evaluated for humerus, radius, ulna and combined arm length separated for males and females

	humerus (n=81) male	female	radius (n=74) male	female	ulna (n=66) male	female	arm length (Hu1+Ra1) (n=56) male	female
right	30 (75,0)	30 (73,2)	23 (57,5)	25 (73,5)	20 (54,1)	18 (62,1)	24 (80,0)	19 (73,1)
equal	2 (5,0)	0 (0,0)	5 (12,5)	1 (2,9)	4 (10,8)	0 (0,0)	1 (3,3)	2 (7,7)
left	8 (20,0)	11 (26,8)	12 (30,0)	8 (23,6)	13 (35,1)	11 (37,9)	5 (16,7)	5 (19,2)
mean asymm.	12,60	9,40	4,88	9,58	4,14	9,40	8,95	8,25
t-test	1,362	0,902	0,460	0,711	0,383	0,610	5,451hs	0,635

(values in brackets=percentage of total)

Table 53 shows the results of directional asymmetry distributed by sex. In previous studies of Steele and Mays (1995) as well as Čuk et al. (2001) males and females did not show significant differences in asymmetry scores. Differences between sexes are present in the Grevenmacher sample however they are not significant. Looking at the mean asymmetry as expression of the degree of asymmetry males show higher values in the humerus, whereas females show higher values in the bones of the lower arm. Values in arm length are equal in both sexes. As mentioned above comparisons between sexes are rare. One explanation for this would be a division of labor where males perform work concerning the upper arms whereas female work lead to more load of the lower arms. The t-test value indicates the difference between the body sides. In no bone, differences are significant except the male arm length ratio. Here the difference between right and left side is even highly significant.

8.5. *Physical adaptation and activity*

The evaluation of traces of physical activity on the bones of the Grevenmacher individuals revealed some interesting results. Males show in general higher values in connection with muscle attachment sides as well as entheseal changes than females, although the distributions do not differ significantly between the sexes. The majority of the population preferred the right arm and hand for their activities. The question that rises from these facts is now what kinds of activity can be deduced from these specific results?
In general, physical adaptation studies only investigate how physical load affects muscles and entheses. The associated activities that cause specific traces on bones are always diverse and it is very often not possible to link specific traces to one specific activity. In their study Havelková et al. (2011), tried to combine entheseal changes in males and females with specific activities derived from an archaeological context. Although they link every change in the respective entheses to specific muscle activity, it is not possible to work out specific occupations. Every muscle activity and changes in entheses can be linked to diverse activities carried out in a verified archaeological context.

In the case of the Grevenmacher sample only approaches to possible activities can be made. In males entheseal changes concentrate on the insertion of the M. subscapularis (HSC) as well as the insertions of the MM. supraspinatus and infraspinatus (HSI), slightly dominant on the right side. Also the insertion of the M. biceps brachii (RBB), the great muscle of the upper arm is affected, whereas in this case the left side shows slightly higher values. The extensors (HEL) and flexors (HEM) of the wrists are affected to a lesser extent in both sides. It seems that physical load dominantly affected the areas of the shoulder and upper arm and can be linked to the carrying of heavy loads with the arms bent or similar strenuous activities (Havelková et al. 2011). The same distribution of entheseal changes with an increased occurrence on insertions of the shoulder and upper arm is visible in the female individuals. Here also the right body side dominates, except in the insertion of the M. biceps brachii (RBB). The same distribution in males and females is visible in entheseal changes of the lower limbs. In this context it is much complicated to link entheseal changes to associated activity. The studied entheses are located mainly on the proximal femur and pelvis and are involved in movements of the hip and knee, associated with common activities like walking or lifting from a seated position (Havelková et al. 2011). That leads to the conclusion that males as well as females from Grevenmacher were integrated more or less equally into a mainly agricultural occupation that included diverse activities. However, a division of labor between males and females, which has to be expected, is not reflected in the formation of entheseal changes. The evaluation of bilateral asymmetry however indicates a different load of upper and lower areas of the arms in males and females. However, these differences are not significant.

How distinct the division of labor in a medieval rural society is still under debate. Following some authors, the work on the fields were carried out by both, males and females. Thereby the man were walking behind the plow while the woman had to drive the cattle. Sow and harvest was also collective work, followed by the threshing and grinding of the grain. Livestock and poultry farming also concerned both sexes as well as work in the vineyards which was a main cultivation in Grevenmacher as well as in the surrounding region (Pauly 2011). The further processing of the agricultural products like backing, brewing and the production of vine, butter and cheese as well as slaughtering, curing and the production of different meat products was also carried out by both sexes whereas easier tasks were mainly given to the women. Work in and around the house including cooking or care of the vegetable garden are jobs generally attributed to the women. Also the whole textile work starting with production of the fabric from lamb's wool or flax till the tailoring of the cloths. Males had to carry out mainly the harder physical work like carpentry or building operations (Rösener 1987, Goetz 2000, Dinzelbacher 2010). Overall the various work on a farm needed every hand including the children. Most of the work was done by both sexes, only a few jobs were carried out exclusively by males or females. This theory could explain the slight differences in manifestations visible on the bones between males and females in the Grevenmacher sample.

8.6. *Features of body posture*

Body postures that were habitually adopted by individuals for work or rest can leave specific features on bones. One of these postures is the squatting position. In this position the weight of the body rests on the feet but the knees and ankles are in a persistent flexion. This flexion puts the talar neck and the anterior distal tibia in close contact and induces specific markers on the talus and the tibia (Boulle 2001a, 2001b).
To reconstruct to what extent postures like the squatting position were used in the Grevenmacher sample, facets on the anterior area of the distal tibia of adult individuals were recorded. The results are shown in table 54.

tab. 54. Presence of squatting facets at the distal tibia of males and females and combined for both sexes

	males		**females**		**total**	
	right	left	right	left	right	left
region present	60	59	56	57	116	116
facet present	15	13	23	25	38	38
%	25,0	22,0	41,1	43,9	32,8	32,8

In the Grevenmacher sample 32,8% of all adult individuals show squatting facets at the distal tibia. A significant difference is visible in the appearance of facets between the sexes. In females the amount of individuals that show specific markers is almost as twice as high as in males. Boulle (2001a) examined the occurrence of squatting facets at the talar neck in individuals from different French cemeteries from 1st to 18th century. However, a direct comparison between the results of Boulle (2001a) and the outcomes from the Grevenmacher examination is just possible to a limited extent due to the methodological bias. Nevertheless, some of the results indicate remarkable similarities. Boulle (2001a) states that in different cemeteries dating from 6th to 16th century the amount of individuals with squatting facets is between 38,8% in the older and 26,6% in the younger phases. She also found significant differences between the sexes with 30,3% in males and 40,2% in females. The values from Grevenmacher would confirm the results gained by Boulle (2001a). Although a comparison of facet frequencies through the periods of time show a decline from antiquity to the end of the medieval period, values of around 38% in medieval populations demonstrate that the habitual use of the squatting position was still a common posture. Boulle (2001a) explains this fact with open fires located on the ground for heating and cooking and in this context she integrates the much higher rates of facets in women. With the introduction of stoves and the increasing presence of furniture at the end of the Middle Ages, changes in domestic habits and postures lead to a decrease in facet frequencies in skeletal samples from this time period on. The same living conditions stated by Boulle (2001a) can be assumed for the rural population of Grevenmacher. Striking is that the squatting facets are so far the only feature that indicate a significant division of labor between males and females in this sample. The fact that activities concerning the household are mainly carried out by women cannot be denied. However activity related features at the bones that can directly be linked with such occupations are rare.

9. Paleopathology

The recording of pathological changes in human remains is an important factor in anthropological study. They allow conclusions about the burden of disease of a specific population and to what extent this burden was somehow related to sex or specific age groups (Grupe et al. 2005). The fact that we deal with bone material limits the significance of diagnoses because relatively few diseases leave traces on bones or teeth. Nevertheless, the evaluation of pathological changes within a skeletal series often results in important information about the lifestyle of a population (Wahl 1988). In this work, every pathological feature on bones or teeth was recorded and classified due to its aetiology. It could be distinguished between degenerative changes, infectious, congenital and metabolic diseases as well as traumatic injuries.

9.1. Joint diseases

Arthropathies are the most frequent pathological modification in (pre-)historic skeletal series (Roberts and Manchester 2007). Every element of a joint can potentially be injured. All joint structures including musculature and bones form one functional unit and a lesion of one element can cause damage to the whole joint (Rössler and Rüther 2007).
Osteoarthritis or degenerative joint disease is the most occurring arthropathy in human skeletal remains, as well as, in modern clinical contexts (Roberts and Manchester 2007).
Osteoarthritis is a primary chronic degradation and reconstruction of articular cartilage that leads to secondary changes of the fibrous joint capsule, the bones and the musculature. In some cases inflammation of synovial tissue (synovitis) can occur (Rössler and Rüther 2007, Arden and Nevitt 2006). The Anglo-American term osteoarthritis summarizes non-inflammatory and inflammatory features. In some German medical literature this kind of joint disease is differentiated due to its aetiology. Joint diseases originating from the articular cartilage are called osteoarthrosis. Joint diseases originating from the synovial tissue often show clinical characteristics of inflammation and therefore are called osteoarthritis (Rössler and Rüther 2007). In this work, no further differentiation between osteoarthrosis and osteoarthritis was made and the author follows the definition of Arden and Nevitt (2006) mentioned above. Prerequisite for the development of osteoarthritis is damage of the articular cartilage with a retained mobility of the joint. Over- and misload of joints are the major causes of damage of joint cartilage. Loss of cartilage tissue and compression of underlying bone tissue leads to flattening and deformity of the bony joint parts. Formation of additional bone at the margins of the joint leads to characteristic osteophytes (Rössler and Rüther 2007). In paleopathology osteoarthritis is often referred to as degenerative joint disease (Aufderheide and Rodriguez-Martin 1998, Roberts and Manchester 2007).

This fact is based on the assumption that osteoarthritis is a mechanical process of abrasion and wear that is an age-related physiological phenomenon (Rössler and Rüther 2007). This is in part supported by modern medical literature. Niethard et al. (2009) states, that every human develops osteoarthritis. An increasing aging process of connective and supporting tissue leads to morphological changes beginning around the age of thirty. Around forty years, half of a population shows morphological changes of the joints. With the age of around 65 almost every human shows degenerative changes. On the other hand aetiology and pathogenesis of osteoarthritis are considered much more differentiated. However, the term "degenerative joint disease" points to the slow development of the process, to the higher preferred age and to lesser occurrence of symptoms in earlier stages (Rössler and Rüther 2007).

The paleopathological picture of osteoarthritis is dominated by two main processes, the formation and the destruction of bone. The formation of bone is visible in bony outgrowths (osteophytes) mainly on the margins, but also on the surface of the joints. This kind of bone formation is an attempt to adapt the form of the joint to the changes of mechanical load. The destruction of bone starts with the breakdown of articular cartilage resulting in direct bone to bone contact. The abrasion of subchondral bone leads to reactive bone formation (sclerosis) and a polishing (eburnation) of compact bone and in the trabeculae (Roberts and Manchester 2007, Ortner 2003). Important to state is that these pathological features visible in the skeletal remains mainly reflect the later stages or more severe manifestations of osteoarthritis (Ortner 2003).

The evaluation of joint diseases in this work, is separated into two parts. First, results in the main joints of the long bones are discussed. The second section describes the major changes of the spine.

The evaluation of osteoarthritis is divided according to the main joint areas of the skeleton: shoulder, elbow, hand and fingers, hip, knee and foot and toes. The term joint always includes the parts of the respective bones involved. For example the distal part of the humerus and the proximal parts of ulna and radius form the elbow joint. All adult individuals with known sex and age were evaluated (119 males, 115 females) separated by sex and body side. The recording was carried out according to the simplified classification of Schultz (1988) also used in Trautmann (2012) following four main stages:

0 = The bone is present but no changes are visible

1 = Sclerotic lesions at the margins are visible but they do not change the outline.

2 = Slight bony outgrowth and erosive lesions at the joint surface and margins are visible. The outlines are modified and enlarged.

3 = Osteophyte growth is pronounced, a deformation of the joint is visible. Polishing of the joint surface can occur. Probable disability of the joint.

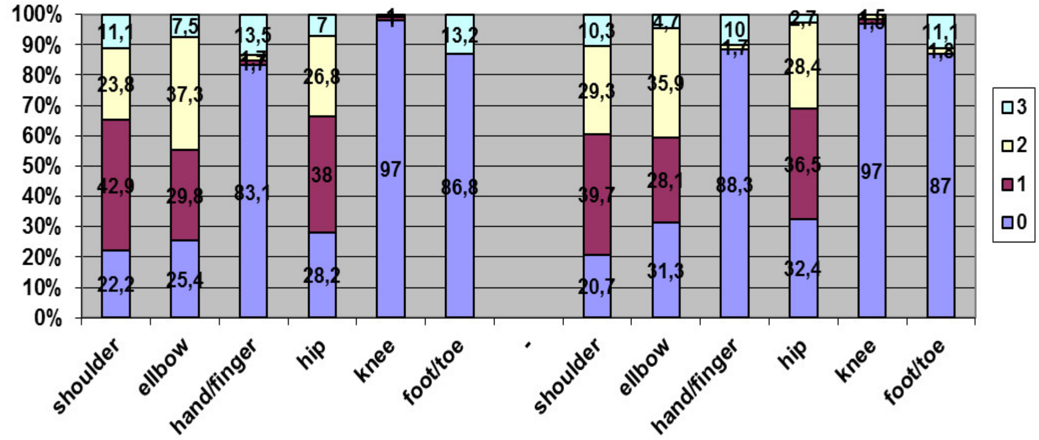


fig. 24. Severity code of osteoarthritis of males, right and left body side

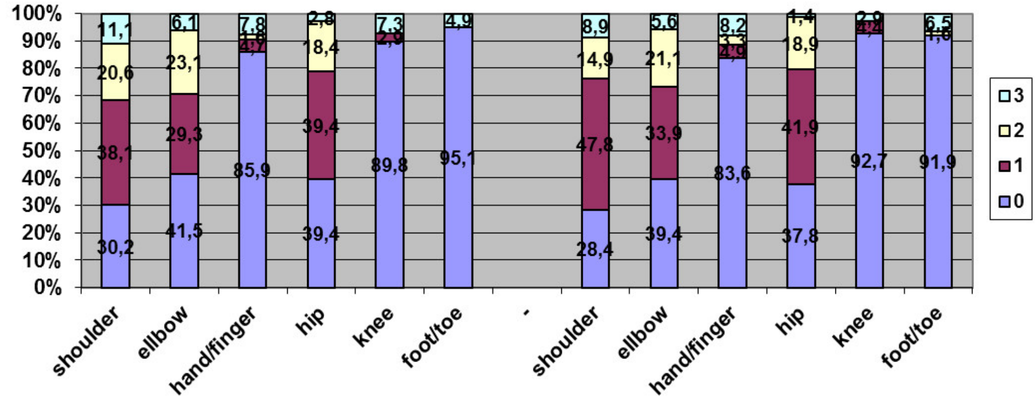


fig. 25. Severity code of osteoarthritis of females, right and left body side

In males 94 out of 119 individuals show osteoarthritis in at least one joint. This means a percentage of 79%. In females 85 out of 115 individuals show traces of joint disease. This corresponds to a percentage of 73,9%. In total there are no larger differences between the sexes. Also no greater difference is visible in the severity code (fig. 24, fig. 25). Males, as well as, females show in particular slight and intermediate manifestations. Traces of severe features are represented to a lesser degree. In recent, as well as, in archaeological populations the hip and knee are generally described as the most commonly affected joints of the body in osteoarthritis because these are the major weight-bearing joints. The shoulder, elbow and joints of the hands are affected to a lesser extent (Ortner 2003, Rössler und Rüther 2007, Roberts and Manchester 2007). However, the Grevenmacher population does not follow this sequence. In both sexes the knee is the least affected area compared to the other joints. Moreover, osteoarthritis in the upper part of the body especially in the shoulder and elbow are very common in males, as well as, females. Changes in bones of hands/fingers or foot/toes are relatively rare in total, whereas females show slightly higher values in changes of the finger bones.

In a second step all individuals were distributed due to their respective age.

tab. 55. Individuals affected by osteoarthritis separated by age

	males		females	
age class	n	n affected by osteoarthritis	n	n affected by osteoarthritis
20-30	10	2 (20,0%)	29	9 (31,0%)
30-40	36	20 (55,5%)	39	19 (48,7%)
40-50	38	25 (65,8%)	30	22 (73,3%)
50-60	25	19 (76,0%)	13	11 (84,6%)
60+	10	8 (80,0%)	4	3 (75,0%)
total	119	74 (62,2%)	115	64 (55,7%)

As expected the proportion of affected individuals increase from younger to older age classes in both sexes. In males, an increase from 20% in the younger to 80% in the oldest category is visible. In females, the values decrease in the age class senilis to 75,0%. However, this is caused by the few individuals represented. A summation of the age classes 50-60 and 60+ results in a proportion in males of 77,1%, in females of 82,4%. Striking are the over all higher values of affected joints in women compared to the men. These values correspond to statements about epidemiology of osteoarthritis in medical literature. Age and sex are characterised as systemic risk factors for joint disease. Age-related increase of osteoarthritis can be observed in all joints but especially in joints most commonly affected like hip, knee and hands. The reasons are not understood completely but are assumed in cumulative joint damage over lifetime and the reduced capacity for tissue reparative capacity (Busija et al. 2010, Arden and Nevitt 2006). Other risk factors to develop osteoarthritis are genetic influences and female gender. Women have an up to 50% higher risk of osteoarthritis than men, especially in the age around 50 and older (Busija et al. 2010). Therefore, possible reasons are assumed in oestrogen deficiency following menopause. However, no consistent association between osteoarthritis and sex hormone levels are identified so far (Busija et al. 2010, Arden and Nevitt 2006). The higher prevalence of women in the younger age classes in the case of Grevenmacher is hard to explain. There is still a lack of studies in recent medical literature, concerning rates and prevalence of osteoarthritis in young individuals in general and especially in women. On one hand a smaler amount of young individuals develop osteoarthritis today. On the other hand detection and classification of symptoms with radiographic methods is difficult when traces on bones are just slightly developed. At this point reasons for the formation of lesions in younger age just can be speculative. Genetic susceptibility to osteoarthritis in some individuals as well as influences of body mass and height are possible causes.

Osteoarthritis and occupation

One question that is discussed in osteoarchaeological literature for years is if osteoarthritis can be used for the reconstruction of activity and occupation. A lot of studies were published about changes in the skeleton and their relation to activity (Capasso et al. 1999, Jurmain 1999). However, a review of the literature by Jurmain (1999) and Weiss and Jurmain (2007) did not render clear answers to this question. Some studies support and others disprove links between activity and a prevalence of osteoarthritis. One recently visible trend is that studies focusing on specific risk groups of individuals engaged in mechanically stressful activities show higher positive correlations of increased prevalence of osteoarthritis. For example, studies of individuals engaged in farming resulted in significantly higher rates of osteoarthritis in specific joints (Thelin and Holmberg 2007, Walker-Bone and Palmer 2002). According to Weiss and Jurmain (2007) this is far sparse evidence to state a concrete relation between osteoarthritis and activity. Therefore, they come to the conclusion that osteoarthritis is not an ideal indicator of specific activity or occupation. Its varying aetiology and in particular the genetic and environmental influences on different joints complicate reconstructions of occupation on individual level.

The question remains what statement can be made about the distribution of osteoarthritis in the population of Grevenmacher. Striking is the high rate of osteoarthritis in the upper joints of the shoulder and elbow. Despite the varying aetiology of osteoarthritis an increased stress to the upper part of the body can be derived. This is supported by an increased rate of osteoarthritis in the sternal end of the clavicle, additional bone formation at the sternum and at the sternal end of the ribs, visible in a lot of individuals in both sexes. A connection between osteoarthritis of the upper part of the body and specific activities must be speculative because a lot of activities cause stress to the arms, shoulder and elbow. The same applies to degenerative changes of the hip which also shows high rates in the Grevenmacher population. The reconstruction of activity and occupation only with analysis of osteoarthritis rates is therefore a highly speculative matter.

Diseases of the spine

The spine is the most complicated joint system of the human body. All of its components (vertebral body, intervertebral disc, joint facets, ligaments and musculature) can be affected by degenerative changes (Niethard et al. 2009). However, not all areas of the spine are affected the same way. A backward curve in the thoracic region and a forward curve in the cervical and lumbar region leads to different points of maximum and minimum flexibility and therefore to maximum and minimum stress. This is responsible for the variation in frequency of degenerative disease in the spine (Roberts and Manchester 2007). Wear effects occur first in the most stressed and the most flexible cervical and lumbar areas of the spine. Spine diseases mostly start with degeneration of the intervertebral disc. These discs consist of the so called nucleus pulposus, surrounded by the fibrous structures of the annulus fibrosus. Throughout life, the nucleus pulposus looses its ability to bind water. Therefore, crack formation occurs in the annulus fibrosus (Chondrosis intervertebralis) resulting in reduction of height in the intervertebral space and instability of the affected segment. The reduction of height and reduced biomechanical buffering leads to increased stress of the vertebral plates. The vertebral plates react with increased reactive bone-condensing and the formation of bead, spur or buckle like osteophytes, a so called Spondylosis deformans occur. The additional bone formation in relation with the decreasing intervertebral space can lead to adhesion of single vertebrae and the formation of a so called block vertebra. The posterior apophyseal joints, as well as, the transverse process joints of the vertebrae can be also affected by degenerative disease. Increased instability and, therefore, increased flexibility leads to spondylarthrosis in the joints including degeneration of cartilage tissue and formation of osteophytes (Niethard et al. 2009, Rössler and Rüther 2007, Adler 1998).

In this work, the characteristics of both spondylosis and spondylarthrosis were recorded for adult individuals (n=234) seperated by sex. Recording follows the classification of four stages based on the grading of osteoarthritis at the appendicular skeleton mentioned above:

0 = The vertebra is present but no changes are visible

1 = Slight osteophyte outgrows. Sclerotic lesions at the margins are visible but they don't change the outline.

2 = Osteophyte development is intensified and erosive lesions at the vertebral body surface and margins are visible. The outlines of the vertebral body are modified and enlarged.

3 = Osteophyte growth is pronounced, a deformation of the vertebral body is visible. Probable adhesion of two or more vertebral bodies.

nm = not measurable

Recording was divided in the three main parts cervical, thoracic and lumbar spine. Every vertebra was evaluated and spondylosis was recorded superior and inferior of the vertebral body. Spondylarthrosis was recorded at the intervertebral joints superior and inferior, as well as, for the right and left body side respectively. The results are presented in figures 26 and 27 separated for males and females, superior and inferior side of the vertebral body, as well as, summed up for both sexes.

Spondylosis

Spondylosis of the cervical spine

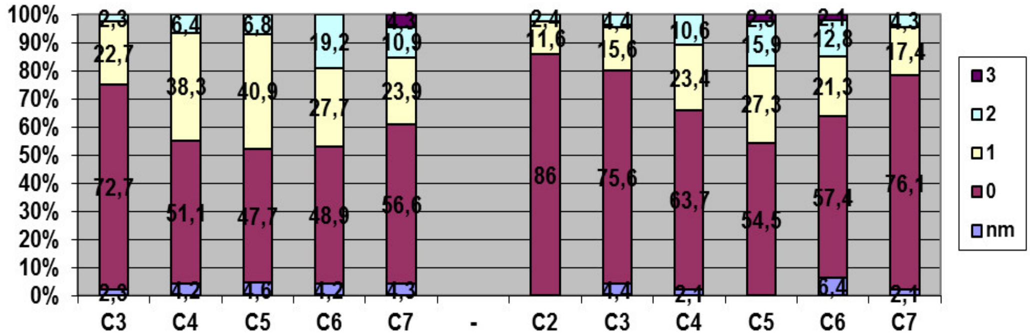


fig. 26. Severity code of spondylosis of the cervical spine of males, superior (left) and inferior (right)

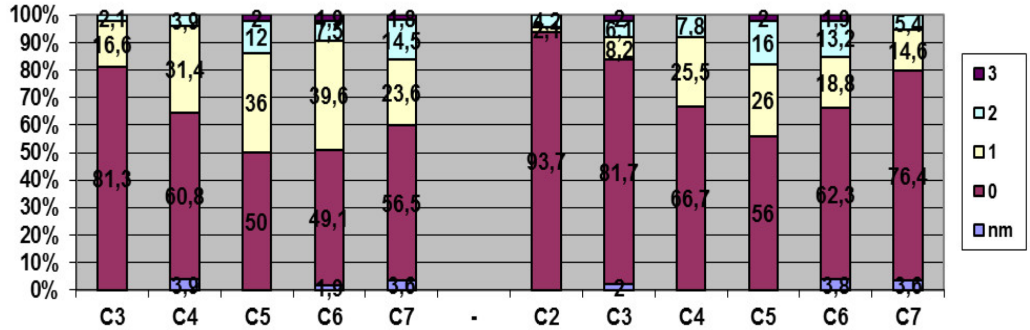


fig. 27. Severity code of spondylosis of the cervical spine of females, superior (left) and inferior (right)

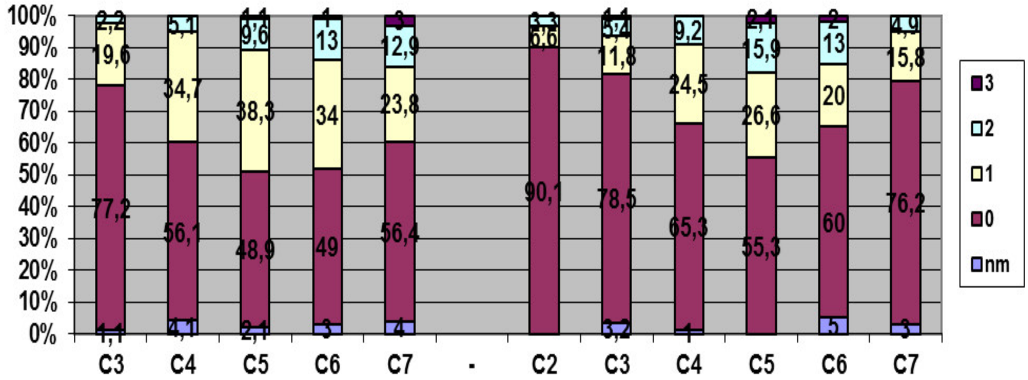


fig. 28. Severity code of spondylosis of the cervical spine combined for both sexes, superior (left) and inferior (right)

A total of 579 cervical vertebrae from126 individuals were examined. 231 vertebrae belonging to 85 individuals show traces of Spondylosis at the cervical spine. That means 36,3% of all adult individuals of Grevenmacher are affected. The C1 was not included in the examination because of its lack of a vertebral body. 119 (51,5%) of the affected vertebrae belong to 46 (54,1%) males, 112 (48,5%) vertebrae could be assigned to 39 (45,9%) females. So males are slightly more affected than females. Overall males and females show the same curve shape in the superior as well as in the inferior surfaces of the vertebrae. The severity increases from C3 and C2 respectively, to its peak in C5 which is the most affected vertebrae on the superior, as well as, the inferior side. This was to be expected because the C4-C6 vertebrae of the cervical spine form a transition area from a well flexible to a less flexible section. Load is the highest in this area so degeneration is as well (Rössler and Rüther 2009). C6 and C7 are again lesser affected, however, more than C3 and C4. In both sexes the vertebrae show more lesions on the superior surface than on the inferior surface. The majority of the lesions are less severe. Stage 1 with only slight bony outgrowth dominates. Fewer vertebrae show stronger ostephytosis categorised as stage 2. Stage 3 with eburnation and/or complete joint deformation is although rare but two individuals (both female) show a fusion of two cervical vertebrae due to Spondylosis. Both individuals are 40-50 years of age. In one (ID 70; 265/141) the vertebrae C3 and C4 are fused at the corpus as well as at the processus articularis. The same can be diagnosed in the second individual (ID 76; 562/198), however, the fusion is between C6-C7.

Spondylosis of the thoracic spine

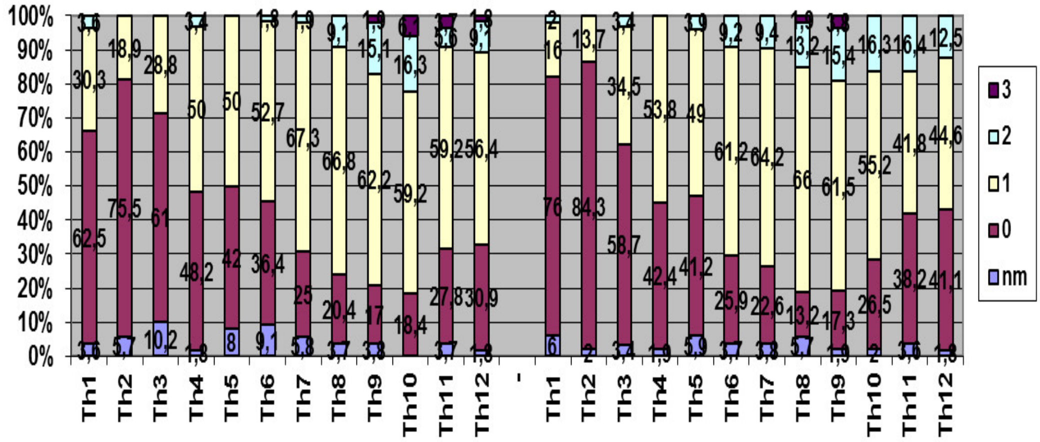


fig. 29. Severity code of Spondylosis of the thoracic spine of males, superior (left) and inferior (right)

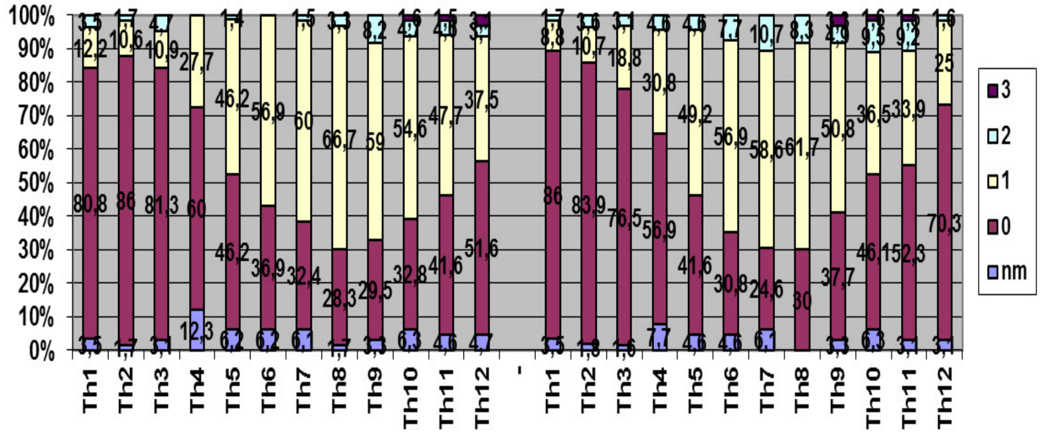


fig. 30. Severity code of Spondylosis of the thoracic spine of females, superior (left) and inferior (right)

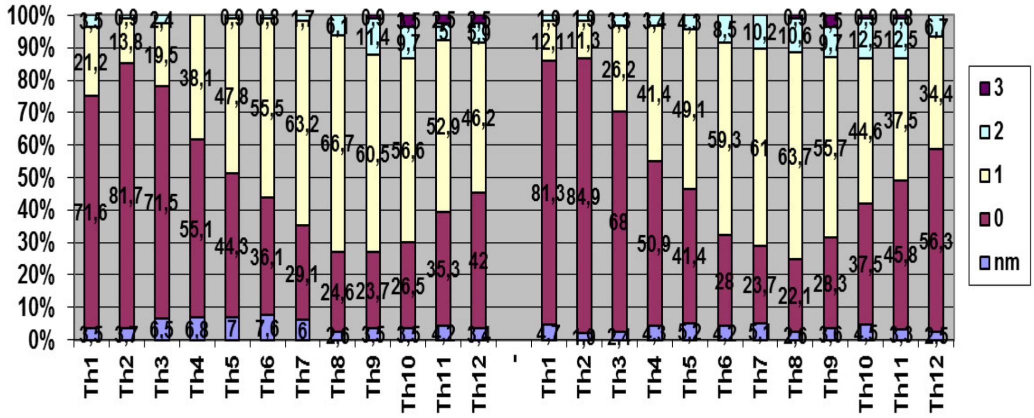


fig. 31. Severity code of Spondylosis of the thoracic spine combined for both sexes, superior (left) and inferior (right)

1397 thoracic vertebrae from 147 individuals were examined. Traces of spondylosis in the thoracic spine are visible at 765 vertebrae from 129 individuals. That means 55,1% of all adult individuals at Grevenmacher are affected. 397 (51,9%) affected vertebrae belong to 66 (51,2%) male individuals. 368 (48,1%) vertebrae originate from 63 (48,8%) female individuals, so males and females are equally affected. In contrast to the cervical spine the superior as well as inferior side of the thoracic vertebrae are affected to the same extent in both sexes. Also the curve shape shows the same progress in both sexes. The upper vertebrae Th1-Th3 are less affected. However, Th4 shows a big difference. In males this vertebra is a lot more affected than in females on the superior, as well as, on the inferior side. The area of Th7-Th10 on the superior, as well as, on the inferior side is the most affected in both sexes. However, some differences are visible. In males Th9 and Th10 are the most frequently affected vertebrae on the superior side. Inferior Th8 and Th9 are the most affected. In women superior Th8 and Th9 show the highest values, as well as, Th7 and Th8 at the inferior side. The vertebrae Th11 and Th12 are overall lesser affected whereas males show again higher values than females superior as well as inferior. Lower stages of affection (1) dominate in both sexes. Stage 2 and 3 is visible in particular in the most frequent affected vertebrae Th7-Th10, in males also in Th11-Th12. Here again the results meet the expectations. In the thoracic spine, the area around Th8 is the most affected due to its increased flexibility and therefore increased susceptibility to degenerative disease (Roberts and Manchester 2007). Three male individuals show fusion of thoracic vertebrae due to Spondylosis. In one of them, 50-60 years old, the Th3 and Th4 fused at the right side of the corpus. At both vertebrae the Fovea costalis are also fused and thus the rips are fused with the vertebrae. In a 30-40 years old individual the vertebrae Th5 and Th6 are fused at the anterior side of the corpus due to a dumping of the spine in the thoracic area. The third individual, 50-60 years old, shows fusion of Th10-Th12 at the right side of the corpus.

Spondylosis of the lumbar spine

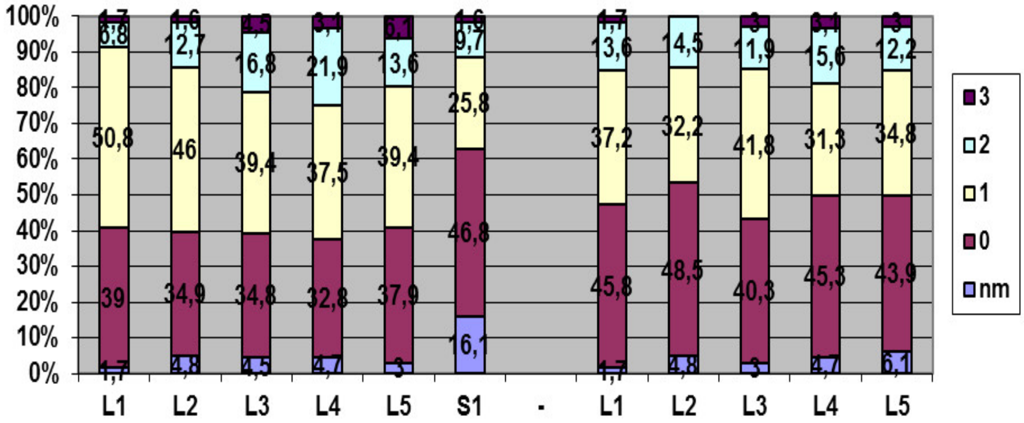


fig. 32. Severity code of Spondylosis of the lumbar spine of males, superior (left) and inferior (right)

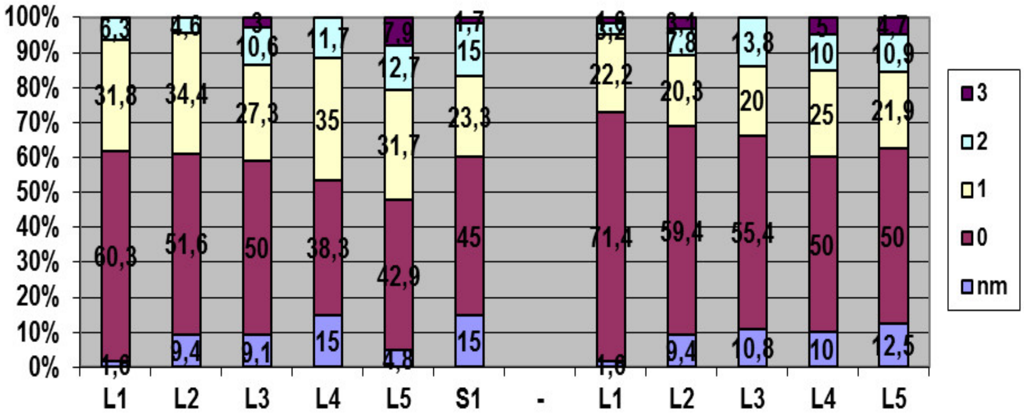


fig. 33. Severity code of Spondylosis of the lumbar spine of females, superior (left) and inferior (right)

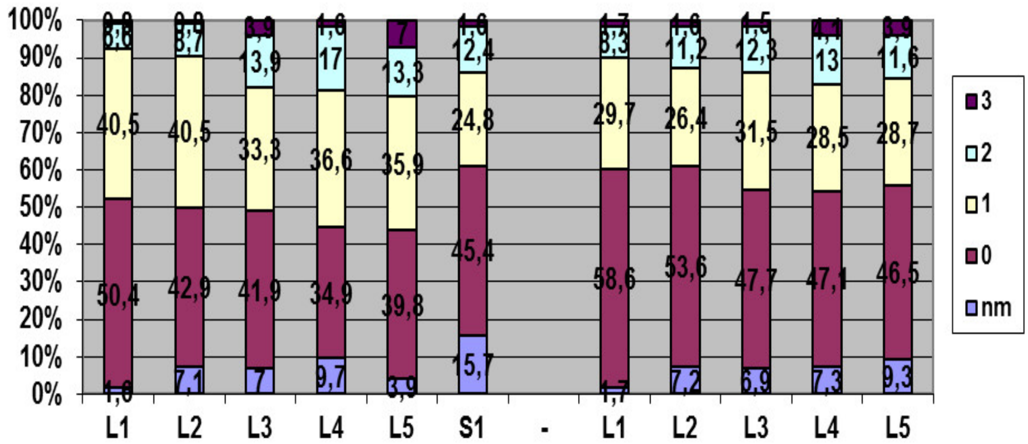


fig. 34. Severity code of Spondylosis of the lumbar spine combined for both sexes, superior (left) and inferior (right)

755 lumbar vertebrae originating from 147 individuals were preserved for examination. 394 vertebrae show traces of Spondylosis, affected were 116 individuals. This means a percentage of 49,6% of all Grevenmacher adults. 226 (57,3%) affected vertebrae belong to 62 (53,4%) male individuals while 54 (46,6%) female individuals provide 168 (42,7%) affected vertebrae. As seen in the cervical spine, affection of the superior body side of the lumbar vertebrae is also higher than affection of the inferior side in both sexes. Striking is the curve shape. In contrast to the former sections of the spine, no vertebra shows a significant higher rate of affection. All five vertebrae are affected to more or less the same rate on the superior, as well as, the inferior side, with a slightly higher susceptibility of the L4 and L5. This corresponds to literature were L4 is stated to be the vertebra most often affected in the lumbar spine. The overall values in males are higher than the female values. The lumbar section is the area that has to bear the highest load, but on the other hand is a very flexible part of the spine. Therefore, it is very susceptible for degenerative changes (Roberts and Manchester 2007).

Distribution of Spondylosis related to age

tab. 56. Individuals affected by spondylosis of the cervical spine separated by age

cervical spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	5	19	22	81	6	17	27,3%	21,0%
30-40	22	21	98	93	40	24	40,8%	25,8%
40-50	14	14	53	75	23	42	43,4%	56,0%
50+	20	11	100	57	50	29	50,0%	50,9%
total	61	65	273	306	119	112	43,6%	36,6%

tab. 57. Individuals affected by spondylosis of the thoracic spine separated by age

thoracic spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	7	21	64	226	28	72	43,8%	31,9%
30-40	22	22	211	229	118	109	55,9%	47,6%
40-50	20	17	154	163	101	96	65,6%	58,9%
50+	25	13	217	133	150	91	69,1%	68,4%
total	74	73	646	751	397	368	61,5%	49,0%

tab. 58. Individuals affected by spondylosis of the lumbar spine separated by age

lumbar spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	8	21	39	114	10	34	25,6%	29,8%
30-40	24	24	108	118	57	49	52,8%	41,5%
40-50	20	17	102	75	61	36	59,8%	48,0%
50+	25	12	133	66	98	49	73,7%	74,2%
total	77	74	382	373	226	168	59,2%	45,0%

As seen in the study of the appendicular skeleton, degenerative changes of the spine also show strong relations to age. The values presented in tables 56 to 58 confirm this fact for Spondylosis. Here an age-related distribution in all three areas of the spine is visible. The lowest rates of affection are visible in the age class early adult (20-30 years). Whereas the age classes maturus (40-50 years) and the summarized class of late maturus and senilis (50+) show the highest rates.

Spondylarthrosis

Spondylarthrosis of the cervical spine

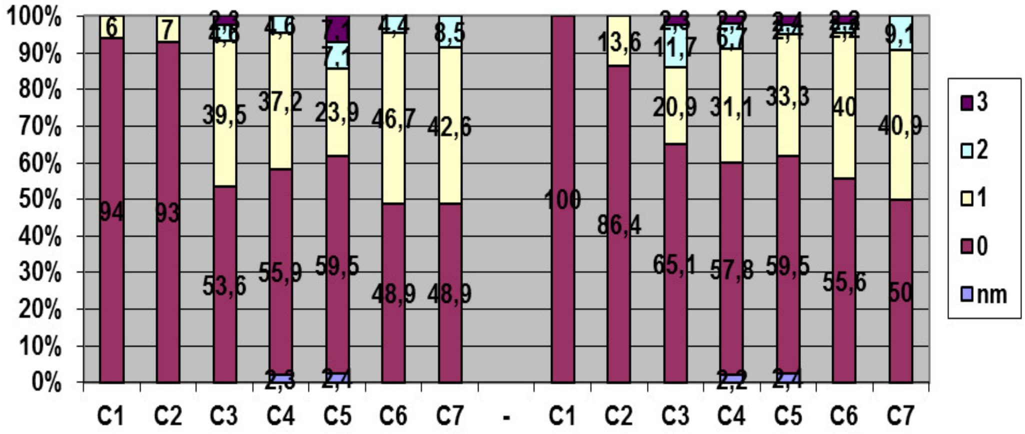


fig. 35. Severity code of spondylarthrosis of the cervical spine of males, superior, right and left body side

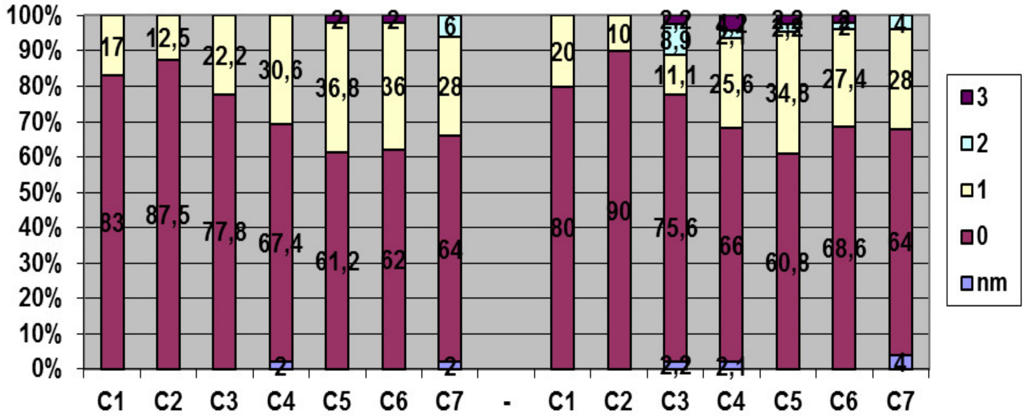


fig. 36. Severity code of spondylarthrosis of the cervical spine of females, superior, right and left body side

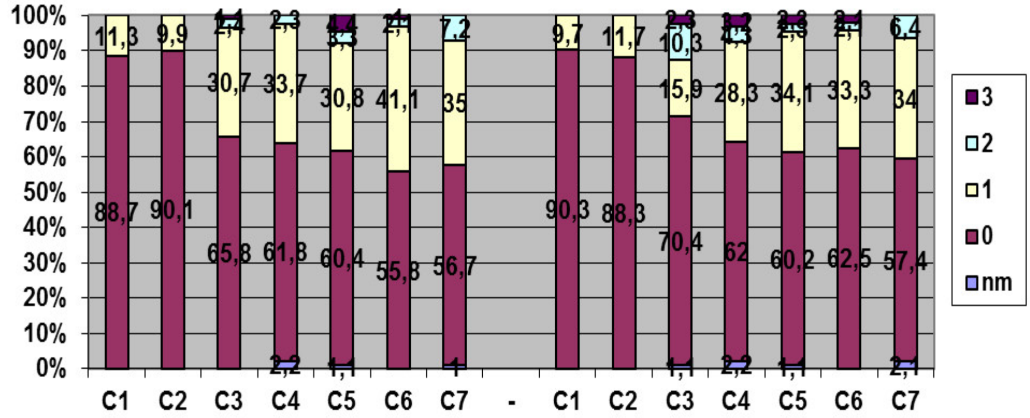


fig. 37. Severity code of spondylarthrosis of the cervical spine combined for both sexes, superior, right and left body side

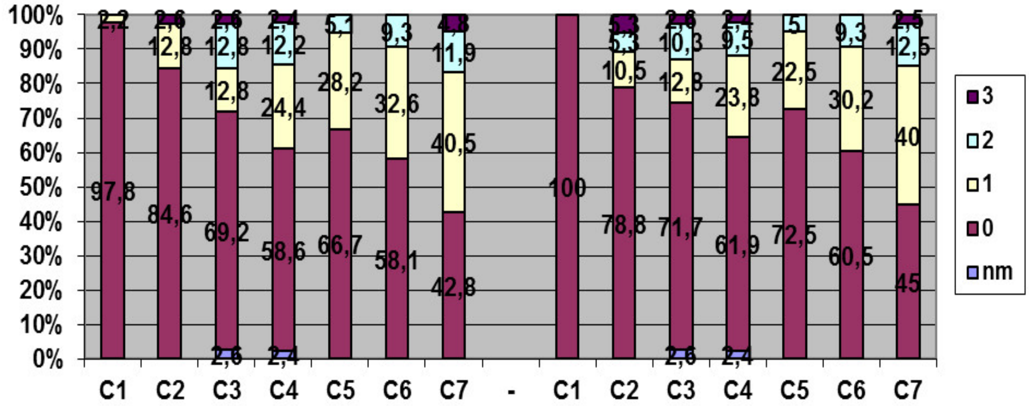


fig. 38. Severity code of spondylarthrosis of the cervical spine of males, inferior, right and left body side

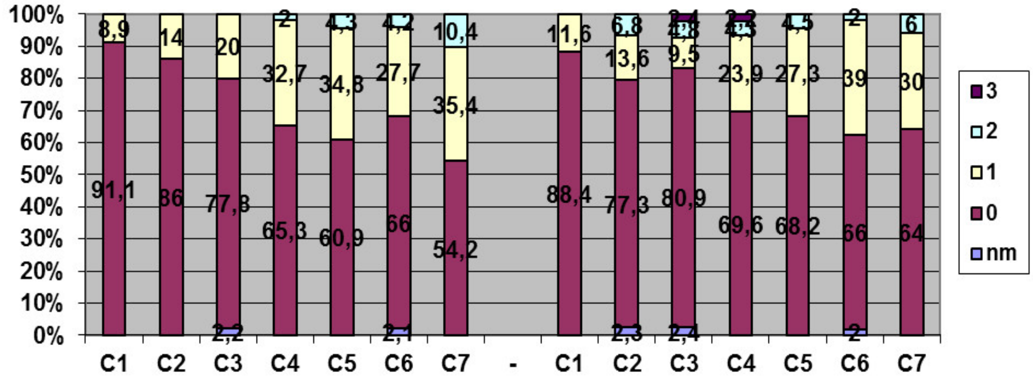


fig. 39. Severity code of spondylarthrosis of the cervical spine of females, inferior, right and left body side

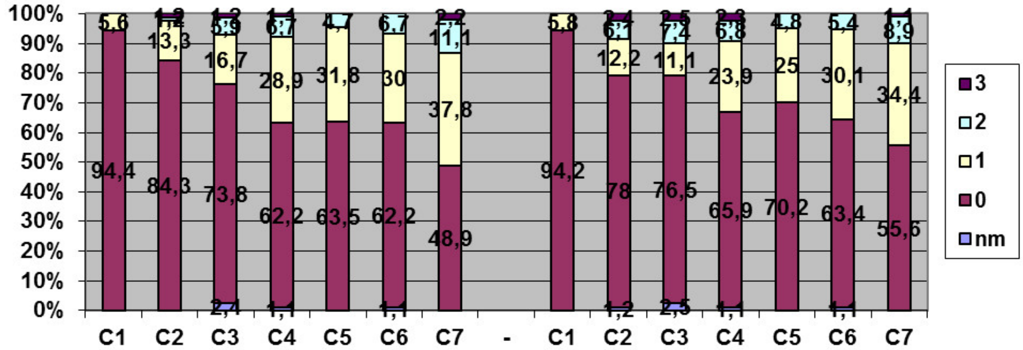


fig. 40. Severity code of spondylarthrosis of the cervical spine combined for both sexes, inferior, right and left body side

The intervertebral joints of 663 cervical vertebrae from 134 individuals were examined. 296 show traces of spondylarthrosis originating from 103 individuals. So 44,0% of all adult individuals are affected. 154 (52,0%) affected vertebrae belong to 57 (55,3%) male individuals, whereas 46 (44,7%) female individuals show 142 affected vertebrae (48,0%). Overall lesions in the intervertebral joints increase from C1 to C7 in males, as well as, in females. Women show a higher affection in the upper vertebrae C1 and C2. Males however show overall higher values in the affected vertebrae. The differences between affection of the superior and inferior side is not as pronounced as in the Spondylosis affection. Slightly higher values are visible on the superior side, as well as, in the right body side. This is the case for both sexes, so unbalanced load of the cervical spine occurred in males as well as in females. Two individuals show fusion of two cervical vertebrae in the intervertebral joints. A male 60-70 years old in the C3-C4 area and a female 50-60 years old in the C2-C3 area.

Spondylarthrosis of the thoracic spine

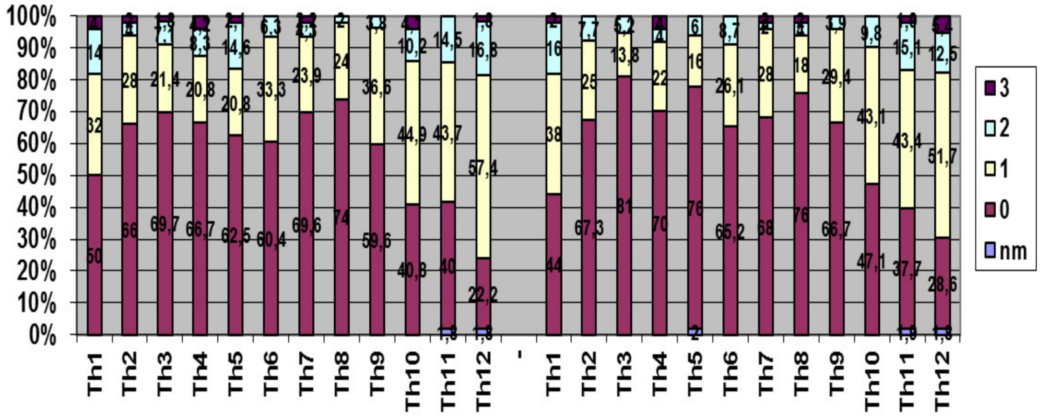


fig. 41. Severity code of spondylarthrosis of the thoracic spine of males, superior, right and left body side

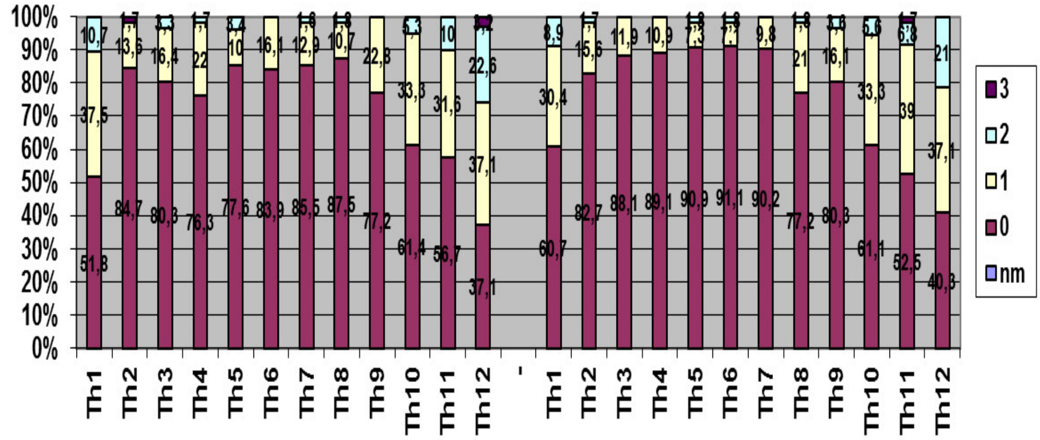


fig. 42. Severity code of spondylarthrosis of the thoracic spine of females, superior, right and left body side

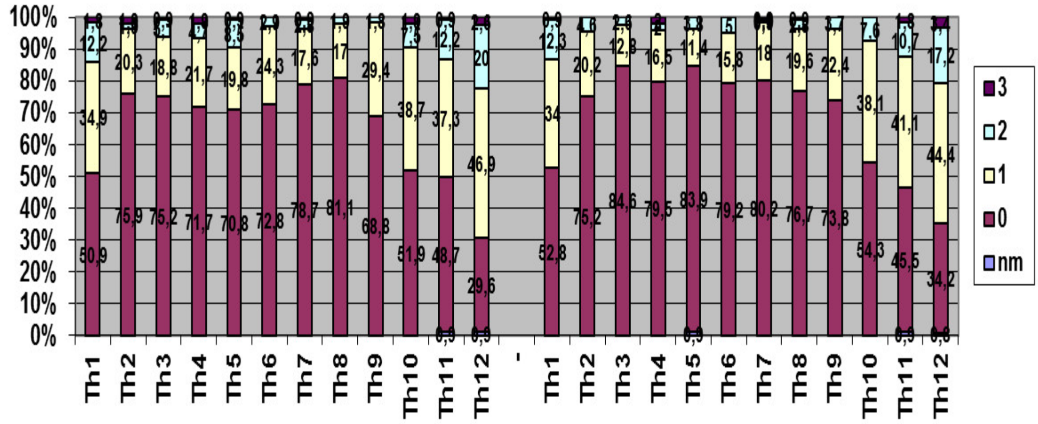


fig. 43. Severity code of spondylarthrosis of the thoracic spine combined for both sexes, superior, right and left body side

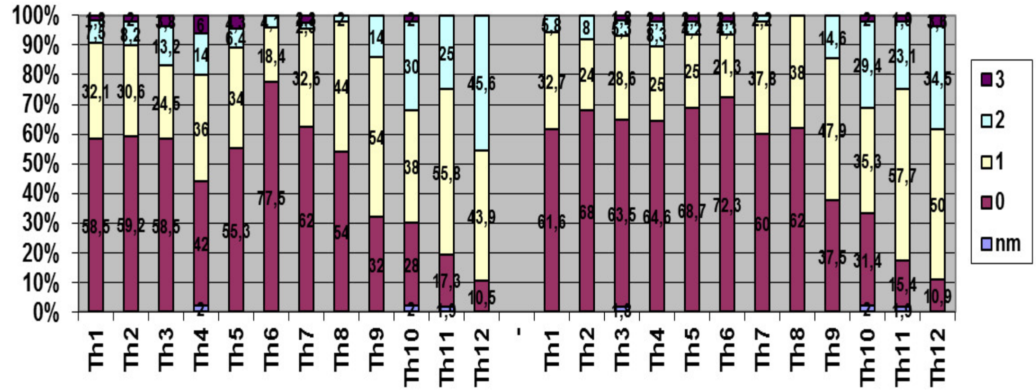


fig. 44. Severity code of spondylarthrosis of the thoracic spine of males, inferior, right and left body side

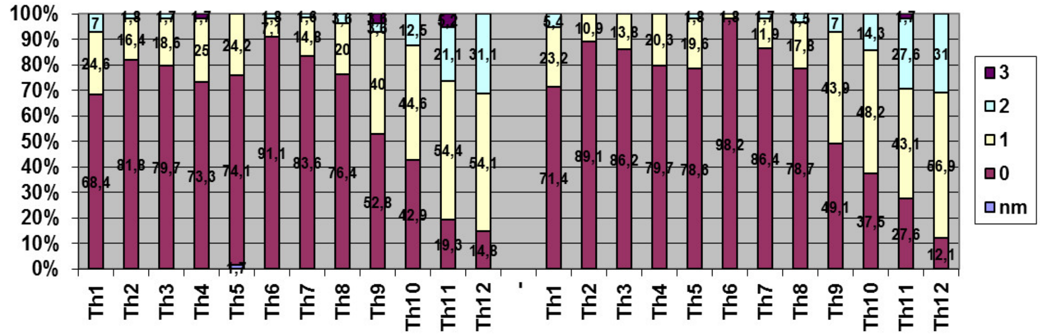


fig. 45. Severity code of spondylarthrosis of the thoracic spine of females, inferior, right and left body side

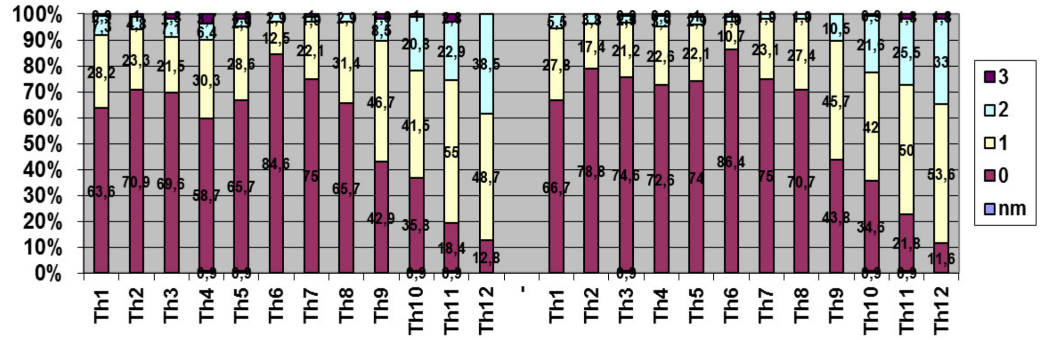


fig. 46. Severity code of spondylarthrosis of the thoracic spine combined for both sexes, inferior, right and left body side

In the thoracic spine 1362 vertebrae from 144 individuals were evaluated. 732 vertebrae from 138 (58,9%) individuals were affected. 69 males, as well as, 69 females show stress related traces in the intervertebral joints. 395 (54,0%) vertebrae originate from male, 337 (46,0%) from female individuals. Striking is the high affection of the superior side of the first thoracic vertebra in males, as well as, in females. This corresponds to a higher affection rate in the inferior side of the last cervical vertebrae (C7). So the transition from the cervical to the thoracic spine seems to be an area of higher load and, therefore, of susceptibility for spondylarthrosis in the intervertebral joints. On the superior side affection rates are relatively low from Th2 to Th9, but then increase from Th10 to Th12, with Th12 as the most affected vertebrae in males, as well as, in females. The same is visible on the inferior side whereas Th4 shows a high rate of affection in both sexes. Overall inferior joints are more affected than superior joints and the right body side is more affected than the left. Severity is very low, stage one and two dominate, joints with lesions in stage three are rare. As seen in the cervical spine, the joints of the right body side are slightly more affected than joints of the left body side, especially in the superior area.

Spondylarthrosis of the lumbar spine

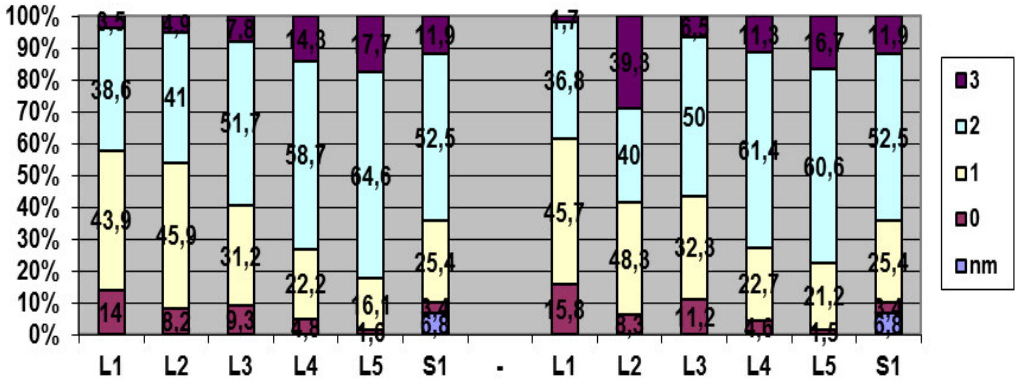


fig. 47. Severity code of spondylarthrosis of the thoracic spine of males, superior, right and left body side

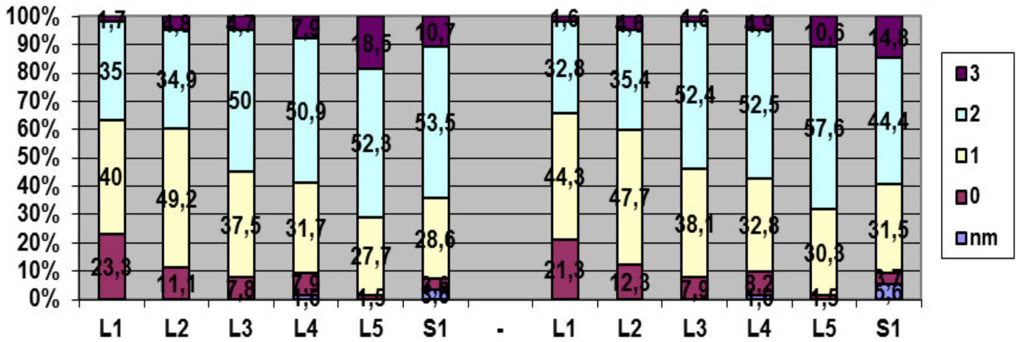


fig. 48. Severity code of spondylarthrosis of the thoracic spine of females, superior, right and left body side

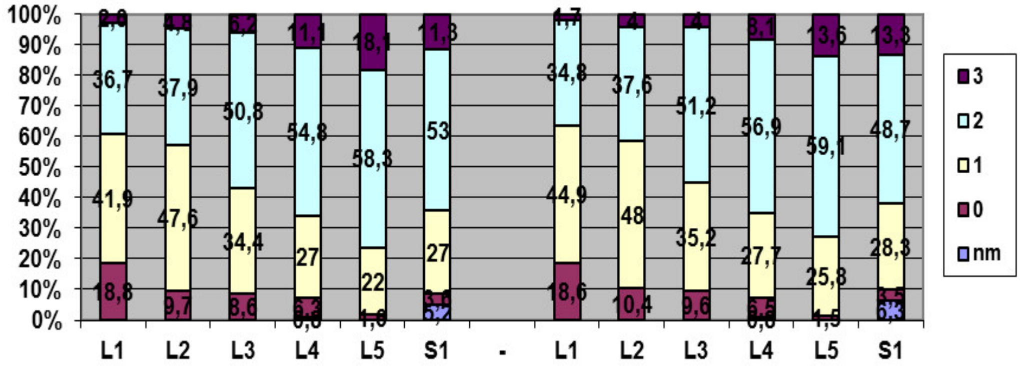


fig. 49. Severity code of spondylarthrosis of the thoracic spine combined for both sexes, superior, right and left body side

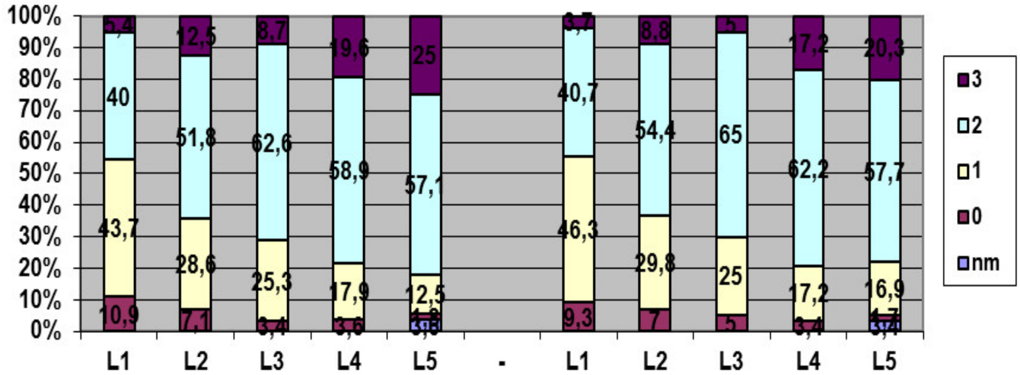


fig. 50. Severity code of spondylarthrosis of the thoracic spine of males, inferior, right and left body side

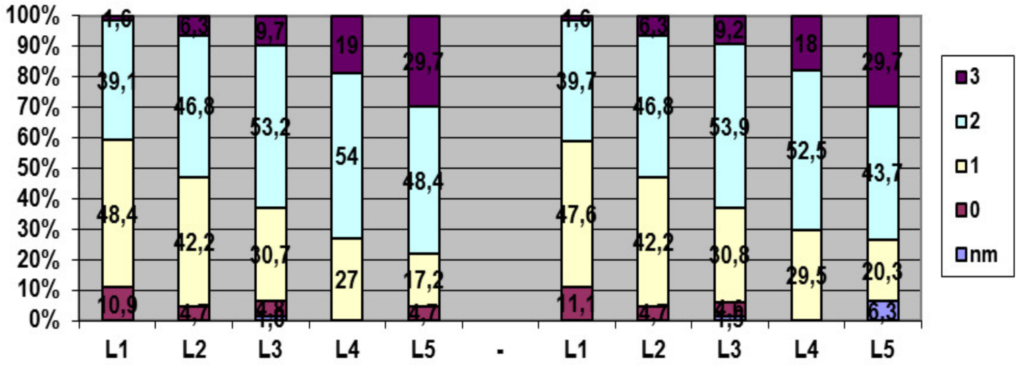


fig. 51. Severity code of spondylarthrosis of the thoracic spine of females, superior, right and left body side

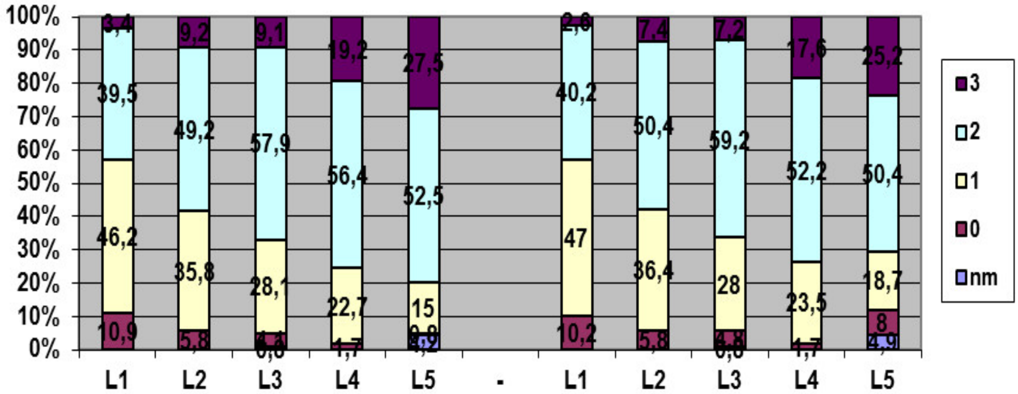


fig. 52. Severity code of spondylarthrosis of the thoracic spine combined for both sexes, inferior, right and left body side

In the lumbar spine 769 vertebrae from 153 individuals were examined, whereas, 731 vertebrae were affected. That means that 64,9% of all adult individuals show lesions in the intervertebral lumbar joints. Males are represented with 76 (50,0%) individuals and 362 (49,5%) affected vertebrae. Females have almost the same values with 76 (50,0%) individuals and 369 (50,5%) affected vertebrae. The lumbar spine shows the highest affection more or less even distributed over all vertebrae. L1 and L2 show slightly lower values L4 and L5 are the most affected. The inferior joints are slightly more affected than the superior joints, whereas, no difference is visible between body sides. Severity is overall higher than in the cervical or thoracic spine. L4, L5 and superior S1 show a relatively high percentage in stage three.

Distribution of Spondylarthrosis related to age

tab. 59. Individuals affected by spondylarthrosis of the cervical spine separated by age

cervical spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	5	20	20	87	6	28	30,0%	32,2%
30-40	23	22	115	114	46	37	40,0%	32,5%
40-50	17	13	67	77	39	49	58,2%	63,6%
50+	23	11	116	66	63	28	54,3%	42,4%
total	68	66	318	344	154	142	48,4%	41,3%

tab. 60. Individuals affected by spondylarthrosis of the thoracic spine separated by age

thoracic spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	7	21	63	221	27	73	42,9%	33,0%
30-40	22	21	207	221	119	92	57,5%	41,6%
40-50	19	17	143	146	99	95	67,8%	65,1%
50+	24	13	226	135	150	77	66,4%	57,0%
total	72	72	639	723	395	337	61,8%	46,6%

tab. 61. Individuals affected by spondylarthrosis of the lumbar spine separated by age

lumbar spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	8	21	38	121	25	111	65,8%	91,7%
30-40	23	24	104	115	103	109	99,0%	94,8%
40-50	21	17	103	77	99	77	96,1%	100,0%
50+	25	14	136	75	135	72	99,3%	93,5%
total	77	76	381	388	362	369	95,0%	95,1%

In contrast to the distribution of increasing spondylosis rates which follow increasing age evenly, the distribution of spondylarthrosis is more unbalanced. In males the highest values are already reached with the age class early mature (40-50 years) in the cervical and thoracic spine. In the lumbar spine values are high even in the late adult class (30-40 years). In all three areas these values remain at a high level until the highest age class. In females values of the cervical and thoracic spine also raise to the age class early mature (40-50 years), but then drop to a lower level in the category late mature and older (50+). This fact is unusual because degenerative changes do not recede with age. However, these kinds of fluctuations can be related to the lower number of individuals especially in the female age class of 50 years and older. Overall the individuals from Grevenmacher show rather lower degrees of degenerative joint disease of the spine. The severety level in spondylosis range mostly between 0 and 1. Only 10% of the individuals reach the higher levels 2 and 3. This applies to both sexes as well as all three sections of the spine. In spondylarthrosis values are more or less the same in the cervical and the thoracic spine. However, in the lumbar spine around 50%-60% of the individuals reach the higher levels 2 and 3. So the lumbar spine seems to be the most affected area especially in the apophyseal joints. This fact is also visible in studies of Knüsel et al. (1997) as well as Weber et al. (2004). One feature that is noticeable in the Grevenmacher material is the marked difference in spondylarthrosis rates between body sides in the thoracic vertebra. In both sexes the apophyseal joints on the right body side are more affected than on the left side. In the cervical and the lumbar spine no significant differences in body sides is visible. One possible reason for this can be seen in the preferred use of the right arm and hand. Unbalanced load with preference of arm and hand of one body side can also affect the spine. The one-handed carrying of loads leads to lateral bending and thereby to a slight compression of the spine which affect also the apophyseal joints (Oda et al. 1996).

Degenerative changes of the spine and occupation

The relation between degenerative joint disease and occupation of the appendicular skeleton was already discussed in the section above. A further question that is raised, concerns possible connections of degenerative changes of the vertebral column and activity. In their study Knüsel et al. (1997) tried to answer this question by examination of the vertebral columns of individuals from a medieval cemetery at York, England. The aim of the study was to examine if groups of individuals of different social status show different rates of degenerative disease in the spine. For this purpose they evaluated lesions of the intervertebral, as well as, the apophyseal joints of all vertebrae. The results of the study showed no significant differences in the rates of degenerative joint diseases between the respective groups. All individuals showed more or less the same pattern of degenerative joint disease along the vertebral column. With the most severely affected intervertebral joints at C5-C6, Th8-Th10 and L2-L3. The least severely affected vertebrae are C7-Th1, Th12-L1 and L5-S1. The apophyseal joints also showed a common pattern with highly severe affects on C2-C4, C7-Th1, Th10 and L3-L5. The lowest affection was found in C1, C5-C6 and Th1-Th9. The comparison of these results by Knüsel et al. (1997) with the stress patterns of the Grevenmacher individuals show the same distribution of highly affected, as well as, the lower affected areas of the spine. The authors state that the severity pattern along the vertebral columns under study is the result of biological factors rather than activity-related or social differences. So the distribution of different rates of Spondylosis as well as Spondylarthrosis along the spine is the result of adaptation of the respective spinal areas to their different kinds of tasks in flexibility and fixation. Due to this fact, rates of degenerative joint disease in the vertebral column do not permit the distinction of groups of different social status. Nor could it be used to work out specific kinds of activity or occupation. The latter statement is also confirmed by clinical studies by Videman et al. (1995) and Videman and Battié (1999).

Schmorl’s nodes

Another phenomenon visible in the spine is the occurrence of Schmorl’s nodes. Schmorl’s nodes are described as vertical herniations of intervertebral discs penetrating into the vertebral body (Dar et al. 2010, Üstündag 2009, Faccia and Williams 2008). Its aetiology is still under debate and as possible causes trauma, congenital weakening of the vertebral endplate as well as various spinal diseases are discussed (Dar et al. 2010, Üstündag 2009). In their study Dar et al. (2010) argue that a combination of the vertebral developmental process during early life, diverse pressures and strains of the nucleus pulposus on the weakest part of the end plates and intervertebral disc as well as torsional spinal movement as main causes for Schmorl’s nodes development. Due to the lack of standardized recording methods evaluation of Schmorl’s nodes in this work is referred to Knüsel et al. (1997) also used by Üstündag (2009). The lesions are graded in two scores. A score of 1 is noted for nodes that are less than 2 mm deep and cover an area equivalent to less than half of the anteposterior length of the vertebral body. A score of 2 is noted when the lesion exceeds these values. It was further differenced in superior and inferior part of the vertebral body as well as age and sex of the individuals. The results are shown in the following figures.

Schmorl’s nodes of the cervical spine

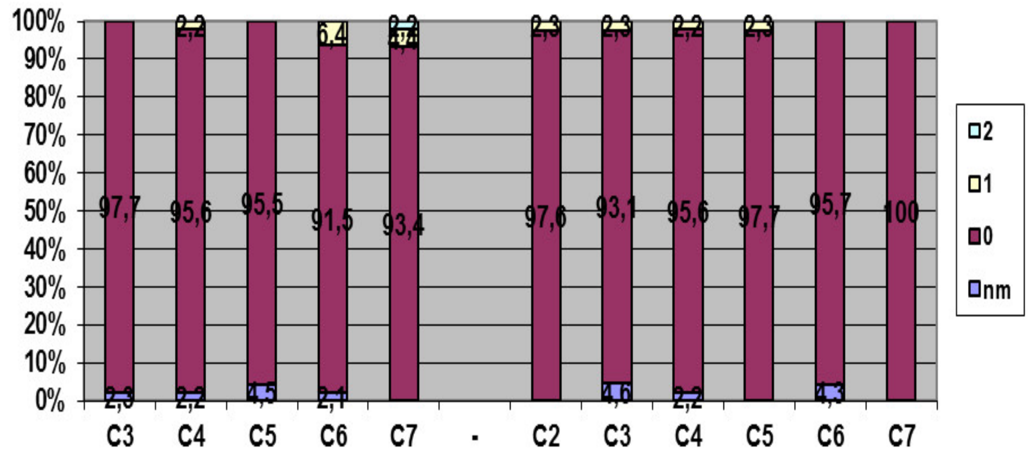


fig. 53. Severity code of Schmorl’s nodes of the cervical spine of males, superior (left) and inferior (right)

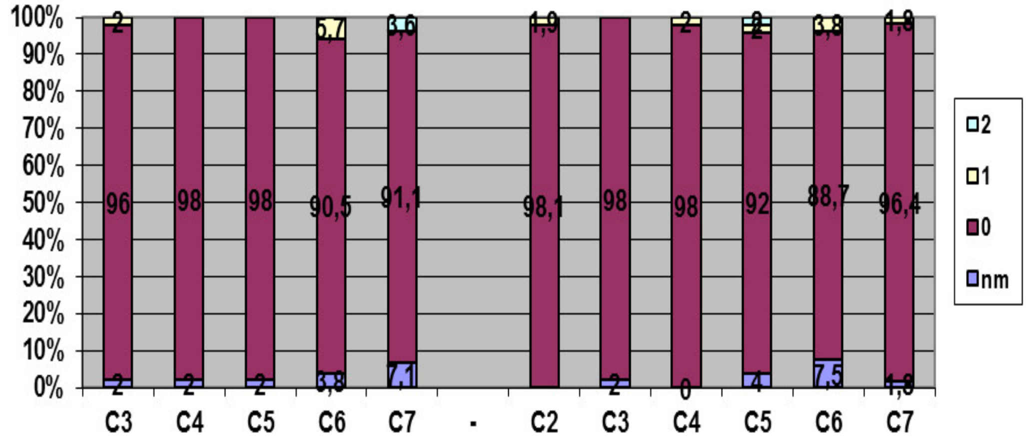


fig. 54. Severity code of Schmorl's nodes of the cervical spine of females, superior (left) and inferior (right)

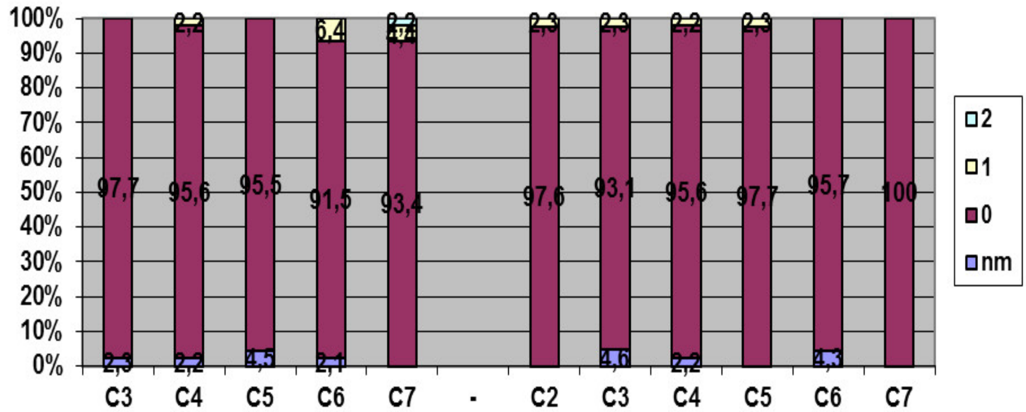


fig. 55. Severity code of Schmorl's nodes of the cervical spine combined for both sexes, superior (left) and inferior (right)

In the cervical spine 585 vertebrae from 124 individuals were examined. Only 24 (4,1%) vertebrae from 15 (12,1%) individuals show Schmorl's nodes. 11 (45,8%) of the affected vertebrae originate from 8 (53,3%) males, 13 (54,2%) vertebrae are obtained from 7 (56,7%) females. Altogether Schmorl's nodes are very rare in the cervical spine. Little affects are visible at the inferior side of C2-C5 in males and C2, C3-C7 in females. C6 and C7 are little more affected on the superior side in both sexes.

Schmorl's nodes in the thoracic spine

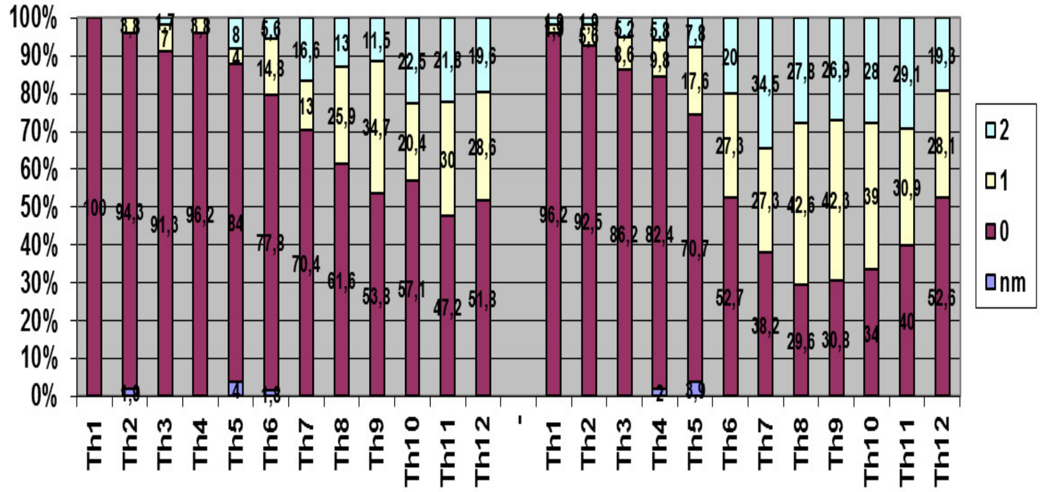


fig. 56. Severity code of Schmorl's nodes of the thoracic spine of males, superior (left) and inferior (right)

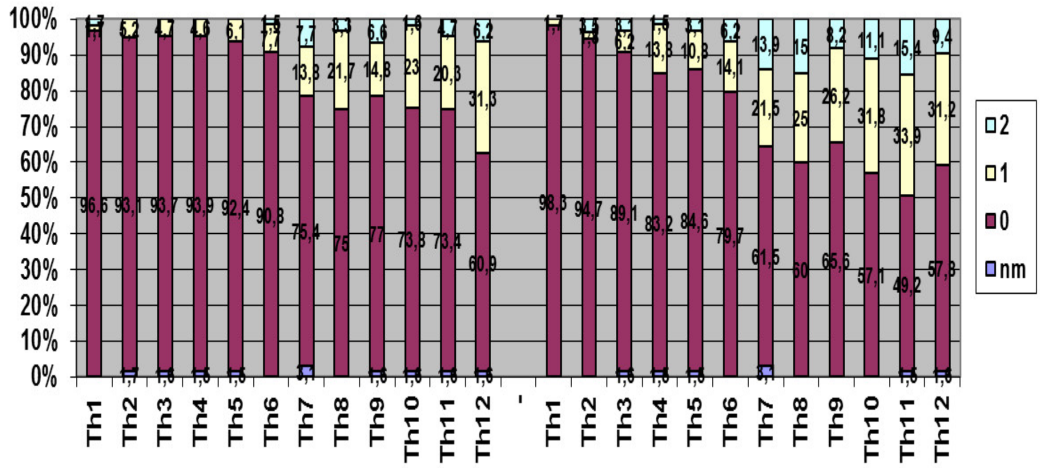


fig. 57. Severity code of Schmorl's nodes of the thoracic spine of females, superior (left) and inferior (right)

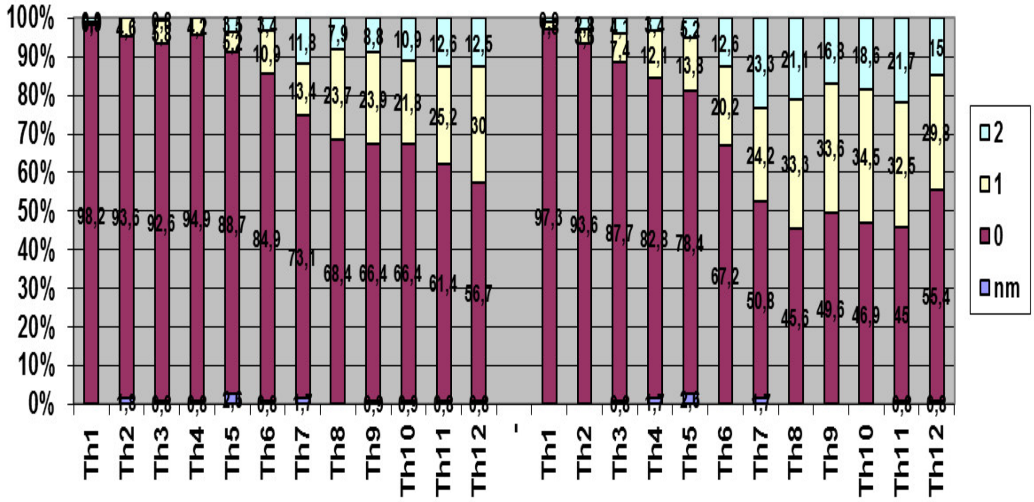


fig. 58. Severity code of Schmorl's nodes of the thoracic spine combined for both sexes, superior (left) and inferior (right)

The thoracic spine is affected to a higher extend. 1395 vertebrae from 147 individuals were examined. 501 (35,9%) vertebrae from 110 (74,8%) individuals were affected. 285 (56,9%) vertebrae from 60 (54,5%) male individuals exhibit Schmorl's nodes, 216 (43,1%) affected vertebrae originate from 50 (45,5%) female individuals. Th1 to Th4 are only affected to a low rate in both sexes. From Th5 downward the curve shape of the superior and inferior side differs. Superior the most affected vertebrae are Th11 and Th12 in both sexes. Inferior Th8 and Th9 are the most affected vertebrae in males and Th10 and Th11 in females. Overall the inferior side is more affected than the superior side. An increase in the severity rate is also visible from Th5 on. Striking is here the high values of stage 2 in Th7 and Th8 especially on the inferior side.

Schmorl's nodes in the lumbar spine

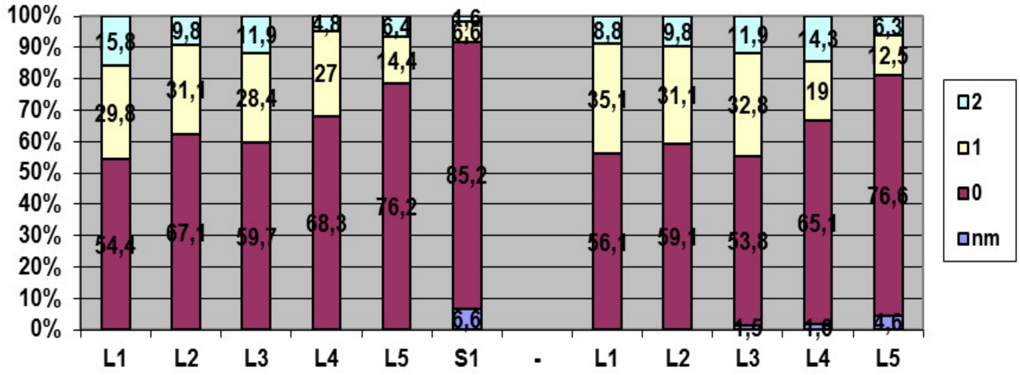


fig. 59. Severity code of Schmorl's nodes of the lumbar spine of males, superior (left) and inferior (right)

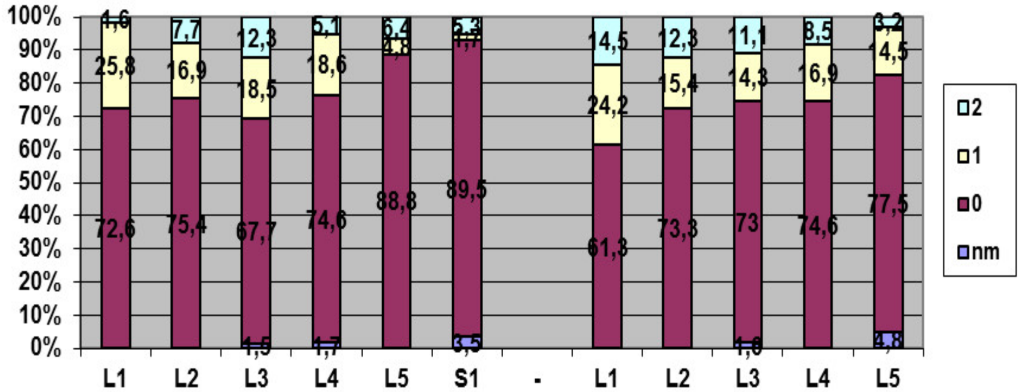


fig. 60. Severity code of Schmorl's nodes of the lumbar spine of females, superior (left) and inferior (right)

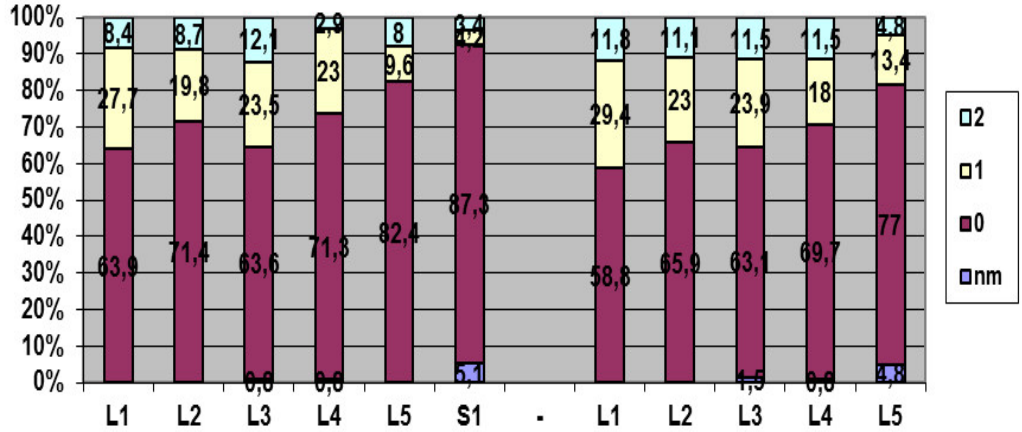


fig. 61. Severity code of Schmorl's nodes of the lumbar spine combined for both sexes, superior (left) and inferior (right)

793 lumbar vertebrae from 150 individuals were available for examination. 261 (32,9%) were affected belonging to 96 (64%) individuals. 154 (59,0%) vertebrae originate from 56 (58,3%) males, 107 (41,0%) vertebrae came from 40 (41,7%) females. The affected vertebrae in the lumbar spine decrease from L1 to S1. Mostly affected are the upper vertebrae L1 to L3 in both sexes, as well as, on both sides. The differences between infestation of the superior and inferior side are less pronounced compared to the thoracic spine. Still on a high level are the severity rates. Stage two is present in almost all of the affected vertebrae.

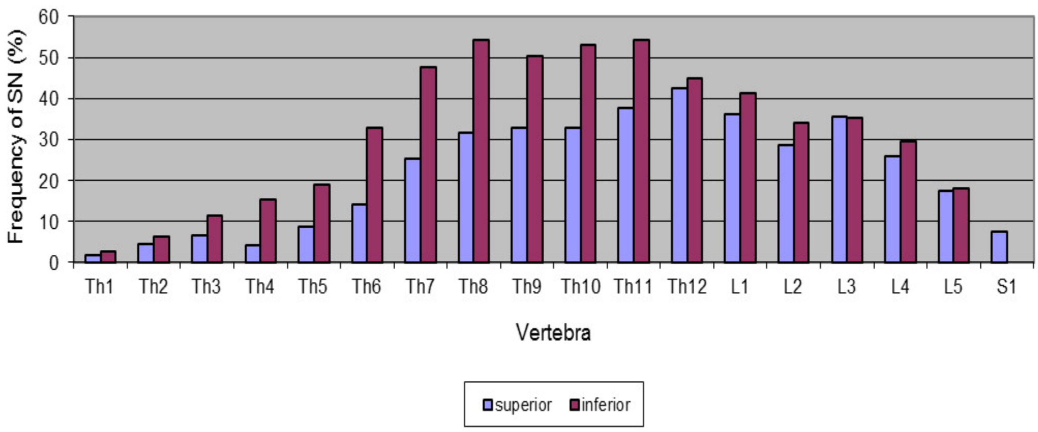


fig. 62. Prevalence of Schmorl's nodes

Figure 62 shows the distribution of Schmorl's nodes summed up by vertebra from Th1 to S1. The distribution varies between the superior and inferior surface. Overall the vertebrae are more affected in the inferior side than on the superior surface. When examining the superior surface, an increase in affected vertebrae is visible from Th1 to Th12 were it shows its highest value. From Th12 to S1 the number of vertebrae decreases with again a slightly higher value in L3. The inferior surface also shows an increase in affected vertebrae starting from Th1, but reaches its highest values at Th8 – Th11. From Th11 a decrease is visible till L5, whereas, slightly higher values are seen again in L3. More cranial located thoracic vertebrae as well as the lower lumbar region are affected to a much lower rate. The reasons for an increased affection on the inferior side of the vertebrae are still under debate. Dar et al. (2010) argue developmental processes of the vertebrae during early life as decisive factors.

Distribution of Schmorl's nodes related to age

tab. 62. Individuals affected by Schmorl's nodes of the thoracic spine separated by age

thoracic spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	7	21	65	227	9	40	13,8%	17,6%
30-40	22	22	209	226	89	64	42,6%	28,3%
40-50	21	17	164	164	81	55	49,4%	33,5%
50+	24	13	208	133	106	57	51,0%	42,9%
total	74	73	645	750	285	216	44,2%	28,8%

tab. 63. Individuals affected by Schmorl's nodes of the lumbar spine separated by age

lumbar spine	n examined male	/ female	n vertebrae examined male	/ female	n vertebrae affected male	/ female	n vertebrae affected male	/ female
20-30	8	20	38	108	3	21	7,9%	19,4%
30-40	22	24	97	117	45	31	46,4%	26,5%
40-50	22	16	105	73	46	29	43,8%	39,7%
50+	24	12	128	66	60	26	46,9%	39,4%
total	76	72	368	364	154	107	41,8%	29,1%

An increase in the occurrence of Schmorl's nodes related to age is visible in both areas of the spine. However, from the category late mature (30-40 years) on, the frequency is almost the same with no significant differences. Remarkable are the differences in the values between males and females. In the youngest age class (20-30 years) more females than males are affected. This fact turns with the next higher category of the late adults (30-40 years). In the higher age classes males show overall higher rates of affected vertebrae. In the Grevenmacher material remains of the cervical spine were present in 162 individuals. 131 individuals show one or more Schmorl's node along the spine. This means a prevalence of 80,9%. The frequencies per vertebra shown in figure 62 reach values in the inferior part of Th8, Th10 and Th11 of 54,4% and 55,0% respectively. Dar et al. (2010), as well as, Üstündag (2009) describe much lower prevalence rates of 48,3% and 24,1% respectively. Also the frequencies distribution along the spine is much lower. In both studies they never reach 20%. One possible reason for this fact is the different sociocultural backgrounds of the respective samples under study. Dar et al. (2010) examined skeleton spines of the Hamann-Todd Osteological Collection located at the Cleveland Museum of Natural History, Cleveland, OH, USA. These individuals died during the first half of the twentieth century. Üstündag (2009) examined skeletal remains from the cemetery of the Cistercian monastery of Klostermarienberg, Austria dating from the 16th to 18th century. The vertebral segments of 464 individuals were examined, whereas, it is not clear to what group these individuals belong. The fact that the study included remains of males and females makes it very likely that not just members of the monastery, but also people from a nearby village were buried in the cemetery. A direct comparison of the Grevenmacher results with results gained from the Hamann-Todd Collection is difficult due its temporal and spatial distance, as well as, its different kind of activity and occupation of the individuals. The Grevenmacher individuals originate from a medieval rural environment. So it is assumed that agricultural activities and craftsmanship was the main occupation. The occupation of individuals of the Hamann-Todd Collection is unknown, but it is not assumed that the majority was engaged in farming activities. How much manual activities were practised can not be reconstructed. One possible cause for the difference in the prevalence rate between these two samples is that different activities were carried out by the respective individuals. The sample from Klostermarienberg examined by Üstündag (2009) is very similar to the Grevenmacher sample both spatial and temporal. Therefore, the difference in frequencies between these two samples is much harder to explain because it is assumed that there are no great differences in activities between these two populations. The distribution pattern of the prevalence of Schmorl's nodes in the Grevenmacher material correspond to the data Dar et al. (2011) and Üstündag (2009) estimated in their studies. The lesions appear most frequently in the Th7-L1 region. Upper thoracic and lower lumbar vertebrae are less frequently affected. The frequencies with regard to age and sex are again in agreement with the results presented by Üstündag (2009). The higher age classes are affected to more or less the same level in both sexes, whereas, males are more affected by Schmorl's nodes than females. Dar et al. (2010) renounced a presentation of frequencies differenced for age and sex.

Overall, the results gained from the examination of Schmorl's nodes in the Grevenmacher material complies with the results of the other studies shown above. However, the high prevalence rate in the Grevenmacher population is a reason for further discussion. Dar et al. (2010) state an enhanced rotational movement of the spine as main factor for the formation of Schmorl's nodes. An increased load of the upper part of the body, indicated by an increased rate of degenerative joint disease in shoulder and elbow is also visible at a large number of individuals. Maybe a combination between these two phenomena is the decisive key to the increased prevalence of Schmorls' nodes in the Grevenmacher sample. However, the kind of activity leading to increased burden of the shoulder and upper extremities as well as torsion of the spine is not easy to identify. Cutting of the cornstalks during grain harvest with the sickle, later in the high Middle Ages with the scythe are possible answers (Goetz 2002).

9.2. Non-specific infections

Periostitis

Inflammation of the bone surface, especially the periosteum, is a clinical picture often diagnosed in archaeological skeletal samples. Periostitis is a symptom occurring in many diseases, therefore it is difficult to verify which disease caused this symptom. New bone formation occurs as longitudinal striation, little plaques or fine pittings. They mostly affect the diaphysis of the long bones especially the tibia (Roberts and Manchester 2007, Ortner 2003). In the Grevenmacher sample a total of 37 adult individuals (14,3%), 18 males and 19 females, show traces of periostitis on different bones in different manifestations. The most frequent affected bone is the tibia (33 cases) the fibula (12 cases) and the femur (9 cases). In a few cases bones of the upper extremities are affected (2 x humerus, 2 x ulna, 2 x radius). In the case of a male individual (ID 144, 998/381), 30-60 years of age, the inflammation spreads from the femora to the pelvis bones and also bones of both hands are involved (fig. 63). Unfortunately, most of the skeleton is not preserved but the fact that all of the present bones show periostitis in different rates of severity leads to the assumption that a generalized chronic infection concerning the whole body was present.

fig. 63. Periostitis on a femur shaft of a 30-60 years old male individual (ID 144; 998/381)

fig. 64. Osteomyelitis, osteitis and periostitis of the shaft of the right second metatarsal of a 50-60 years old male indvidual (ID 71; 1048/409)

Osteitis and Osteomyelitis

Infections of the bone mostly affect all parts such as the bone marrow, corticalis and periosteum. In general this kind of infection is called osteomyelitis. If the bone tissue itself is affected this feature is called osteitis, but both expressions describe the same clinical picture (Rössler and Rüther 2007). Two individuals show lesions that can be diagnosed as infection of the bone. A male individual (ID 557; 1007/371) 20-40 years old shows osteitis and periostitis at a delimited area of the right proximal tibia shaft. The infection occurred most probably after a local injury at the anterior side of the tibia. Another male individual (ID 71; 1048/409), 50-60 years of age shows osteomyelitis, osteitis and periostitis of the shaft of the right second metatarsal (fig. 64). Again an injury was the most probable origin of the infection.

9.3. Neoplastic disease

In clinical literature an osteoma is described as a local formation of tumour mass of abnormal dense with slow expansive growth formed in the periosteum (Niethard et al. 2009, Capasso 1996). Capasso (1996) considered an osteoma as "a form of hypertrophy related to focal hyperostosis". Hyperostosis is caused by a variety of stimuli like mechanical, inflammatory, vascular or thermic features as well as intoxications. In the Grevenmacher material osteomata are found at the inside of the skull in three cases as well as at the tibia in two cases. According to Capasso (1996) an osteoma almost exclusively involves the skull bones. Lesions at the long bones are referred to as osteochondromata with ossified cartilaginous caps. The manifestations at the skull concern three males. One individual, 30-40 years old (ID 54; 373/154), shows an osteoma at the inside of the Os occipitale. It is rounded and measures 8 mm in diameter. Two individuals, 30-50 years (ID 206; 965/375b) and 50-60 years old, (ID 41; 658/272) exhibit osteomata at the inside of the Os frontale and left Os parietale (fig. 65). They are also rounded and measure 5 mm and 8 mm respectively. The osteochondromata are found at the right tibiae of two female individuals 30-40 (ID 12; 180/61) and 50-60 (ID 87; 1054/424) years of age in more or less the same position alongside of the shaft. They measure 30,7 mm and 38 mm in length and 7,3 mm and 7,4 mm in breath respectively.

A female individual (ID 125; 1192/303), 30-40 years of age shows a defined depression on the inside of the Os frontale of about 5 cm in diameter. At the outside of the skull a little elevation of the bone is visible. The depression shows a slight hyperostosis. In clinical literature these kinds of symptoms describe a so called meningioma (Roberts and Manchester 2007, Ortner 2003, Aufderheide and Rodriguez-Martin1998). This is not primarily a tumour of the bone but a tumour of soft tissue that produces a bony reaction (Roberts and Manchester 2007). It arises from the arachnoid cells associated with the dura mater of the brain (Ortner 2003). A meningioma can lead to massive bone destruction, as well as, depression of the brain up to lethal consequences. It cannot be answered for certain whether the lesion discussed in the case here, caused health problems.

fig. 65. Osteoma at the left Os parietale of a 50-60 years old male indvidual (ID 41; 658/272)

9.4. *Metabolic disease*

Bone changes that are also common in the remains from Grevenmacher are porotic lesions in the orbital roofs. 25 adult individuals (9,7%), 12 males and 13 females, show this kind of lesions referred to as Cribra orbitalia. In eight individuals these lesions are highly visible, 17 individuals show only healed traces. These kinds of lesions are symptoms associated with different kinds of diseases often caused by malnutrition. The deficiency of Vitamin C can cause these kinds of lesions (Schutkowski and Grupe 1997). It is also often considered as a symptom for anaemia (Roberts and Manchester 2007). The term anaemia in general describes a variety of abnormalities of red blood cells. A reduction of red blood cells lead to a decreased ability of the circulatory system to exchange oxygen. As blood is produced within bones, disturbances of blood production lead to structural changes in skeletal tissue. Genetically induced forms of anaemia like Thalassemia and sickle cell anaemia can be differenced from forms like iron deficiency anaemia that is caused by the undersupply of iron that is needed for the development of red blood cells. (Aufderheide and Rodriquez-Martin 1998, Ortner 2003). Thalassemia and sickle cell anaemia are connected with malaria and geographically limited to subtropical and tropical areas. Therefore, in the case of the Grevenmacher material the assignment of the symptoms to iron deficiency anaemia is more likely. Iron deficiency is the most common anaemia today concerning up to 30% of the world's population and it is very likely that it was also common in the past (Roberts and Manchester 2007, Ortner 2003). It can be caused by dietary deficiency of iron, by acute blood loss, excessive bleeding

during menstruation or infection of the gastrointestinal track. Iron is an important constituent of haemoglobin. Deficiency of iron inhibits the production of red blood cells. The body reacts with a stimulus to the hematopoietic bone marrow to compensate the blood deficiency. Marrow hyperplasia is the cause for bone resorption that manifests in Cribra orbitalia and often accompanying porotic hyperostosis (Cribra cranii) of the skull (Aufderheide and Rodriquez-Martin 1998, Roberts and Manchester 2007, Ortner 2003).
From the 25 individuals affected by Cribra orbitalia eleven show also traces of Cribra cranii, in fourteen individuals the skull vault is not affected. However Schultz (2003) indicates that lesions like Cribra orbitalia and Cribra cranii can also be parts of syndromes originating from inflammatory, haemorrhaging or tumour-related processes, as well as, dietary disorders or genetic causes. The proportion of 9,7% of the adult individuals showing Cribra orbitalia is overall very low. This leads to the conclusion that the nutritional status of the Grevenmacher population was generally good.
Four males all in the age between 20 and 55 years share some noticeable features (ID 38; 915/313; ID 46; 617/155; ID 78; 559/230; ID 82; 935/351). In all four individuals the femora are bent anteriorly, as well as, in medially. In the posterior direction additional bone formation led to a thickening of the Linea aspera. In one individual the sacrum is bent angularly forward (ID 46; 617/155). One disease that leads inter alia to deformity of long bones is rickets and osteomalacia respectively. Rickets is a disease caused by vitamin D deficiency in childhood. Vitamin D is necessary for calcium and phosphorus absorption and the mineralization of osteoid and cartilage. Its deficiency leads to a "softening" of the bones (Ortner 2003, Roberts and Manchester 2007). When this deficiency occurs during the growth phase the weight bearing bones of the legs become bent and deformed. Other effects are kyphosis and lordosis of the spine, metaphyseal flaring of the rib ends or flattening of parietal and occipital bones of the skull (Aufderheide and Rodriquez-Martin 1998). Osteomalacia is the product of vitamin D deficiency in adults. When the period of bone growth has passed, effects of the disease are less dramatic than in rickets. It can lead to osteopenia where deformities are mostly restricted to the trunk skeleton (Aufderheide and Rodriquez-Martin 1998, Ortner 2003). In literature deforming of long bones caused by rickets in childhood is reported also in connection with deformity of long bones with the ending of the growth phase (Ortner 2003). This could be one possible cause for bone deformity in the cases described. However, the diagnosis of healed rickets must be treated with caution. Pitt (1991) states that rickets and osteomalacia describe abnormalities common to more than 50 diseases that vary in cause and clinical picture.

9.5. Congenital changes

Congenital anomalies or malformations are often initiated by pathological changes in normal development during intrauterine life (Aufderheide and Rodriguez-Martin 1998). Causes for congenital abnormalities can be either genetic or intrinsic, they are mostly hereditary and affect the foetus, or causes are environmental or extrinsic and have influence on the mother (Roberts and Manchester 2007). 90% of congenital malformations are genetic disturbances. The degree of severity varies from minimal variants to very severe, sometimes lethal deformities (Aufderheide and Rodriguez-Martin 1998). In the skeletal remains of Grevenmacher most of the congenital changes are diagnosed as malformations of the spine.

Spinal dysraphism

Kumar and Tubbs (2011) define spinal dysraphism as all forms of congenital spinal disorders involving anomalous differentiation and/or incomplete midline closure of mesenchymal, osseous and neural tissue. These disorders are differentiated in open and closed (occult) forms depending on if the nervous tissue and/or meninges are exposed to the environment or protected by skin. An incomplete fusion of the spinal neural arch is visible in vertebrae of five individuals. Three females and two male individual are affected. Two female individuals show an unfused arch of the atlas (arcus posterior atlantis) (ID 2; 324/185; ID 90; 871/329) (fig. 66). In a female individual the arch of a seventh cervical vertebra is not fused completely (ID 211; 259/121a). One male shows non-fusion of the arch of the fifth cervical vertebra (ID 132; 958/349). Another male shows non-fusion of the arch of the fifth lumbar vertebra (ID 86; 236/116).

An incomplete fusion of dorsal vertebral elements can also occur in the Os sacrum. In a male individual (ID 134; 128/54) 20-30 years of age, as well as, in a female individual (ID 52; 330/137) also 20-30 years old, the Processus spinosus of the first sacral vertebra is not fused completely. In both cases it seems that the posterior part of the first sacral vertebra is not fused properly with the caudal parts of the sacrum. In addition parts or even the whole Crista sacralis mediana can stay unfused and sacral nerves can be exposed. For every individual under study the segments that are unfused are evaluated. A total of 14 individuals (eight males and six females) show an incomplete fusion of the Crista sacralis mediana. This means a percentage of 5,6%. Completely unfused is the Crista of a male individual (ID 54; 373/154) (fig. 67). Another individual, also male, shows a possibly complete unfused Crista (ID 72; 913/359). This diagnose is uncertain because some breakage is visible on the margins of the Crista. Most of the individuals show an incomplete fusion in the inferior part of the Crista. Non-fusion from S2 to S5 is visible in one female individual 20-30 years old (ID 140; 356/162). Non-fusion from S3 to S5 is present in eight individuals. Five males (ID 41; 658/272) 50-60 years, (ID 56; 311/199) 30-60 years, (ID 127; 443/87) 30-40 years, (ID 132; 958/349) 40-50 years and (ID 134; 128/54) 20-30 years, as well as, in three females (ID 52; 330/173) 20-30 years, (ID 519; 644/231) 20-30 years and (ID 556; 842/no No.) 30-40 years. The Crista in three Individuals in incompletely fused superiorly and inferiorly (S1 to S2 as well as S3 to S5). This concerns one male over 60 years (ID 115; 135/40), one female 30-50 years (ID 130; 558/229) and one female 40-50 years (ID 201; 1052/383).

fig. 66. Unfused arcus posterior atlantis of a 30-40 years old female individual (ID 2; 324/285)

fig. 67. Unfused crista sacralis mediana of a 30-40 years old male individual (ID 54; 373/154)

Lumbosacral transitional vertebrae

Lumbosacral transitional vertebrae are common congenital anomalies of the spine. In the lumbosacral region two forms of transitional vertebrae are distinguishable. If the fifth lumbar vertebra assimilates with the sacrum a sacralisation of the vertebra occurs. When the first sacral vertebra shows signs of transition to a lumbar vertebra, a lumbarisation occurs. The transition can be complete, incomplete or unilateral. A further feature is the adhesion of the Os coccyges to the sacrum (Bron et al. 2007, Aufderheide and Rodriguez-Martin 1998). In the Grevenmacher sample sacralisation of the fifth lumbar vertebra, as well as, the Os coccygiis can be diagnosed. Both cases occur in eight (3,2%) out of 249 individuals respectively. Three males are affected by sacralisation of the LW5, (ID 36; 434/163) 20-30 years old, (ID 127; 443/87) 30-40 years and (ID 315; no No./K15) 40-50 years, as well as, five females, (ID 15; 313/201) 30-50 years, (ID 55; 117/47) 50-60 years, (ID 138; 539/206) 30-50 years, (ID 140; 356/162) 20-30 years (fig. 68) and (ID 142; 119/38) 30-40 years of age. Sacralisation of the Os coccyges can be diagnosed also in eight individuals (3,2%), six are males (ID 5; 948/312) 35-45 years, (ID 63; 1042/417) over 60 years, (ID 92; 818/307) over 60 years, (ID 123; 134/42) 40-50 years, (ID 143; 377/144) 30-40 years and (ID 203; 1040/427a) 40-50 years of age. Two are females (ID 29; 314/204) 30-40 years and (ID 106; 184/57) 30-40 years of age.

fig. 68. Sacralisation of the LW5 of a 20-30 years old female individual (ID 140; 356/162)

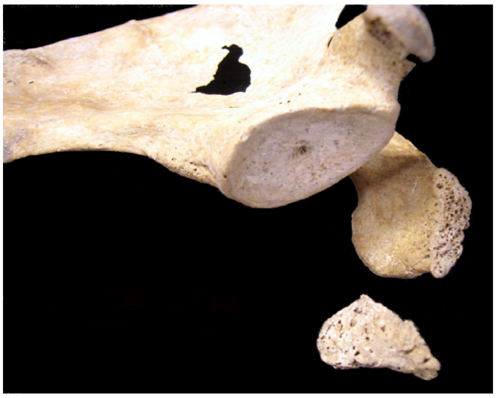


fig. 69. Os acromiale at the right scapula of a 40-50 years old male individual (ID 123; 134/42)

Os acromiale

Os acromiale is the result of a non-fusion of the acromial epiphysis. This results in the retention of a separate epiphyseal end to the acromial process (Hunt and Bullen 2007). The aetiology of Os acromiale has not been fully determined. One hypothesis sees traumatic effects due to activity as the main cause (Stirland 2000). Other authors assume a merely genetic predisposition (Angel et al. 1987). More recent studies favour a combination of both hypothesis (Hunt and Bullen 2007, Case et al. 2006). Frequencies from 4-18% were indicated in literature whereas males are more often affected than females (Case et al. 2006). Data of frequencies of Os acromiale from medieval skeletal remains are rare. Case et al. (2006) report a frequency of 7,7% for a medieval Dane sample, Stirland (2000) who studied skeletal remains of the Tudor war ship Mary Rose found a value of 12,5%. In the case of Grevenmacher a total of ten individuals show non-fusion of the acromial process. Two of these individuals were not considered in the study because of their young age of 20-25 years. Fusion of the acromial epiphysis occurs between the ages of 18-25 years. (Baker et al. 2005, Schaefer et al. 2009). As a result, the non-fusion in these two individuals can also reflect their young age. From the remaining eight individuals seven show Os acromiale on one body side: two on the right side (ID 38; 915/313) 50-60 and (ID 228; 983/386) also 50-60 years of age, five on the left side (ID 57; 172/72) over 60 years, (ID 72; 913/359) 20-30 years, (ID 86; 236/116) 30-40 years, (ID 123; 134/42) 40-50 years (fig. 69) and (ID 215; 945/353a) 40-50 years of age. One individual was affected bilateral (ID 112; 1008/352) 30-40 years old. All of the affected individuals were males. The frequency with regard to the whole adult population is 3,2%, with regard to the male proportion of 129 individuals it is 6,2%.

Spondylolysis

Spondylolysis is a partial or complete separation between the vertebral body and the arch of the vertebra (Ortner 2003). The separation occurs after fracture or dissolution of the Pars interarticularis of the lamina (Ward et al. 2010). An occasional appearance of Spondylolysis in combination with other vertebral malformations such as spina bifida, lumbarisation of the first sacral vertebra or asymmetries of vertebral processes can be observed. Therefore, a congenital malformation of the vertebral arch is assumed as trigger for a separation (Rössler and Rüther 2007). The separation itself is mainly the result of fatigue failure of the neural arch due to heavy long-term cyclical loading (Ward et al. 2010), but also acute injury is a possible cause (Roberts and Manchester 2003). 95% of the defects concern the fifth lumbar vertebra. An affection of the fourth and third lumbar vertebra is rare (Rössler and Rüther 2007). A prevalence rate of 3,0%-6,0% is stated for modern clinical, as well as, archaeological skeletal samples (Ward et al. 2010) but higher rates of over 40% are known in Inuit populations of North America and Canada. Also men are, in general, more affected than women (Merbs 2002, Kalichman et al. 2009). In the Grevenmacher material three males and seven females out of 249 adult individuals, show complete or partial separation of the neural arch of a lumbar vertebra. That means a percentage of 4,0%. Separated for males and females that implies percentages of 2,5% and 5,8% respectively. Eight individuals show a complete separation in the fifth lumbar vertebra. In males (ID 83; 862/323) 40-50 years, (ID 112; 1008/352) 30-40 years (fig. 70) and (ID 115; 135/40) over 60 years of age. In females (ID 90; 871/329) 40-50 years, (ID 98; 996/380) 20-30 years, (ID 100; 294/100) 20-30 years, (ID 107; 1057/413) 20-30 years, and (ID 138; 539/206) 30-50 years of age. In one female the fourth vertebra is affected (ID 119; 410/167) 40-50 years old and in another female a formation of a gap is visible in the right Pars interarticularis (ID 139; 792/285) 30-40 years old. The prevalence rate of 4,0% complies with the rates mentioned above. Striking is the higher value in females than in males. In most of the affected individuals the features mentioned above are only singular events. The more features are detectable in one individual, the higher the probability that these features are symptoms of a serious syndrome. 13 out of 43 individuals (9 males, 4 females) show two of the features discussed above in different combinations. More than two features are not present. However, in one case a male individual, 40-50 years of age (ID 132; 958/349) shows different features from congenital origin. The fourth and fifth cervical vertebrae are fused at the corpus and the right arch, whereas, the fifth vertebra shows an unfused spinous process. The dorsal surface of the sacrum is not completely fused. The first sacral vertebra shows a separation by a cord of connective tissue (fig. 71). This must have happened in the infant phase and lead to an adaptation of the fifth lumbar vertebra, this in turn is responsible for a scoliosis of the spine. To what extend these features are symptoms of a special syndrome cannot be answered for certain. As possible diagnoses Klippel-Feil syndrome or Pterygium-syndrome can be listed (Witkowski et al. 1999).

Another case should be discussed at this point. A female individual, 30-40 years old (ID 139; 792/285) shows a significant reduction in body height. With an average height of 144,5 cm she falls below the third percentile of body height in all of the calculated formulas. In general this is the limit value for retarded growth (Niethard et al. 2009). Reasons for a short stature in an adult are various and even harder to detect in dry bone. In this case retarded growth is proportioned, spondylolysis of the fifth vertebra occurred as well. Therefore metabolic or congenital disorders are the most likely reasons. A chronic disease in childhood or a syndrome cannot be excluded (Niethard et al. 2009, Mayatepek 2007).

fig. 70. Spondylolysis in the LW5 of a 40-50 years old male indvidual (ID 112; 1008/352)

fig. 71. Congenital malformation of the LW5 and the SC1 of a 40-50 years old male individual (ID 132; 958/349)

9.6. *Traumatic injuries*

Trauma in general means any bodily injury or wound (Roberts and Manchester 2007). Ortner (2003) describes four ways the skeleton can be affected: 1) partial or complete break in a bone, 2) an abnormal displacement or dislocation of joints, 3) a disruption in nerve and/or blood supply and 4) an artificially induced abnormal shape or contour of a bone.

Five males and seven females show traces of traumatic injury. That complies a percentage of 5,2% for the population. Three more bone fragments out of the bone accumulations show traumatic injury as well. Unfortunately, it is not possible to assign them to specific individuals.

Traumatic injuries in skeletal remains mostly occur in the form of fractures. A fracture can be defined as either a discontinuity of or a crack in skeletal tissue caused by external forces. Overlaying soft tissue can be involved (Auderheide and Rodriguez-Martin 1998). The type of fracture depends on the strength and the direction of the external force and the mechanical characteristics of the bone e.g. the stability and elasticity (Rössler and Rüther 2007). In the Grevenamcher sample the most affected elements are the upper and lower arm, as well as, the clavicle. A male individual 40-60 years old (ID 369; 381/132) (fig. 72) shows a shearing fracture in the distal part of the right humerus. The fracture is healed in a slight malposition with callus development. The most probable cause is a fall or a blow from the lateral side. The same individual shows a fracture of the first metacarpal of the left body side. This injury is also healed in slight malposition and secondary osteoarthritis on the proximal and distal articular surface is visible. It is possible that the same accident caused both injuries. A 50-60 years old woman (ID 104; 841/302) shows fractures of bones of the lower arm of both body sides. The ulna of the left side was fractured in the distal part of the shaft. It healed without malpositioning and just slight callus formation. The ulna of the right side fractured in the middle of the shaft. It healed in a so called bayonet deformity. The radius of the same side fractured in the same level as the ulna. It is probable that both injuries were the result of the same event. The bone of the radius did not merge anymore but developed a pseudoarthrosis. These injuries show the typical pictures of so called parry fractures. This kind of fracture can happen during the defence against blows with the lower arm or most probable caused by falls on the lower arms. The same kind of fracture can be diagnosed at an ulna out of the bone accumulations (KL21). It belongs most probable to a male individual at least of adult age. Here again a fracture in the distal part of the shaft is visible healed with no malpositioning and slight callus formation. Some unusual injuries could be diagnosed in two individuals. The ulna and radius of the right body side of a woman 30-50 years old (ID 130; 558/229) (fig. 73) show an incomplete fracture (greenstick fracture) of the distal part of both shafts. The distal epiphyses are bended in posterior direction and traces of subperiosteal haematoma are visible. This injury is most probable the result of squashing of the hand and lower arm area in anterior posterior direction probably during adolescence. The same cause can be assumed for an injury visible in the right radius of a 55-65 year old male (ID 4; 309/197). In this case the bone was not fractured but distorted. The fracture of the fifth metacarpal of the right side supports the thesis of an injury caused by squashing of the hand and lower arm area.

fig. 72. Shearing fracture of the right distal humerus of a 40-60 years old male (ID 369; 381/132)

fig. 73. Greenstick fracture of the right ulna and radius of a 30-50 years old female (ID 130; 558/229)

Two males and two females show fractures of the clavicle. In a 50-60 years old male (ID 41, 658/272) the fracture of the right clavicle healed in bayonet deformity in anterior-posterior direction with pronounced callus formation. The left clavicle of a 30-40 years old man (ID 102; 325) healed also in bayonet deformity but in superior-inferior direction also with pronounced callus formation. A 30-40 years old woman (ID 142; 119/38) fractured her left clavicle in the lateral area. This injury did not merge but developed a pseudoarthrosis with pronounced additional bone formation. A severe accident can be assumed for a 50-60 year old women (ID 109; 837/334). She shows a fracture of the left clavicle as well as a fracture of the left os ilium (fig. 74, fig. 75). The clavicle is healed in bayonet deformation in anterior-posterior direction with massive callus formation. The os ilium was fractured in transverse direction in the middle of the Ala ossis ilii. This fracture healed in malformation and with massive formation of cancellous bone anterior and posterior. These injuries were caused most probably by a fall on the left body side most likely from a significant height.

fig. 74. Fracture of the left clavicle of a 50-60 years old female (ID 109; 837/334)

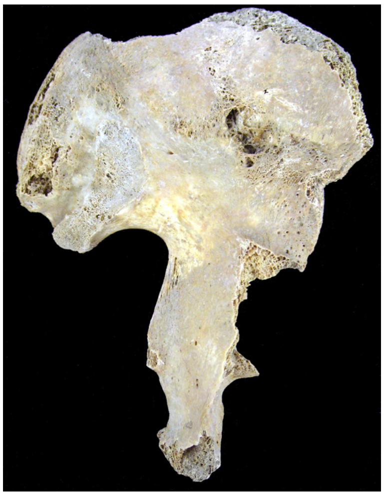


fig. 75. Fractured left Os ilium also found at the 50-60 years old female (ID 109; 837/334)

Three cases of rip fractures are present. One occurs in a 30-40 years old male (ID 3; 322/172), one in a 40-50 years old female (ID 376; 241/111). The third case comes from an adult individual with unknown sex out of the bone accumulations (KL6). This fracture healed in a malposition with massive callus formation.

Fractures of elements of the lower extremities can be diagnosed in three cases. A 30-40 years old female (ID 106, 184/57) (fig. 76) shows a typical fracture of the left femoral neck. The left acetabulum shows an abraded margin, so an impairment of walking can be assumed. A 25-30 years old female (ID 108; 295/92) (fig. 77) shows a fracture of the left femur shaft. The injury caused subperiosteal bleeding and during the healing process a thick callus was developed around the fracture. This callus fixed the shaft in a malposition due to incorrect or failure of repositioning. The femur shaft shows now an angle of 22° in lateral-medial direction. The main cause is most probable a bending fracture incurred by a fall to the left side. A right femur found in a bone accumulation (KL6) shows a fracture in the proximal part of the shaft. Due to its dimensions it belonged most probably to a male individual of at least adult age. The fracture was not repositioned so it healed in bayonet deformity fixed by a thick bulky callus.

fig. 76. Fracture of the left femoral neck of a 30-40 years old female (ID 106; 184/57)

fig. 77. Fracture of the left femur shaft of a 25-30 years old female (ID 108; 295/92)

Another unusual injury can be found at a fragment of a skull. The fragments of the skull-cap were found in a bone accumulation (KL24) and belong most probably to a male individual of 40-50 years of age. The injury is located on the right site of the Os frontale, 5,7 cm above the right orbita (fig. 78). It is diagnosed as perforating blunt trauma. It perforated the tabula externa as well as the diploe and pushed fragments of the tabula interna into the skull. The injury shows vascularisation due to an epidural haematoma. In the inside of the skull the injury healed without traces of further complications. On the outside the perforation into the diploe is still visible. As most probable cause a blow with a pointed weapon like a halberd is assumed. The fact that the injury was not lethal leads to the conclusion that the victim used a helmet to protect his head. The blow perforated the helmet first and caused, therefore, only the moderated perforating injury of the skull. Another skull injury can be diagnosed at a 40-50 year old male (ID 10; 1292/373). On the left frontal bone a cut of 4,9 cm in length most likely from a sharp blade runs at a slightly slant angle downwards. The wound is up to 1 mm wide and intrudes the tabula externa. Around the cut traces, healing is visible.

Altogether the thirteen cases of traumatic injuries referring to a number of 249 evaluated adult individuals result in a low rate of 5,2%. In all cases except two, accidents like falls are the most probable causes. The two head injuries are the only cases that indicate interpersonal violence. All cases show traces of healing so no accident caused an immediate death. However, in some cases the injuries lead to restriction of movement or disability. In particular the fractures of the femora and the bruising of the hand and forearm had a limiting affect on the use of the particular skeletal element.

One special case should be mentioned separately. A male individual 20-30 years of age (ID 94; 228/97) shows an unbalanced growth of shoulder and arm bones (fig. 79). The right bones of the shoulder and arm are shorter and overall smaller as the analogous bones of the left side. The metacarpals of the right hand are distorted, but no signs of trauma like fractures or illness related features like inflammation of bone tissue are observable. The absence of traumatic features leads to the conclusion that the malformation has most likely congenital or birth traumatic reasons. As differential diagnosis poliomyelitis, skeletal dysplasia, skeletal dysostosis, muscular dystrophy, as well as, venous malformations with disproportionate retarded growth was discussed. As most probable diagnosis a brachial plexus palsy was considered. This feature describes an injury of the brachial plexus during parturition caused by strong pull of the arm or head of the foetus. This pull can lead to avulsion of nerve fibres or nerve roots out of the spinal cord. Consequences are an atonic palsy of the affected shoulder, arm and hand with loss of sensibility (Giunta 2010). In the case of the discussed individual this lead to palsy of the affected musculature, disuse atrophy, disturbance of bone growth, muscle contracture and loss of sensibility of the hand during infantile growth.

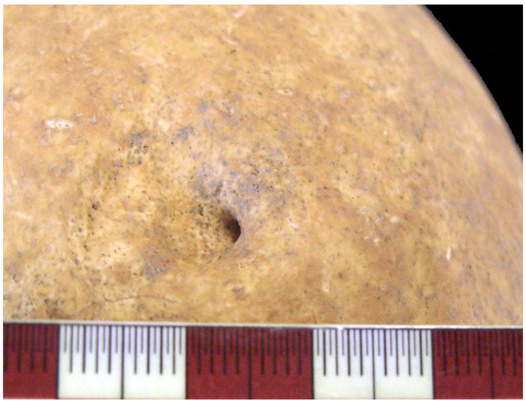


fig. 78. Skull injury of a 40-50 years old male (KL24)

fig. 79. Unbalanced growth in the shoulder and upper extremities of a 20-30 years old male (ID 94; 228/97)

9.7. Calcification of soft tissue

Among the remains of a 40-50 year old male (ID 10; 1292/373) two flat ossified structures with jagged margins were found (fig. 80). They measure 52,8 mm and 47,4 mm in length and 23,9 mm and 22,7 mm in breath. The thickness varies from 1,2 mm to 3,6 mm. They weight 2,2 and 2,5 gram. These two features are most likely referred to as pleural plaques (Baud and Kramar 1990). These kinds of plaques develop during sero-fibrinous inflammation of the pleura (pleurisy) (Koester 1940). Initiated is this kind of pleurisy by diverse causes such as tuberculosis or the inhalation of lung threatening substances like asbestos (Gevenois et al. 1998).

With the remains of a female individual of 30-40 years (ID 142; 119/38), a calcified structure of oval shape came to light (fig. 81). It measures 34,7 mm x 25,7 mm x 19,1 mm and weights 8,7 gram. The object is hollow with crater like depressions and holes that perforate the shell. It resembles an object Komar and Buikstra published in 2003. The authors came to the result that the object in their case is most likely an eggshell pattern calcified lymph node or a calcified ovary. The author cannot follow the diagnosis of Komar and Buikstra (2003) completely because the diagnosis made in the case of the Grevenmacher material is based exclusively on macroscopic examination. To falsify the differential diagnosis further, histological investigations have to be carried out.

fig. 80. Calcified pleural structures found with the remains of a 40-50 years old female (ID 10; 1292/373)

fig. 81. Calcified structure found with the remains of 30-40 years old female (ID 142; 119/38)

9.8. Dental Disease

Dental enamel is the hardest and most chemical stable tissue in the human body. Therefore, teeth are often the only remains that survive taphonomic effects and are available for examination. The kinds of information we can receive from teeth include diet, stress, occupation, oral hygiene as well as cultural behaviour and subsistence economy (Roberts and Manchester 2007). Ortner (2003) points out the many parallels between the diseases that affect both, bone and teeth. Due to the many different pathological features affecting teeth and the bony jaws, it is only possible to examine a few of them in this work. These include the occurrence of dental calculus, dental caries, intravital tooth loss and attrition. As diseases of the jaws periodontal disease and apical periodontal lesions were examined.

Dental plaque and dental calculus

The initial point for the development of different dental diseases is the so called plaque. Plaque covers teeth, as well as, the gingiva in absence of oral hygiene and consists of food debris, micro-organisms like different kinds of bacteria, salivary proteins and bacterial polysaccharide (Caselitz 1998). Different kinds of plaque are found in different parts of the teeth, in particular in fissures and pits, surface of the cusps and sides of the crown, also in the interdental space, in the crevice and the sulcus around the tooth neck (Hillson 2005). In general plaque occurs as transparent film covering teeth and gingiva. Another way plaque can occur is in the mineralized form of dental calculus. First the deepest layers of plaque deposits next to a tooth become mineralized. The mineral originates from the plaque fluid and the saliva which is saturated with calcium phosphate (Hillson 2005). Over time calculus can cover the teeth with a solid crust of grey or brown colour that can reach thickness of several millimetres and is called supragingival calculus (fig. 82). On the other hand subgingival calculus can be seen on exposed tooth roots and green or black in colour (Roberts and Manchester 2007).

In this work recording of dental calculus was carried out in four stages:

0 = tooth is preserved but no calculus is visible

1 = small edge is visible mostly at the crown-neck junction

2 = calculus covers less than 50% of the tooth surface

3 = calculus covers more than 50% of the tooth surface

Every tooth in the upper and lower jaw was examined separately and the results are presented separately for both sexes.

fig. 82. Massive depositions of dental calculus on the teeth of a 25-30 years old female (ID 307; 176/68)

Figures 83 to 86 show the infestation with dental calculus for every tooth in the upper and lower jaw separated for both sexes.

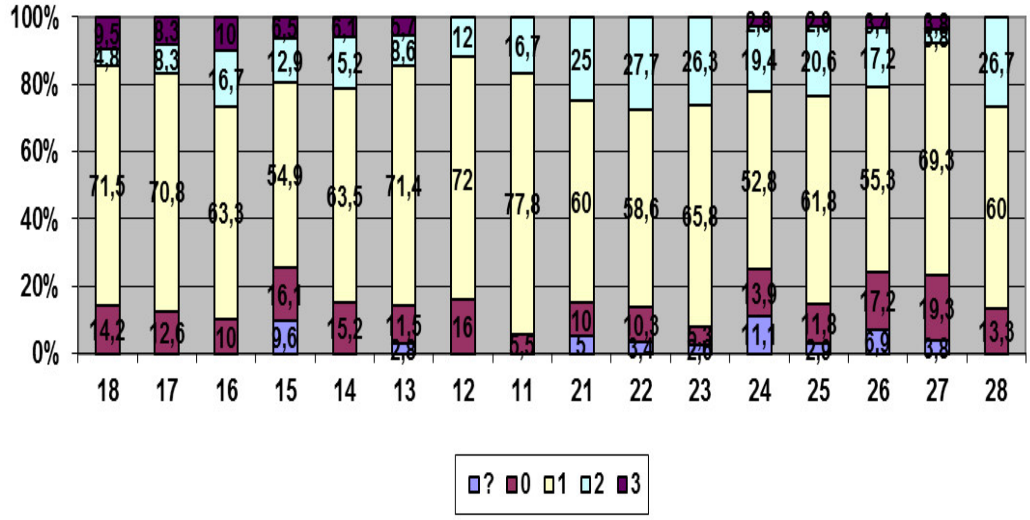


fig. 83. Severity code of dental calculus of males upper jaw

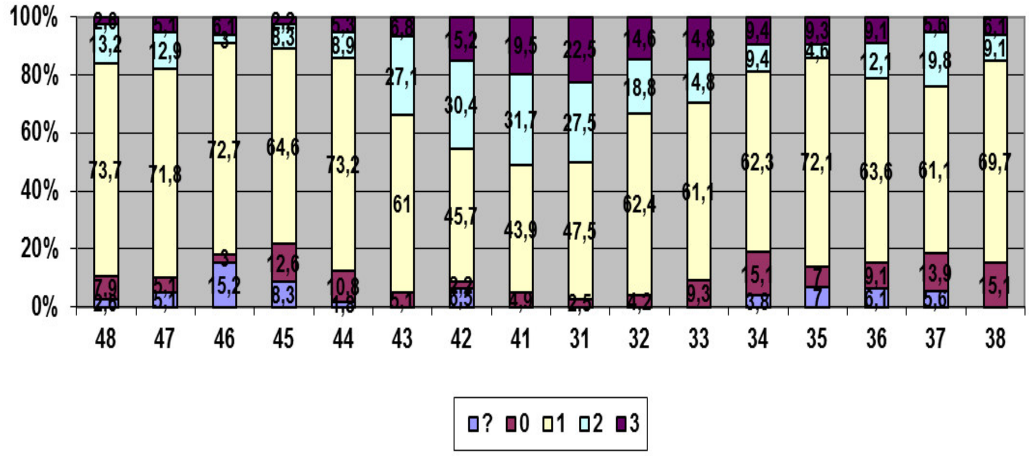


fig. 84. Severity code of dental calculus of males lower jaw

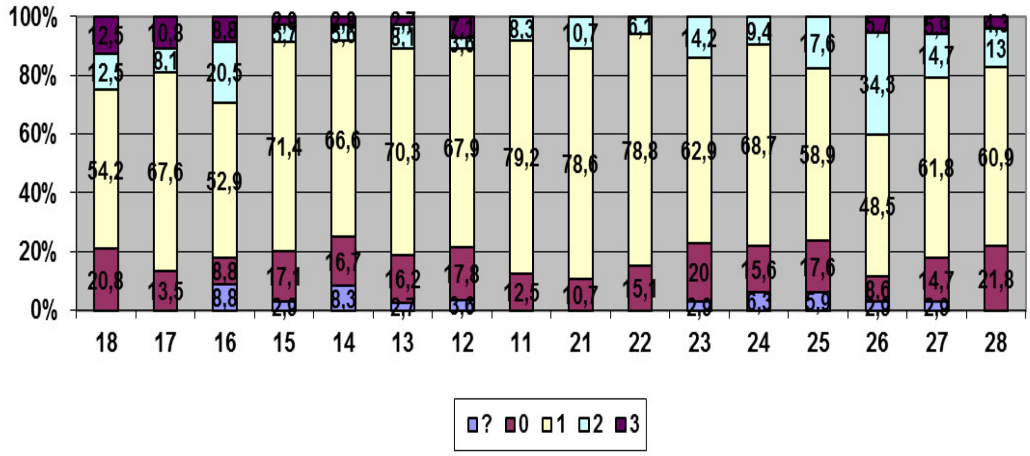


fig. 85. Severity code of dental calculus of females upper jaw

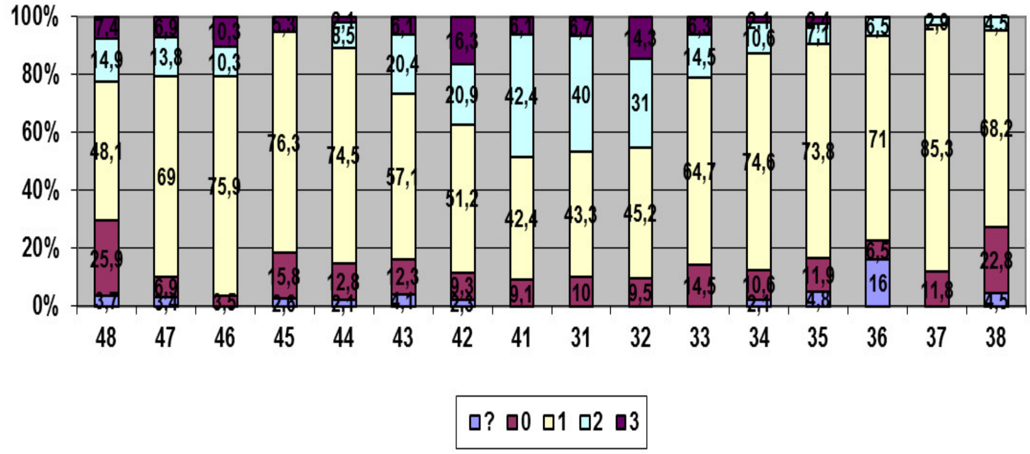


fig. 86. Severity code of dental calculus of females lower jaw

In males 1144 teeth were preserved for examination. 992 (86,7%) showed traces of dental calculus 112 (9,8%) were not affected. In 40 (3,5%) teeth no statement was possible. In females values are similar. From 1100 teeth observed, 920 (83,6%) showed traces of calculus, 148 (13,5%) were not affected. In 32 (2,9%) no statement was possible. Exceptionally high is the amount of individuals with calculus affected teeth. In males 79, individuals had good preservation of their teeth for examination. 76 (96,2%) show calculus in at least one tooth. Similar values are visible in females. Here 77 (97,5%) out of 79 individuals show calculus in at least one tooth. In both sexes the front teeth of the lower jaw are more affected than in the upper jaw. In turn molars of the upper jaw are more affected than in the lower jaw. This phenomenon is described in literature. In general, teeth near the salivary glands at the tongue side of the lower incisors, as well as, the cheek side of the upper molars show increased calculus development. The reason for this is the increased saliva occurrence which is the source of minerals used for developing the calculus (Roberts and Manchester 2007, Hillson 2005). Teeth of male individuals are slightly more affected and to a more severe state than teeth of females, but in general, the distribution pattern is very similar in both sexes.

Dental calculus and age in males and females

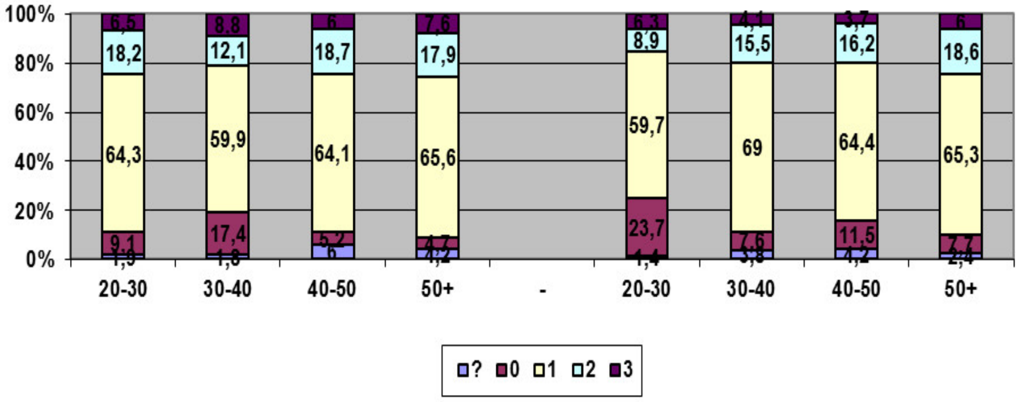


fig. 87. Dental calculus related to age in males (left) and females (right)

Figure 87 shows the distribution of dental calculus over four age categories differenced for both sexes. In total no significant relation between calculus prevalence and age is visible. Values in all severity categories vary around more or less the same level. This conforms to data published by White (1997) who summarized results from different studies. He states that in populations without access to regular professional dental care and those who do not practice regular dental hygiene, supragingival and subgingival calculus formation is found in up to 100% of examined individuals. Furthermore, the formation of calculus starts within the first years after tooth eruption and continues to a maximum at 30 years of age.

Dental Caries

Caries (or tooth decay) is a local disease leading to irreversible and progressive destruction of the hard dental tissue. The initial point of the disease is the dental plaque. Organic acids which are formed during the fermentation of carbohydrates by plaque bacteria lead to demineralisation of dental enamel, dentine and cement. This demineralisation occurs to a large extent underneath the enamel surface. The cavities, the most obvious sign of caries are late manifestation of the disease (Roberts and Manchester 2007, Hillson 2005). The fissures of the tooth crowns, as well as, the cemento-enamel junction of the neck are preferred places of caries formation. Destruction of the dental enamel works progressively through the dentine into the pulp cavity. Destruction of the crown and tooth loss follows (fig. 88). In severe cases an inflammation can occur and spread into the surrounding bone. This often leads to periapical diseases and other, sometimes even deadly complications. Further aetiological factors like genetic predisposition, socio-cultural, as well as, environmental factors and the sort and manner of consumed food

are discussed in literature (Caselitz 1998, Hillson 2001). Different studies emphasize in particular the role of carbohydrates in different diets and their caries promoting effects (Moynihan 1998, Touger-Decker and van Loveren 2003).
In this work caries were recorded for every tooth and differenced for both sexes. The intensity of the lesion was assigned to four stages:
0 = tooth is present but no caries are visible
1 = superficialis: small cavity on the surface only concerning the dental enamel
2 = media: the cavity reaches the dentine
3= profunda: the cavity captures over 2/3 of the dentine layer and extends in direction of the pulpa
Also the direction of the tooth in which the lesion is located was recorded (occlusal, apical, mesial, distal, labial, buccal).

fig. 88. Caries infestation and different rates of attrition on teeth of a 30-40 years old male (ID 8; 940/362)

In the sample of Grevenmacher all 249 identified adult individuals were examined for caries. Teeth were present in 79 out of 129 (61,2%) male individuals as well as in 79 out of 120 (65,8%) female individuals. The caries intensity is given by the number of affected teeth divided by all teeth observed. In Grevenmacher the caries intensity for the whole population is 20,6%. Separated by sex the intensity is 19,9% for males and 21,4% for females. Therefore, women are slightly more affected by caries than men. The term caries frequency describes the number of individuals affected by caries. It is 77,2% for males and 74,7% in females resulting in 75,9% for the whole adult population.

Figures 89 and 90 show the caries intensity for every tooth in the upper and lower jaw separated by sexes

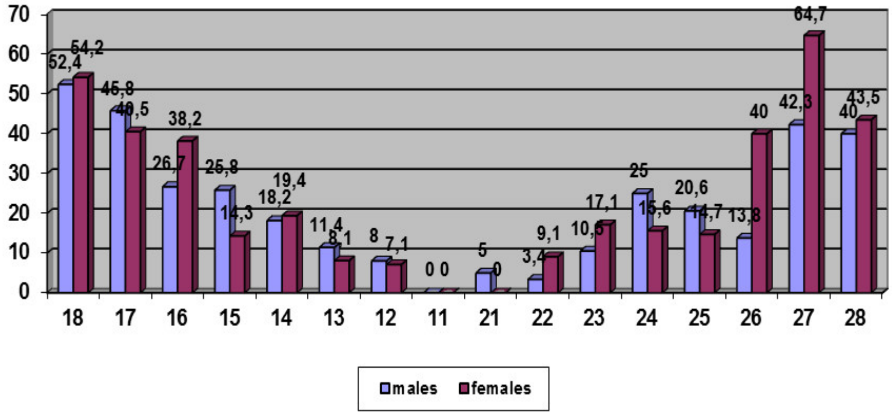


fig. 89. Caries intensity of males and females upper jaw

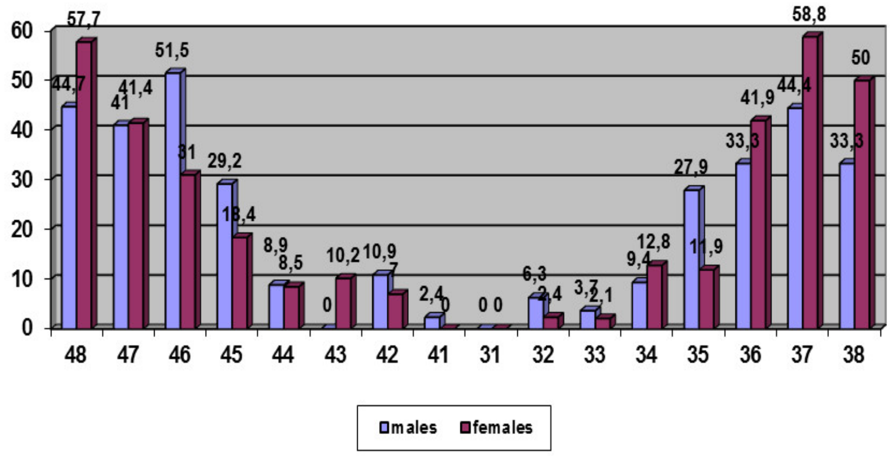


fig. 90. Caries intensity of males and females lower jaw

Both sexes show the highest values in the molars with decreasing prevalence towards the incisors in both jaws. In total teeth of the lower jaw are little more affected than teeth of the upper jaw. Males and females show more or less the same rate of infestation. However, females show significant higher values in the molars of the left side in the upper jaw (26, 27), as well as, in the lower jaw (36, 37, 38). On the right side the third lower molar (48) is also affected to a higher extent. This area seems to be more susceptible to caries in women. Males in contrast show the higher infestation rates in the first lower molar of the left side (46) as well as in the second lower premolars (35, 45).

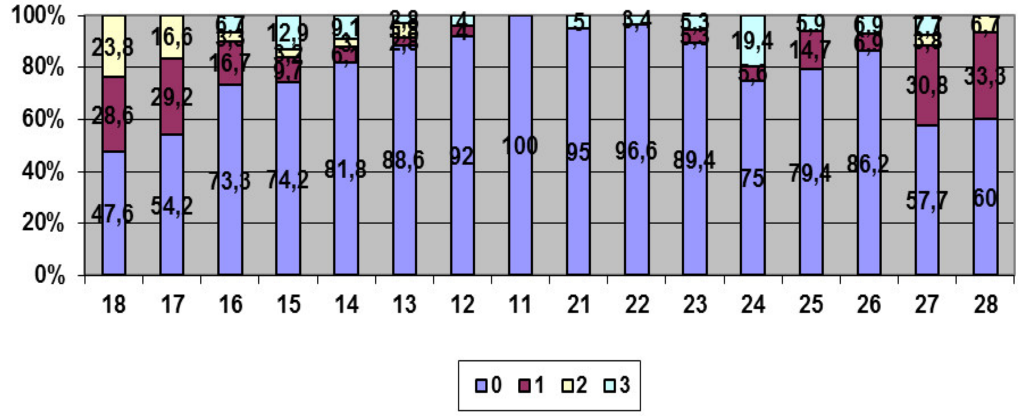


fig. 91. Severity code of caries infestation of males upper jaw

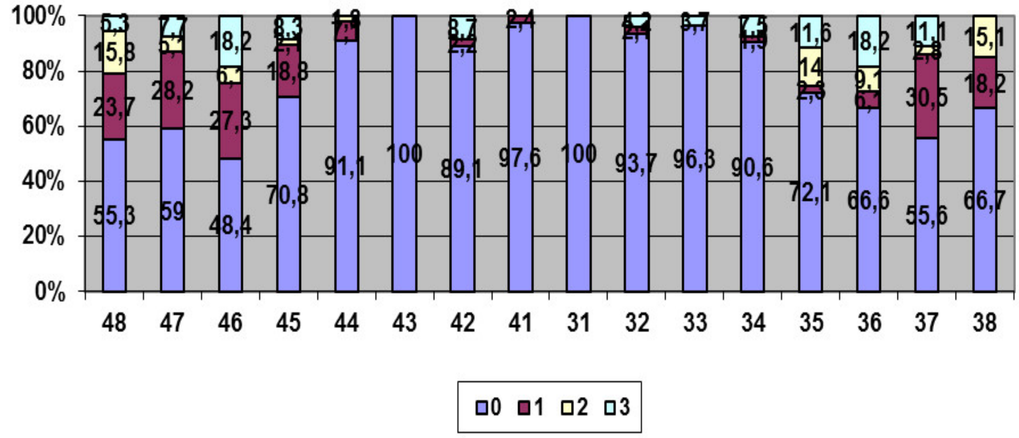


fig. 92. Severity code of caries infestation of males lower jaw

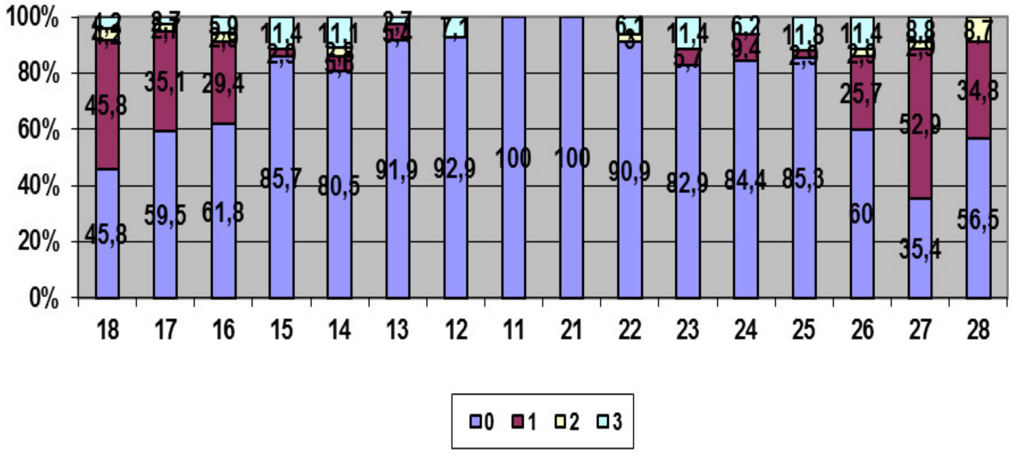


fig. 93. Severity code of caries infestation of females upper jaw

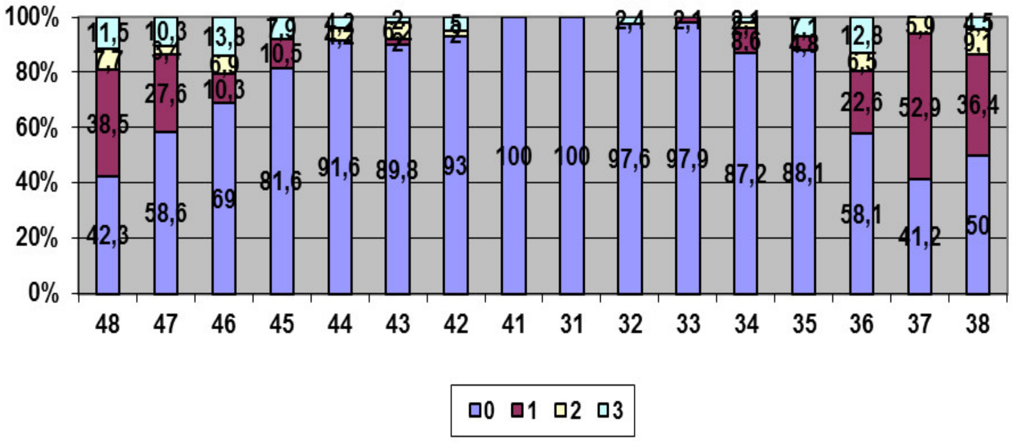


fig. 94. Severity code of caries infestation of females lower jaw

The severity of caries infestation mirrors the prevalence rate of the single teeth shown in figures 91 to 94. In both sexes the most affected teeth are the molars with decreasing values in direction of the anterior region. The molars are also affected to the highest rates 2 and 3.

tab. 64. Caries occurrence and tooth direction

	occlusal	mesial	distal	lingual	buccal
males	51,7%	22,7%	21,7%	1,5%	2,4%
females	65,4%	13,8%	16,5%	1,3%	3,0%

Table 64 shows the preferred direction of caries development in males and females. The preferred occurrence of caries is at the occlusal surface of the teeth, especially in the molars. The second most positions are mesial and distal, that means in the interdental space. This was to be expected because the occlusal fissures, as well as, the interdental space are preferred places were food debris and plaque gets trapped and is not easy to remove. Therefore they are predisposed for caries development. The directions lingual and buccal of the tooth are far lesser affected, because of the smooth surface plaque can not get attached easily but easily removed.

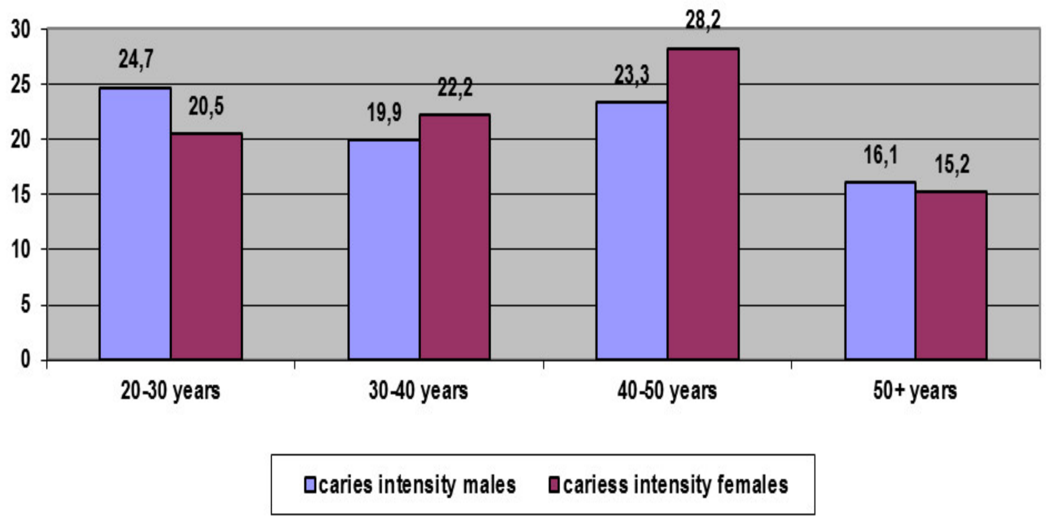


fig. 95. Caries intensity of males and females related to age

Figure 95 shows the caries intensity distributed over four age categories separated by males and females. The caries intensity in males, as well as, in females is on a high rate right from the youngest age category. In males it varies just slightly till its decrease in the oldest age class. In females intensity increases until the category early mature (40-50 years) and then decrease also in the oldest category. The decrease of values in the highest age category can be explained with the higher rate of teeth loss during life. The overall high values of intensity with just little variation between the age categories imply caries infestations from early age. A direct relation between increasing caries infestation and age stated by Hillson (2005) can only be derived in the case of the females in the Grevenmacher sample.

Dental attrition

Dental attrition is strictly speaking not a disease, but rather the result of tooth on tooth contact during mastication and swallowing (Roberts and Manchester 2007). Attrition of the occlusal surfaces destroys the enamel and exposure of the dentine occurs (fig. 88). Continued attrition can finally lead to exposure of the pulp cavity and thereby increase the risk of infection of the pulp and alveolar bone (Ortner 2003). Dental attrition in ancient populations is primarily depending on diet as well as contamination of food with tiny particles of stone due to grinding grain on a stone mortar. Therefore the rate of attrition can be used for the reconstruction of nutrition and food-processing within a population (Roberts and Manchester 2007). Attrition is also an age-related phenomenon, and therefore used for age estimation in skeletal samples (Brothwell 1981). Other types of tooth wear are erosion and abrasion. Erosion is the loss of tooth tissue by chemical processes, whereas, abrasion is wear from contact of teeth with other objects and often the result of cultural activities were teeth were used as tools (Roberts and Manchester 2007).

Dental attrition was recorded in six stages according to Trautmann (2012):
0 = tooth is present but no attrition is visible
1 = "polishing" of the cusps, facets in the enamel
2 = removal of the cusps, single points of dentine are visible
3 = dentine is visible < 50% of the tooth surface
4 = dentine is visible > 50% of the tooth surface, < 50% of the tooth crown is removed
5 = > 50% of the tooth crown is removed

Figures 96 to 99 show the state of attrition for every tooth position in the upper and lower jaw separated by sexes.

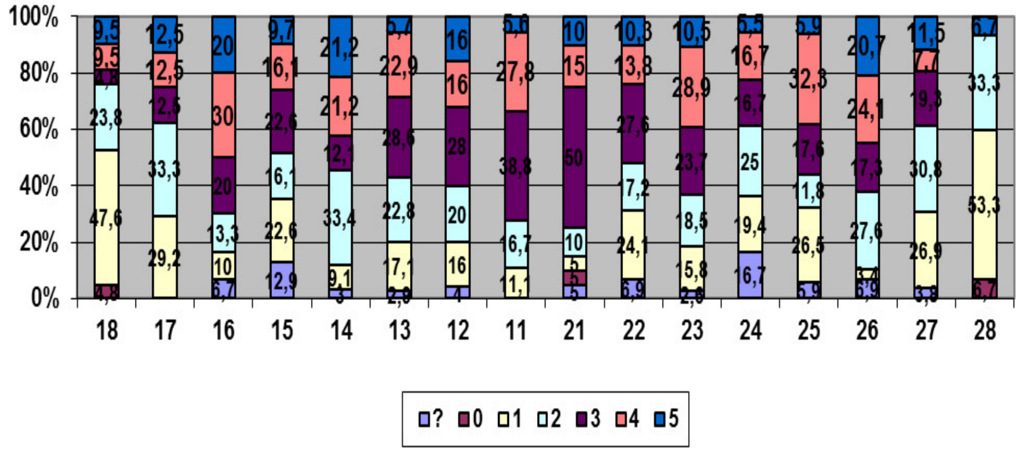


fig. 96. Severity code of attrition of males upper jaw

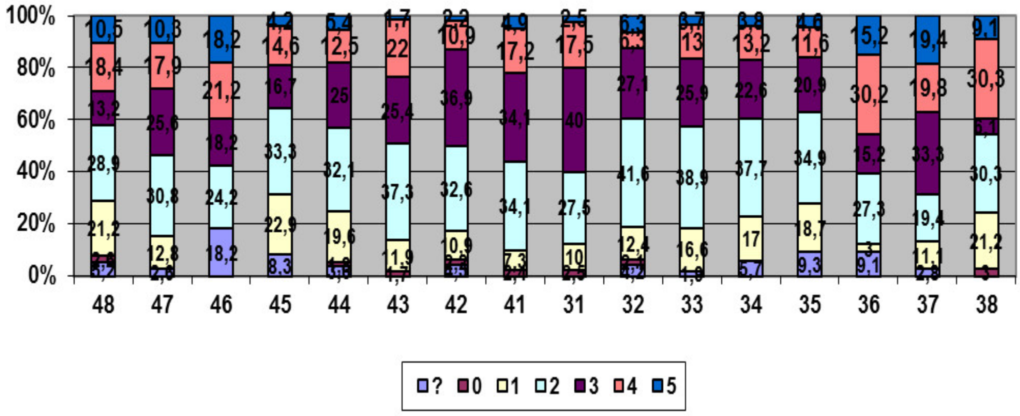


fig. 97. Severity code of attrition of males lower jaw

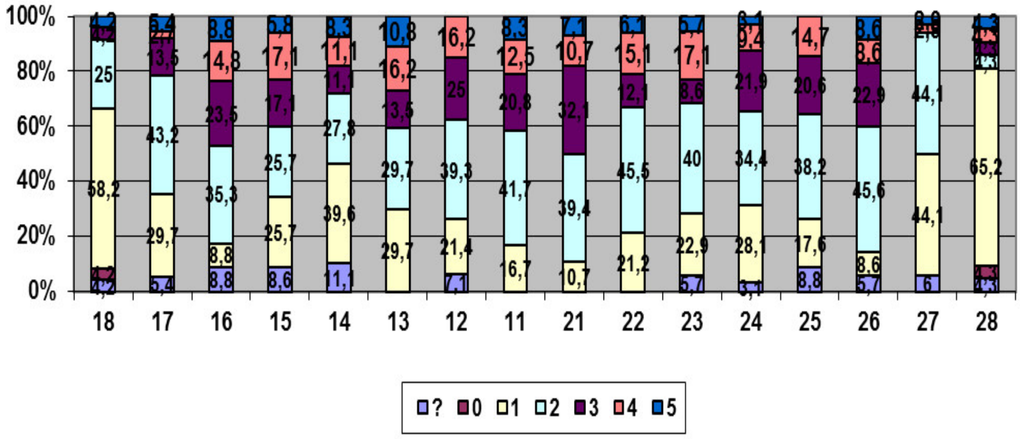


fig. 98. Severity code of attrition of females upper jaw

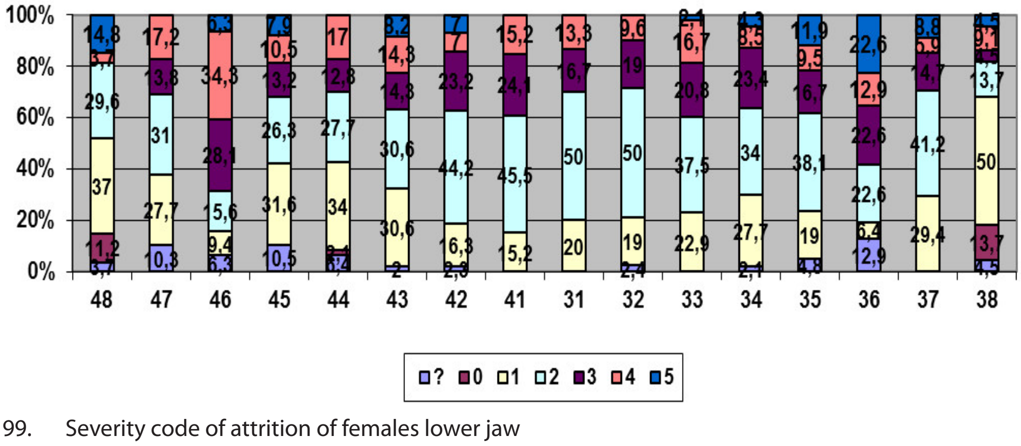


fig. 99. Severity code of attrition of females lower jaw

In males 1144 teeth were preserved for examination. 1071 (93,6%) showed attrition, only 18 teeth (1,6%) were not affected. In 55 (4,8%) teeth no statement was possible.
1100 teeth from females were observed, whereas 1041 (94,6%) showed attrition, only 9 teeth (0,8%) were not affected. In 50 teeth (4,6%) no statement was possible. In males 79 individuals had teeth preserved for examination. 76 (96,2%) show attrition in at least one tooth. 77 (97,5%) out of 79 female individuals show attrition in at least one tooth. In total males and females suffer from attrition to the same extent. However, attrition in males is developed to more severe levels (2,7) than in females (2,3) in the upper, as well as, in the lower jaw. The most affected teeth are the molars, especially the first molar of the upper and lower jaw and the incisors of the upper jaw. No significant difference of attrition is visible between the left and right side.

Dental attrition related to age separated for males and females

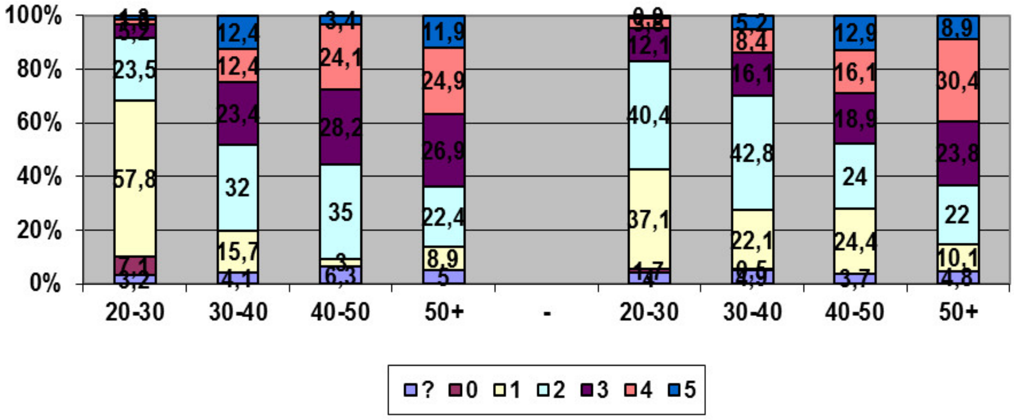


fig. 100. Severity code of dental attrition combined for males (left) and females (right) related to age

Figure 100 shows dental attrition related to four age categories for males and females. In both sexes severity of attrition increases with age, whereas, males show more severe attrition in the younger age classes than females.

Nutritional status of the population from Grevenmacher

The caries rates, as well as, the status of dental attrition can give insights into the nutritional habits of a population. The caries frequency (75,9%), as well as, the intensity (20,6%) is high overall in the Grevenmacher population compared to frequencies of 66,0% for rural and 72,0% for urban populations from medieval Brandenburg published by Jungklaus (2009). Intensities are also lower with 18,0% in both environments. Esclassan et al. (2009) compared caries intensities from different medieval sites from Europe. They state rates from 7,0% to 17,5%. Fluctuations in caries rates between populations strongly depend on the available diet. The same applies for the rate of attrition. In Grevenmacher, the average rate of attrition is 2,7 in males and 2,3 in females and thereby rather moderate. In general high caries rates are associated with diet high in carbohydrates (Moynihan 1998, Touger-Decker and van Loveren 2003) that are found in vegetable food. In medieval rural environments diet was mainly based on grain processed to bread and porridge. Vegetables especially pulses like beans, lentils and pies as well as turnip and cabbage was consumed. Meat, as well as, milk products played just a minor role in medieval diet especially in the lower social classes. Purchasing meat was expensive and fasting rules allowed the consumption of meat at a maximum of 230 days a year (Schubert 2006). This kind of menu fits the results found in the teeth of the Grevenmacher population. The high rate of caries indicate a diet rich in vegetable ingredients which are abrasive and lead to in part massive attrition especially during grinding processes of the molars. However, taking into consideration the relatively low rates in symptoms of malnutrition like Cribra orbitalia or for osteomalacia, the nutritional status of the individuals from Grevenmacher can be considered as overall good.

Ante-mortem tooth loss

The occurrence of ante-mortem tooth loss can occur for various reasons. Caries, periodontal disease or apical abscesses can lead to missing teeth, as well as, traumatic injuries. Ante-mortem tooth loss can be recognised by healing processes around the tooth socket up to a complete closure of the affected socket with new bone (Roberts and Manchester 2007).

In males 1871 tooth sockets from 79 individuals were examined, 356 (19,0%) sockets show traces of ante-mortem tooth loss distributed over 65 (78,5%) individuals. In females 427 (22,7%) out of 1883 tooth sockets show traces of ante-mortem tooth loss. 57 (72,1%) out of 79 individuals are affected in this sample.

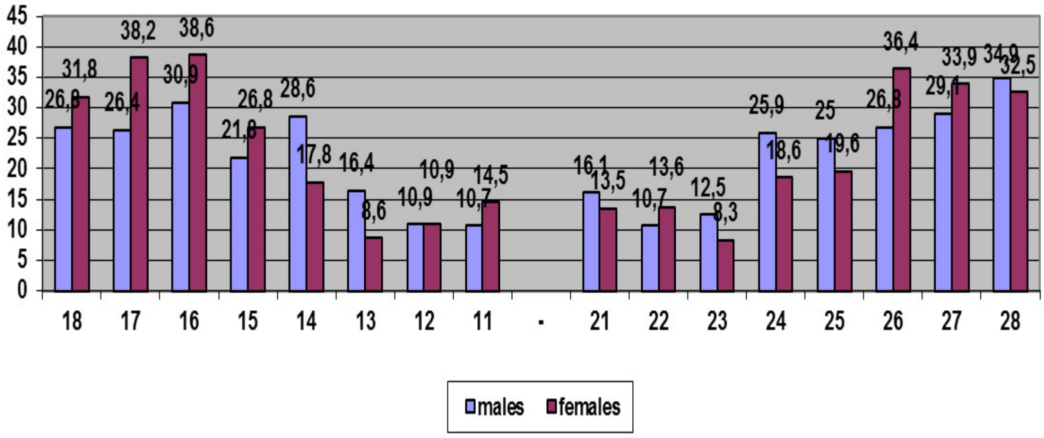


fig. 101. Ante-mortem tooth loss of males and females upper jaw

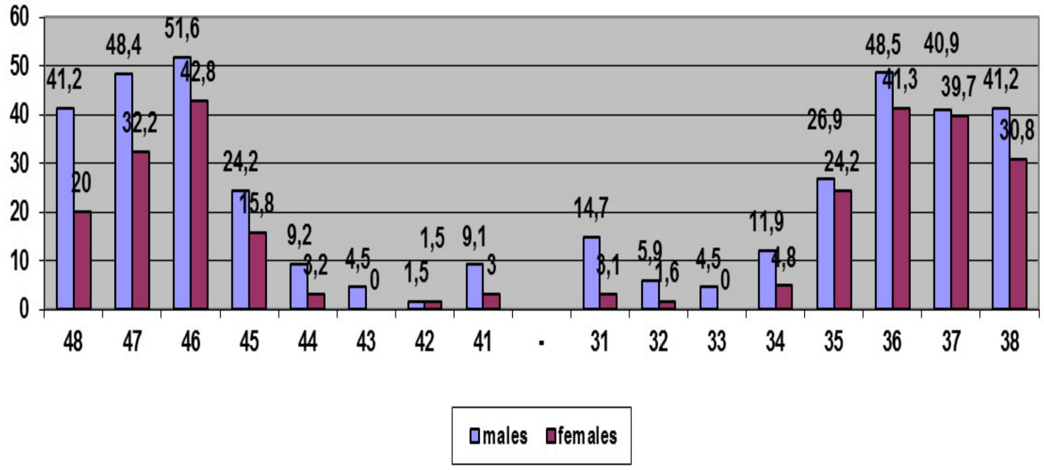


fig. 102. Ante-mortem tooth loss of males and females lower jaw

Molars are lost most often in both sexes with decreasing values in direction to the front teeth. No significant difference is visible in body sides. The same distribution is already visible in the caries infestation where also molars show an increased infection in contrast to the front teeth. Now it can be assumed that caries infestation is a major cause for tooth loss. In males and females the distribution pattern is very heterogenous. In the upper jaw molars (15-18) and (26, 27) are more often missing in females. In contrast in the lower jaw almost all missing teeth show higher values in males.

Ante-mortem tooth loss and age

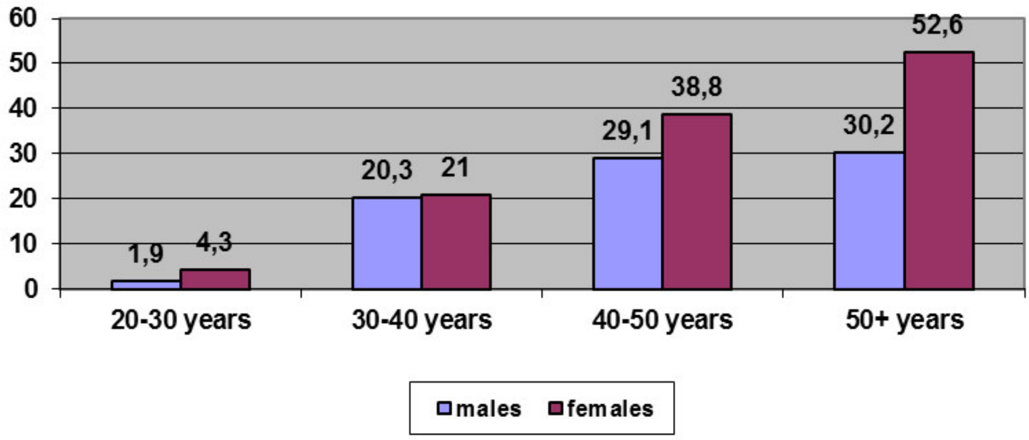


fig. 103. Ante-mortem tooth loss of males and females related to age

Figure 103 shows the distribution of ante-mortem tooth loss over four age categories differenced for males and females. Calculated was the number of lost teeth in relation to all teeth observed. As already indicated in the section about the relation of caries and age, ante-mortem tooth loss is also age related. Striking is a sharp increase from the youngest to the second age class. Both sexes show more or less similar values in the younger categories. From the early mature category on, the females outnumber the males significantly. Caries intensity, caries frequency as well as the intensity in ante-mortem tooth loss are overall higher in females than in males. In females this values are also closely linked to age. Studies by Lukacs (2006, 2011) confirm this kind of sex differences in prehistoric, as well as, in recent populations. As main reasons he states genetic factors, as well as, hormone effects especially during pregnancy and culture or gender-based dietary preferences play a role.

Enamel hypoplasia

Defects in the structure of tooth enamel that are visible in the form of lines, pits or grooves are referred to as enamel hypoplasia (fig. 104). They are defined as deficiencies in enamel matrix composition due to non-specific stress. The aetiology of these defects is various and includes hereditary anomalies, traumatic or toxic causes, as well as, systemic diseases or developmental disturbances. Also infectious diseases or episodes of poor nutrition can be manifest in enamel hypoplasia. (Aufderheide and Rodriguez-Martin 1998, Schultz et al. 1998, Hillson 2005, Roberts and Manchester 2007).

fig. 104. Linear enamel hypoplasia on teeth of a 20-30 years old male (ID 122; 716/276)

In the Grevenmacher material, 18 (13,9%) males as well as 18 (15,0%) females show one or more teeth with traces of linear enamel hypoplasia. This means a percentage of 14,4% of all adult individuals. Figures 104 and 105 show the affected teeth of the upper and lower jaw separated for males and females

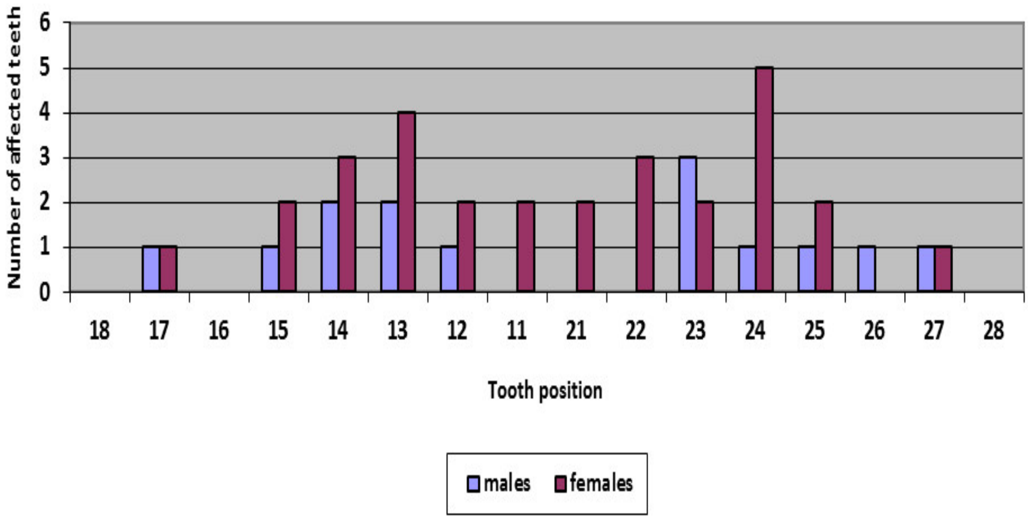


fig. 105. Enamel hypoplasia of males and females upper jaw

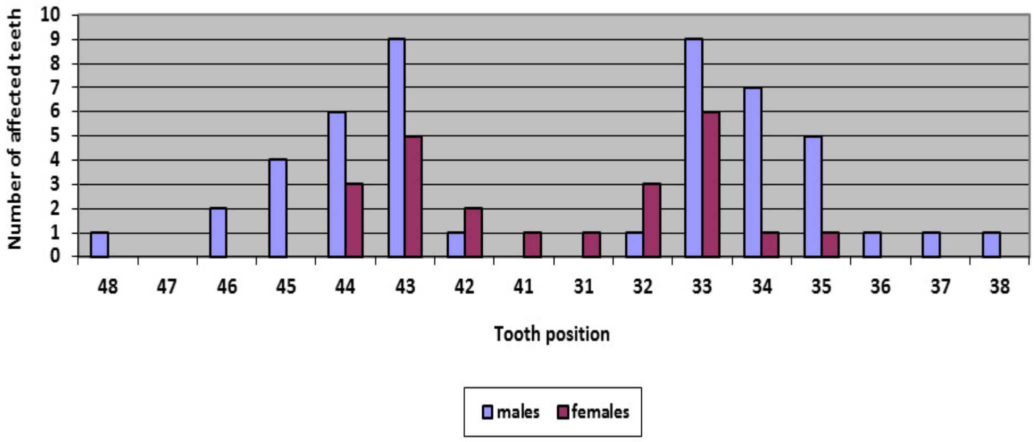


fig. 106. Enamel hypoplasia of males and females lower jaw

In both sexes the same amount of individuals, as well as, almost the same amount of teeth were affected (62 teeth in males, 54 teeth in females). Also the distribution of the affected teeth is very similar in both sexes. However, in males a lot more teeth of the lower jaw (n=48) than of the upper jaw (n=14) are affected. Females show a more balanced distribution of 29 affected teeth in the upper and 25 in the lower jaw. With an adjustment of schemes of tooth development it is possible to reconstruct the year of life in which the enamel defects occurred. The formation times of crown surfaces of the most affected teeth (upper and lower incisors and canines) range from one to six years of age (Hillson 2005). Within this range, the events of stress have affected the respective individuals. Noticeable is an increased occurrence of hypoplasia with the age around three years. It is often assumed that the process of weaning is responsible for an increased stress in children and therefore, promotes the occurrence of enamel hypoplasia around this age (Jungklaus 2009, 2010). However, studies by Palubeckaité et al. (2002), as well as, Boldsen (2007) reveal that dietary habits are not the only reason, in particular when more than one event within the respective time frame can be identified. They assume a general higher vulnerability in the early years of life which is expressed in enamel hypoplasia, as well as, high mortality rates. The same patterns can be identified in the individuals from Grevenmacher. Individuals show an increased occurrence of enamel hypoplasia and the mortality rates are the highest within this time frame in the non-adults.

Periodontal disease

The accumulation of dental plaque between tooth and soft tissue is often the cause of gingivitis, an inflammation of the soft tissue of the gums. Untreated gingivitis can spread to the jaw bone causing a more severe periodontitis (Ortner 2003). The consequences are resorption of alveolar bone including the periodontal ligament leading to a large distance between bone and the cemento-enamel junction of the tooth. In the worst case loss of the tooth occurs (Roberts and Manchester 2007, Ortner 2003).
In this work recording of periodontal disease was carried out according to Trautmann (2012):
0 = no resorption visible
1 = slight resorbtion, < 1/3 of tooth root visible
2 = moderate resorbtion, < 2/3 of tooth root visible
3 = severe resorption, > 2/3 of tooth root visible

From 249 individuals under study 202 jaws, as a whole or in parts were preserved for examination. From 129 male individuals 50 (47,6%) upper and 55 (52,4%) lower jaws were examined. 46 (47,9%) upper and 51 (53,1%) lower jaws originate from 120 female individuals.

Figures 107 and 108 show the severity distribution differenced for the upper and lower jaws for both sexes related to age.

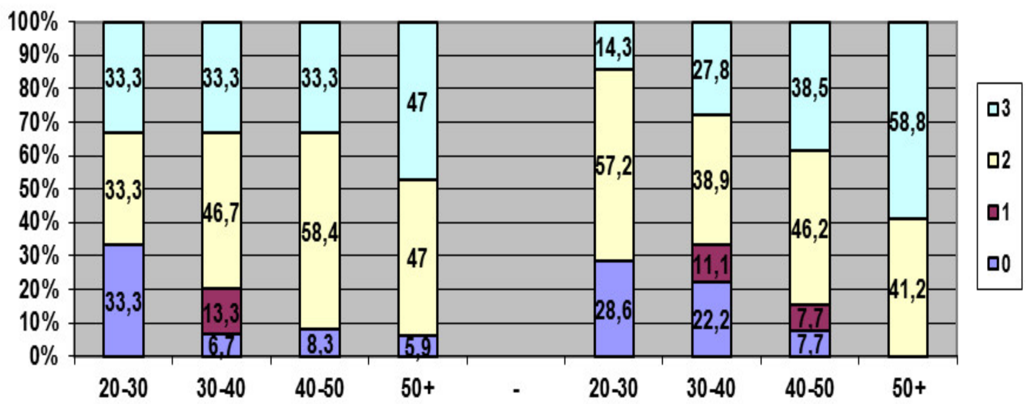


fig. 107. Severity code of periodontal disease of males upper (left) and lower (right) jaw related to age

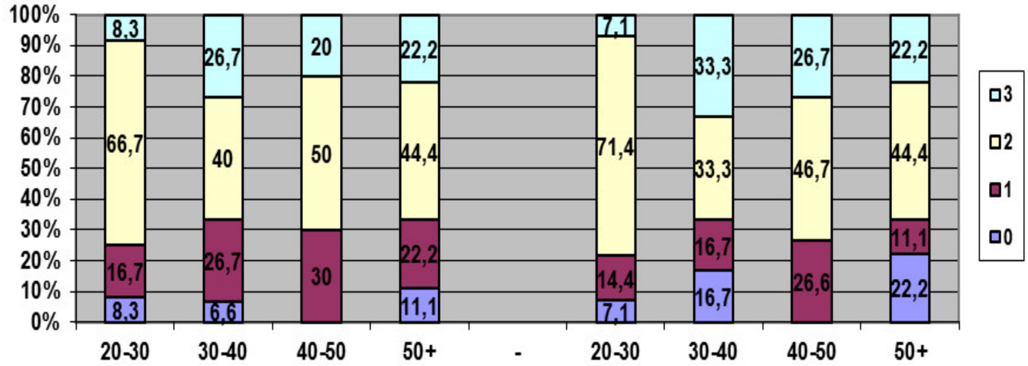


fig. 108. Severity code of periodontal disease of females upper (left) and lower (right) jaw related to age

In males correlation of increasing periodontal disease with increasing age shows a linear course in both jaws. In females the age class early mature (40-50 years) includes the most affected individuals. The most severe cases are found in the age class late adult (30-40 years).

Periapical lesions

Exposure of the pulp cavity by dental caries, attrition or fracturing of a tooth allows microorganisms of the mouth to enter the cavity and cause an inflammation of the pulp (pulpitis). Healing of the pulp is limited due to its narrow connection to the vascular system, so death of the tooth is often the resulting effect. The products of inflammation can emerge from the pulp cavity to the apical foramen and cause inflammatory response in the tissue around the apex of the root (Hillson 2000). As a result of this kind of inflammation, a periapical granuloma emerges. This is a chronic, non-suppurative inflammation with nor or only minor clinical symptoms. The periapical granuloma is surrounded by a capsule of connective tissue infiltrated by different inflammatory cells (Alt et al. 1998). The formation of a granuloma stimulates osteoclastic activity creating a cavity in the bone and resorption of the apex occurs (fig. 109). If epithelial rests that exist within the lesion proliferate and migrate over the surface of the granuloma, an apical cyst develops. This lesion is chronic and progressive and is of greater size than a granuloma. If untreated the cyst and the bone cavity slowly increase in size. This includes resorption of the buccal or lingual bone shelf so the cavity becomes visible on dry bone (Dias et al. 2007; Dias and Tayles 1997). Differentiation between periapical granuloma and apical cyst in dry bone is very difficult. A possible method is differentiation by size of the lesion. Dias and Tayles (1997) specify a size of 2-3 mm in diameter (with allowance made for the portion of the cavity occupied by the root) for periapical granuloma. Anything larger than that is classified as apical cyst. In this work recording of periapical lesions concentrated on periapical granuloma and apical cysts. Other periapical diseases like abscesses, osteomyelits or other odontogenic cysts that are not related to inflammatory processes are rare and in part hard to diagnose (Dias and Tayles 1997).

fig. 109. Periapical lesion in a 50-60 years old male (ID 41; 658/272)

In the Grevenmacher material 74 adult individuals show periapical lesions. This corresponds to a proportion of 28,8%. 47 (36,4%) male and 27 (22,5%) female individuals are affected.

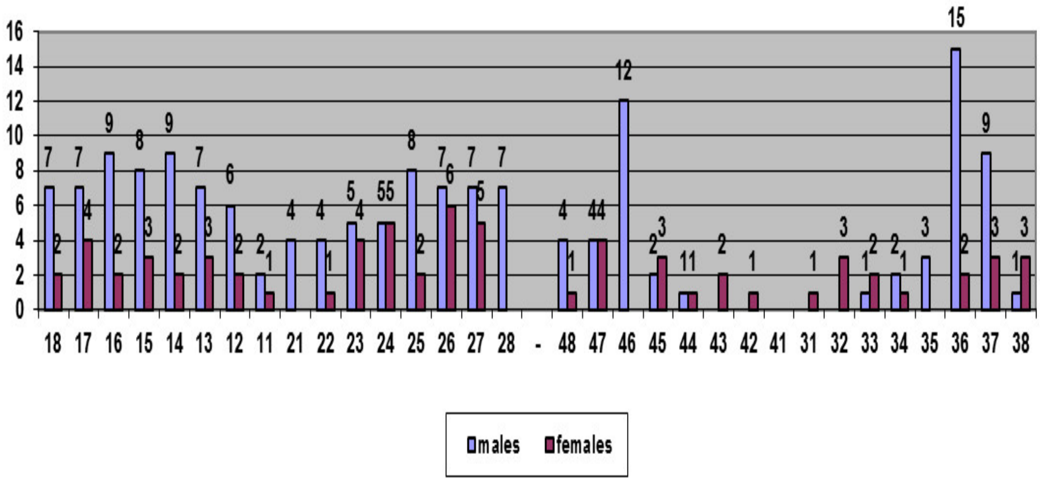


fig. 110. Distribution of periapical lesions for every tooth socket of males and females, differenced in upper and lower jaw

In general, males are more often affected from periapical lesions than females. In the upper jaw both sexes show a more or less similar distribution with a higher impact in the premolars and molars and a lower impact in the front teeth. Caries infestation follows a similar distribution and it can be assumed that there is a connection between the occurrence of caries and the occurrence of periapical lesions. While males are more affected on the right side, females show more lesions on the left side. In the lower jaw no even distribution is visible in both sexes. In females teeth are affected just occasionally. Males show an increasing impact in the premolars and molars, whereas, both first molars are affected to an unusually high extend. As mentioned above the difference between periapical granulomas and radicular cysts is very difficult in dry bone. As boundary value for discrimination a lesion size of 3 mm according to Dias et al. (2007) and Dias and Tayles (1997) was used. In males only nine (5,8%) out of 156 diagnosed lesions are smaller or equal to 3 mm and therefore, assigned to as granuloma. In females this rate is four out of 116 lesions and with 3,4% slightly lower. So the majority of the periapical lesions can be referred to as apical periodontal cysts.

Further tooth anomalies

For the sake of completeness all other anomalies in the dentition diagnosed in the Grevenmacher material should be mentioned in this section.

Several individuals in the Grevenmacher sample show a malposition of one or more teeth. One manifestation is the so called teeth crowding (fig. 111). This feature can occur when there is limited space for the erupting teeth due to disproportion of tooth and jaw size or milk and permanent dentition. It is mostly a congenital feature and as a result teeth grow twisted or shifted. Affected is mostly the front dentition (Reitemeier et. al. 2006). In the Grevenmacher sample it can be diagnosed in four male individuals.

A second manifestation is the rotation of teeth. Five males and six females are affected. The teeth are rotated clockwise or counterclockwise and are positioned obliquely in the jaw. In three cases teeth are rotated by up to 90 degrees.

fig. 111. Crowding of front teeth in the lower jaw of a male over 60 years of age (ID 63; 1042/417)

Dental agenesis describes a congenital lack of teeth. In the majority of cases absence of teeth has genetic causes. Other possible causes are infections, different kinds of trauma or disturbances in jaw innervation. The most absent teeth are the third molars with rates from 9-30% within a population followed by the mandibular second premolars and the maxillary lateral incisors (De Coster at al. 2009). In the Grevenmacher sample 14 adult males and 18 adult females are affected by absence of the third molars. This means a rate of 12,5% of the population. A difference in absence rates is visible in the upper and lower jaw. In males four individuals show a bilateral absence of the upper third molars, in three cases only one tooth is missing. In females three individuals show a bilateral absence of the maxillary third molars, in one individual it is unilateral. Absence rates in the lower jaw are higher. The third molars are missing bilateral in seven males, in one individual unilateral. In females, seven individuals show bilateral missing of the third molars, in four individuals third molars are absent on one side. However, these rates have to be considered with caution. The evaluation was carried out just macroscopically and is not ensured by radiographs. Tooth loss in other positions than the third molars are difficult to connect to dental agenesis especially when the tooth socket is already closed again. In two male Individuals absence of teeth apart from the third molars are probably linked to agenesis. In one male individual (ID 94; 288/97) this concerns the absence of all maxillary incisors (12, 11, 21, 22).

Summary

Overall, the population of Grevenmacher shows a rather low burden of disease, as well as, a low rate of traumatic injuries. On one hand the range of diagnosed disease patterns is diverse and includes infectious and neoplastic disease, as well as, metabolic and congenital changes. On the other hand none of these patterns are spread over-average within the population. The major joints and the spine show overall middle to high degrees of osteoarthritis which indicates excessive physical activity. However, the diverse aetiology, as well as, its strong correlation to age, limits the significance of occupation as a major cause. Traces of malnutrition, as well as, infectious diseases are present, but the rates are also overall low. Therefore it can be assumed that the nutritional status of the population was generally good. The rate of traumatic injuries is also very low and almost all cases can be due to accidental events. Traces of possible interpersonal violence are present in only two cases. The level of dental diseases is slightly higher in the Grevenmacher sample compared to values found in other medieval series. However, they correspond to the overall high rates found in general in medieval populations.

We always have to take into consideration that a great number of diseases can lead to death, but just a small number leaves its traces on the bones. This applies in particular for infectious diseases like pneumonia, diphtheria, meningitis endemica and dysentery. Other diseases like tetanus, typhus, brucellosis, gonorrhoea and tuberculosis were also widespread in all (pre-)historic eras. Especially where hygienic conditions were poor or where humans lived in close proximity to livestock including the intensive use of different animal products (Trautmann 2012, Ruffié and Sournia 2000). Not to mention, the great epidemics in medieval times like plague and leprosy. Therefore, an overall higher burden of disease must be assumed within the population and it is visible in the high rate of death in neonates and infants because these younger individuals are even more susceptible for infectious diseases than adults.

One question that is posed in connection with the rates of disease concerns the existence of a hospital at Grevenmacher. In historical records the establishment of a hospital is mentioned around the year 1265 (Bis-Worch 2010). The existence of a hospital would justify questioning wether patients that died in the hospital were also buried in the cemetery. Among individuals of a hospital an increased rate of ill and old people would be assumed (Vanja 2008). However, the overall low rate of illness related features diagnosed, as well as, only a small number of old people in the cemetery do not indicate burials of hospital patients. However, hospitals often had their own cemeteries (Ohler 1990, Illi 1992). This could also be assumed in the case of Grevenmacher. Unfortunately, neither the location nor the facility of the hospital is known. Therefore, it is not possible to proof the existence of a separate hospital cemetery.

10. The children of Grevenmacher

The human bone material from the cemetery of Grevenmacher includes a lot of well-preserved skeletons of children and adolescents. This fact allows a detailed evaluation of the non-adult remains, which is often not possible in studies of other graveyards due to bad preservation or absence of suitable skeletal material.

10.1. Age and sex distribution

Age and sex distribution of the non-adult individuals was already discussed in detail in chapter 3. For the sake of completeness same basic data should be mentioned again in this chapter.

From 371 individuals that were preserved for further evaluation 114 children and adolescents could be identified. This means a percentage of 30,9%. Figure 112 and table 66 show the age and sex distribution of all 114 individuals. The age distribution follows the classification according to Martin (1975):

tab. 65. Age classes of non-adults according to Martin (1957)

neonatus	infans I	infans II	juvenis
0- < 1 year	1-6 years	7-14 years	15-20 years

fig. 112. Age and sex distribution of non-adults (n=114)

tab. 66. Age and sex distribution of non-adults (n=114)

	neonatus	infans I	infans II	juvenis	total
males	7 (33,3%)	15 (33,3%)	20 (52,6%)	6 (60,0%)	48 (42,1%)
females	3 (14,3%)	14 (31,1%)	5 (13,2%)	3 (30,0%)	25 (21,9%)
indefinite	11 (52,4%)	16 (35,6%)	13 (34,2%)	1 (10,0%)	41 (36,0%)
total	21 (18,4%)	45 (39,5%)	38 (33,3%)	10 (8,8%)	114 (100,0%)

10.2. Measurements and morphology

The measurement sections taken at bones from non-adults correspond mostly to the sections taken at the adult bones. However, some sections were exclusively measured at the bones of the children. This concerns measurement sections of the skull according to Kósa (1978) and of the Os ilium according to Schutkowski (1987). In total 53 measurement sections were taken at the skull. Every tooth crown of the deciduous and permanent teeth were measured in the bucco-lingual, as well as, in mesio-distal direction. 51 measurement sections were taken at the infra-cranial skeleton. A list of the recorded measurement sections and the respective abbreviations is given at the end of the chapter (tab. 90-93).
Due to a better traceability of growth processes in the respective measurements, the above mentioned age categories were divided in ranges of three respectively four years. Range and standard deviation (s) were given for measurements with a minimum of n=3. Due to the uncertain sex determination especially in the younger age categories, a differentiation in males and females was renounced.

Cranial measurements

Tables 67-69 show the 53 measurements of the skull with the respective amount of individuals (n), average values (x), ranges and standard deviation (s) of all age categories.

tab. 67. Measurement sections of the skull of neonate individuals, age 0-1 year

measure	n	x	range	s
M1-M5	0			
W1	8	1,3	0,7-2,1	0,52
W2	1	2,3		
M23-M52	0			
M54	3	14,7	12-19	3,09
M55	3	14,3	13-17	1,18
M60	1	31,0		
M61	1	36,0		
W17	1	7,0		
M65-M79	0			
f.l.	6	66,7	52-76	7,99
f.b.	1	22,0		
t.h.	4	29,0	19-38	7,78
t.b.	0			
o.h.	5	61,6	43-72	10,05
o.b.	3	69,0	55-83	11,43
s.b.	6	10,7	9-12	0,94
p.p.l.	9	33,8	25-41	4,98
p.b.l.	8	13,6	11-16	1,41

In the neonate individuals bones of the skull are not yet fused in a lot of areas. They are also still thin, soft and highly fragile. This is the cause for the very limited measurement sections, as well as, the low amount of individuals where these sections were available.

tab. 68. Measurement sections of the skull for the age categories infans I and infans II

age	1-3				4-6				7-10			
meas.	n	x	range	s	n	x	range	s	n	x	range	s
M1	2	153,0			9	173,4	155-192	10,67	5	170,4	153-192	12,78
M5	0				0				2	85,0		
M8	1	127,0			10	125,7	119-140	8,17	7	125,6	114-137	7,05
M9	3	86,0	82-91	3,74	9	86,4	83-91	2,36	6	89,8	86-93	2,03
M10	3	103,0	100-109	4,24	10	106,5	103-112	3,53	5	106,2	99-110	4,95
M11	1	93,0			5	102,2	99-108	3,37	3	102,7	96-111	6,23
M12	1	101,5			6	103,0	101-107	2,24	3	103,7	101-105	1,88
M13	1	74,0			5	90,8	86-97	4,02	2	91,0		
M17	0				0				2	124,0		
M20	1	104,0			8	108,6	91-124	10,12	4	109,0	104-112	3,08
W1	5	6,3	5,4-7,0	0,61	13	6,9	5,1-8,2	1,03	5	8,0	6,6-9,2	0,91
W2	10	2,3	1,1-3,4	0,76	17	2,6	1,9-3,6	0,46	11	3,3	2,6-4,2	0,51
M23	2	459,5			9	483,8	455-527	22,90	1	487,0		
M24	1	284,0			5	299,0	281-324	14,48	1	287,0		
M25	1	343,0			9	360,3	338-382	13,86	1	361,0		
M26	2	105,5			10	121,9	115-131	5,01	2	128,5		
M27	2	110,0			9	129,8	116-142	8,90	1	123,0		
M28	1	109,0			10	107,6	101-115	4,80	1	115,0		
M29	2	88,0			10	102,4	97-109	3,53	2	112,0		
M30	2	106,0			9	115,7	106-125	8,03	1	110,0		
M31	1	87,0			10	89,2	84-96	3,84	1	93,0		
M38	1	1130,0			7	1208,8	1086-1419	97,98	3	1139,3	1070-1220	61,76
M40	0				0				1	86,0		
M42	0				0				1	91,0		
M43	2	82,0			5	86,4	84-90	2,33	4	88,0	86-91	2,12
M44	1	77,0			4	82,0	79-85	2,55	1	86,0		
M45	1	87,0			3	93,7	90-96	2,62	2	104,5		
M47	1	74,0			3	84,3	81-88	2,87	2	95,0		
M48	1	44,0			4	50,0	45-55	3,53	2	56,5		
M50	2	17,5			7	19,4	17-22	1,40	4	18,0	15-19	1,73
M51	1	32,0			5	31,6	30-33	1,20	2	34,5		
M52	1	28,0			6	31,0	27-34	2,31	3	31,3	30-33	1,25
M54	3	16,3	15-17	0,94	9	18,2	17-20	0,92	5	20,6	20-21	0,49
M55	1	32,0			6	37,0	32-41	3,26	3	40,7	39-43	1,70

(tab. 68. continued)

age	1-3				4-6				7-10			
meas.	n	x	range	s	n	x	range	s	n	x	range	s
M60	1	32,0			6	37,2	34-45	3,62	6	42,7	38-47	2,81
M61	3	46,7	44-48	1,88	7	48,6	37-52	4,98	6	55,7	53-59	2,13
W17	5	11,6	11-13	0,80	10	13,8	11-15	1,40	6	14,5	12-16	1,26
M65	3	83,0	79-88	3,74	6	95,2	83-101	5,78	6	100,5	93-105	3,82
M66	4	62,7	60-67	2,68	10	68,3	58-77	5,81	6	77,3	71-83	3,90
M68	5	43,6	42-46	1,62	10	52,7	43-62	4,50	6	59,3	53-65	4,11
M69	4	20,0	17-21	1,73	6	22,5	22-24	0,76	7	23,1	21-27	1,88
M70	5	31,8	30-34	1,32	10	37,8	34-43	2,60	6	43,8	39-47	3,13
M71	4	21,5	20-24	1,66	10	25,6	22-28	1,85	7	27,0	24-30	1,93
M79	5	138,8	133-124	3,19	10	129,4	113-140	8,92	6	127,5	120-139	6,37
f.l.	3	109,0	105-115	4,32	9	100,6	75-116	11,58	5	106,6	99-118	6,74
f.b.	0				4	71,7	64-77	5,21	0			
t.h.	4	41,7	34-48	5,02	9	48,1	39-57	6,10	4	49,2	45-53	3,03
t.b.	0				3	50,3	38-57	8,73	0			
o.h.	4	100,0	88-111	10,12	9	88,3	69-105	9,28	6	89,7	86-93	3,04
o.b.	0				6	99,0	94-102	2,45	3	105,3	102-109	2,87
s.b.	3	15,0	14-16	0,82	10	16,2	15-19	1,47	2	17,5		
p.p.l.	7	37,6	31-43	4,27	15	41,9	33-47	3,59	7	42,6	36-46	3,29
p.b.l.	4	17,2	17-18	0,43	9	19,0	15-22	2,21	6	20,0	18-22	1,29

tab. 69. Measurement sections of the skull for the age categories infans II, and juvenile

age	11-14				15-17				18-20			
meas.	n	x	range	s	n	x	range	s	n	x	range	s
M1	2	176,5			2	177,5			3	184,3	177-193	6,60
M5	2	91,5			2	89,0			3	99,0	94-107	5,71
M8	3	136,7	129-141	5,43	2	133,5			4	138,0	133-145	4,58
M9	2	93,0			1	91,0			3	96,0	93-100	2,94
M10	2	105,0			1	107,0			4	108,7	93-119	9,65
M11	1	118,0			2	118,5			4	125,7	115-134	7,69
M12	3	105,3	104-107	1,25	2	106,5			4	116,7	111-122	5,26
M13	1	117,0			2	104,5			3	101,0	99-104	2,16
M17	1	122,0			2	130,0			2	125,5		
M20	2	111,0			1	110,0			4	105,2	104-110	3,70
W1	3	8,2	7,2-9,5	0,96	2	9,9			3	11,0	9,4-12,7	1,35
W2	5	3,4	2,4-4,4	0,70	4	4,5	3,9-5,2	0,50	3	4,5	4,0-5,1	0,46
M23	2	502,5			2	503,5			3	520,3	502-545	17,35
M24	1	295,0			2	297,5			3	291,3	287-307	11,95
M25	2	320,0			2	375,5			2	370,5		
M26	3	122,3	111-130	8,18	2	125,5			3	124,7	116-132	6,60
M27	4	125,2	116-141	9,52	2	133,0			4	129,0	122-134	4,36
M28	3	114,0	102-134	14,24	2	115,5			3	114,0	106-127	9,27
M29	3	105,3	99-110	4,64	2	108,5			3	107,3	107-115	6,13
M30	4	111,0	104-120	6,40	2	117,5			4	112,5	104-120	5,72
M31	2	86,0			2	94,5			3	95,0	90-105	7,07
M38	2	1286,5			2	1288,5			3	1292,7	1157-1437	114,47
M40	1	92,0			1	76,0			3	97,0	91-103	4,90
M42	1	90,0			1	86,0			3	104,3	96-111	6,23
M43	2	93,0			1	93,0			4	98,2	91-104	4,66
M44	1	91,0			1	87,0			3	94,0	92-97	2,16
M45	1	106,0			1	109,0			3	117,7	115-122	3,09
M47	1	106,0			1	89,0			3	106,0	102-111	3,74
M48	1	68,0			1	52,0			3	65,3	62-69	2,87
M50	3	18,3	17-20	1,25	2	19,5			4	21,5	20-23	1,12
M51	1	37,0			1	33,0			3	38,0	37-39	0,82
M52	1	34,0			1	29,0			3	33,7	32-35	1,25
M54	2	21,0			1	21,0			3	22,3	21-23	0,94
M55	2	46,0			1	41,0			3	47,7	46-49	1,25

(tab. 69. continued)

age	11-14				15-17				18-20			
meas.	n	x	range	s	n	x	range	s	n	x	range	s
M60	2	31,5			1	44,0			4	50,0	48-52	2,00
M61	3	56,0	53-61	3,56	1	63,0			3	61,3	60-64	1,88
W17	2	15,0			3	18,0	17-19	0,82	4	18,2	15-20	2,05
M65	1	114,0			1	111,0			4	117,0	111-122	3,94
M66	3	80,0	85-70	7,07	2	96,0			4	89,7	80-95	5,76
M68	4	60,0	57-66	3,53	2	73,5			4	72,0	64-82	7,03
M69	3	28,0	26-32	2,83	1	25,0			4	27,5	26-28	0,87
M70	3	51,3	44-58	5,73	2	63,0			4	53,7	51-57	2,77
M71	4	28,5	27-30	1,12	3	30,7	30-31	0,47	4	31,0	25-39	5,24
M79	4	124,2	119-130	4,44	2	121,0			4	128,5	119-136	6,18
f.l.	2	94,5										
f.b.	1	72,0										
t.h.	3	49,7	41-60	7,84								
t.b.	1	52,0										
o.h.	2	85,0										
o.b.	3	105,7	104-107	1,25								
s.b.	2	20,5										
p.p.l.	3	44,3	43-46	1,25								
p.b.l.	2	23,0										

All of the measurements sections show an increasing values from the younger to the older age classes. Negative variations between the age classes are mostly due to a low number of individuals.

Measurements of the teeth

Measurements of the teeth include the bucco-lingual, as well as, the mesio-distal diameter of the crown in the deciduous, as well as, in the permanent dentition. Results are shown in tables 70 and 71 with the respective amount of individuals (n), average values (x), ranges and standard of deviation (s) of all age categories. In this case no differentiation was made between age categories because when a tooth is erupted no further growth occurs. Measurements of the deciduous teeth were used for sex determination according to Black (1978). Measurements of permanent teeth can also be used for sex determination when comparative measurements from adult individuals are available. This method is useful in mixed dentitions.

tab. 70. Measurement sections of deciduous teeth of the upper and lower jaw

position	n	x	range	s	position	n	x	range	s
55bl	30	9,6	7,8-10,4	0,58	85bl	31	8,7	7,6-9,5	0,43
55md	30	8,5	7,3-9,4	0,49	85md	31	9,6	8,6-10,5	0,45
54bl	27	8,4	7,1-9,3	0,54	84bl	28	6,8	6,0-7,9	0,43
54md	27	6,8	5,7-7,7	0,46	84md	27	7,7	6,9-8,7	0,45
53bl	16	5,9	5,0-6,8	0,53	83bl	15	5,5	5,0-6,7	0,44
53md	16	6,5	5,5-7,2	0,54	83md	15	5,6	4,8-6,6	0,44
52bl	5	5,2	4,7-5,9	0,4	82bl	10	4,1	3,2-4,6	0,37
52md	5	5,7	5,5-5,9	0,15	82md	10	4,5	3,6-4,9	0,34
51bl	8	5,1	4,8-5,6	0,24	81bl	8	3,9	3,1-5,6	0,73
51md	8	6,8	6,4-7,1	0,24	81md	8	3,9	3,0-5,0	0,55
61bl	7	5,2	4,9-6,2	0,43	71bl	6	3,6	2,8-4,3	0,51
61md	7	6,7	6,5-7,3	0,26	71md	6	3,9	3,0-4,4	0,44
62bl	9	4,8	3,9-5,2	0,35	72bl	11	4,1	3,2-4,7	0,37
62md	9	5,1	4,8-5,5	0,32	72md	11	4,4	3,5-5,2	0,41
63bl	14	6,1	5,4-8,2	0,71	73bl	17	5,4	5,0-5,9	0,28
63md	14	6,7	5,7-7,1	0,32	73md	18	5,8	4,9-6,7	0,43
64bl	27	8,4	4,8-9,7	1,0	74bl	29	7,1	5,4-8,0	0,62
64md	26	6,9	5,7-8,6	0,57	74md	29	7,8	6,6-9,2	0,53
65bl	29	9,7	9,0-10,6	0,52	75bl	31	8,7	7,6-9,8	0,43
65md	29	8,5	7,4-9,3	0,45	75md	29	9,7	8,2-10,5	0,46

(bl= bucco-lingual; md= mesio-distal)

tab. 71. Measurement sections of permanent teeth of the upper and lower jaw

position	n	x	range	s	position	n	x	range	s
17bl	0				47bl	1	9,6		
17md	0				47md	1	10,1		
16bl	17	10,8	9,8-12,4	0,67	46bl	19	10,1	8,7-11,3	0,63
16md	17	10,0	8,9-11,4	0,69	46md	19	10,5	9,1-11,6	0,65
15bl	1	8,6			45bl	0			
15md	1	6,3			45md	0			
14bl	0				44bl	2	7,8		
14md	0				44md	2	7,0		
13bl	2	8,4			43bl	0			
13md	2	7,7			43md	1	6,1		
12bl	3	5,7	5,6-6,2	0,38	42bl	7	6,1	5,5-6,8	0,51
12md	3	6,3	5,8-6,9	0,45	42md	7	6,0	5,2-6,2	0,38
11bl	7	6,9	6,5-7,5	0,32	41bl	8	6,1	5,1-8,7	1,1
11md	7	8,5	8,0-9,4	0,43	41md	8	5,4	4,7-6,0	0,43
21bl	4	7,1	6,6-8,1	0,58	31bl	8	5,9	5,3-6,7	0,45
21md	5	8,4	8,0-9,3	0,47	31md	9	5,3	4,8-6,0	0,44
22bl	3	5,7	5,4-6,1	0,31	32bl	7	6,1	5,6-7,0	0,43
22md	3	6,6	5,8-7,4	0,65	32md	7	5,9	5,3-6,4	0,38
23bl	2	8,1			33bl	1	5,2		
23md	2	7,7			33md	2	5,9		
24bl	1	8,3			34bl	1	6,5		
24md	1	6,3			34md	1	7,8		
25bl	1	8,4			35bl	1	8,6		
25md	1	6,3			35md	1	9,4		
26bl	16	11,0	9,6-12,4	0,75	36bl	16	9,9	8,8-11,2	0,67
26md	16	9,8	8,8-10,8	0,51	36md	16	10,7	9,5-11,6	0,71
27bl	0				37bl	2	9,8		
27md	0				37md	2	10,0		

(bl= bucco-lingual; md= mesio-distal)

Indices of the skull

tab. 72. Indices of the skull of non-adults

age	1-3				4-6				7-10			
Index	n	x	range	s	n	x	range	s	n	x	range	s
length-width	3	80,0	67,0-95,1	11,57	8	73,0	64,6-83,7		5	73,7	59,4-85,0	8,56
length-height	0				0				2	73,1		
width-height	0				0				2	100,0		
length-earhei.	2	56,9			7	64,6	57,7-68,7	4,32	4	62,5	58,3-66,1	2,78
width-earhei.	2	78,2			6	90,8	76,9-105,3	11,67	4	88,8	82,5-98,2	5,91
jugofrontal	1	114,9			3	112,9	110,5-116,7	2,73	1	100,0		
jugomandib.	1	72,4			3	72,5	66,7-75,8	4,11	2	72,7		
face	1	85,0			3	90,2	85,3-97,8	5,45	2	90,9		
upper face	1	50,6			3	55,3	52,1-61,1	4,13	2	54,0		
orbital	1	87,5			4	83,0	54,5-96,8	16,69	2	88,6		
nasal	1	53,5			6	49,3	45,0-53,1	2,88	3	50,9	48,8-52,5	1,54

age	11-14		15-16		18-20			
Index	n	x	n	x	n	x	range	s
length-width	2	76,1	2	75,3	3	75,7	75,1-76,3	0,50
length-height	1	67,0	2	73,4	2	67,8		
width-height	1	87,1	2	97,3	2	89,6		
length-earhei.	2	62,8	2	62,6	3	57,3	56,5-68,5	0,85
width-earhei.	2	82,4	2	83,1	4	76,3	74,1-78,2	1,51
jugofrontal	1	100,0	1	98,2	3	96,8	95,6-97,5	0,87
jugomandib.	1	66,0	0		3	79,1	77,9-80,0	0,87
face	1	100,0	1	81,6	3	90,1	88,7-91,0	0,99
upper face	1	64,1	1	47,7	3	55,5	53,9-56,6	1,16
orbital	1	108,0	1	87,9	3	88,6	84,2-91,9	3,24
nasal	1	50,0	1	51,2	3	46,9	42,8-50,0	3,02

tab. 73. Direct comparison of the indices of the cranium of non-adults and adults

age	1-3		4-6		7-10		11-14		15-17		18-20		adult ♂		adult ♀	
Index	n	x	n	x	n	x	n	x	n	x	n	x	n	x	n	x
length-width	3	80,0	8	73,0	5	73,7	2	76,1	2	75,3	3	75,7	54	75,5	52	75,4
length-height	0		0		2	73,1	1	67,0	2	73,4	2	67,8	43	70,6	30	70,9
width-height	0		0		2	100,0	1	87,1	2	97,3	2	89,6	41	93,3	30	93,6
length-earhei.	2	56,9	7	64,6	4	62,5	2	62,8	2	62,6	3	57,3	60	61,1	55	61,2
width-earhei.	2	78,2	6	90,8	4	88,8	2	82,4	2	83,1	4	76,3	54	81,0	52	81,9
jugofrontal	1	114,9	3	112,9	1	100,0	1	100,0	1	98,2	3	96,8	37	92,3	29	94,6
jugomandib.	1	72,4	3	72,5	2	72,7	1	66,0	0		3	79,1	29	78,2	24	76,1
face	1	85,0	3	90,2	2	90,9	1	100,0	1	81,6	3	90,1	28	91,8	21	95,5
upper face	1	50,6	3	55,3	2	54,0	1	64,1	1	47,7	3	55,5	33	53,5	27	55,4
orbital	1	87,5	4	83,0	2	88,6	1	108,0	1	87,9	3	88,6	42	85,5	35	86,4
nasal	1	53,5	6	49,3	3	50,9	1	50,0	1	51,2	3	46,9	39	47,3	31	48,6

The non-adults already show the morphological features of the adults. The deviations between children and adults are not significant except for the jugofrontal index. Infants in the youngest age class show a very high value, which is not surprising because young individuals show wider foreheads in relation to the width of the face. In the next categories this relation is already more balanced.

Measurements of the upper limbs, shoulder and pelvis

Tables 74-76 show the 25 measurements of the upper limbs, shoulder and pelvis with the respective amount of individuals (n), average values (x), ranges and standard deviation (s) for the right (ri) and left (le) body side for all age categories.

tab. 74. Measurement sections of the infra-cranium of the neonate individuals, age 0-1 year

age	0-1			
measure	n	x	range	s
Hu1 ri	7	72,3	65-101	12,84
le	7	73,4	64-99	11,66
Hu5 ri	6	6,7	5-10	1,72
le	6	7,0	5-11	2,04
Hu7 ri	2	28,0	25-31	3,00
le	2	28,0	26-30	2,00
Ra1 ri	6	56,5	51-68	6,42
le	6	60,2	52-80	9,46
Ra4 ri	5	4,6	4-7	1,29
le	5	4,4	4-5	0,50
Ra5 ri	5	4,2	3-7	1,64
le	5	4,0	3-5	1,00
Ul1 ri	5	62,0	59-68	3,42
le	1	68,0		
Ul11 ri	4	4,2	4-5	0,47
le	2	5,0	4-6	0,0
Ul12 ri	4	3,0	0	0,0
le	2	4,0	0	0,0
Cl1 ri	6	46,7	44-54	3,87
le	5	45,0	43-48	1,80
Cl4 ri	6	3,3	3-4	0,49
le	5	3,4	3-4	0,50
Cl5 ri	6	4,3	3-6	1,02
le	4	3,4	3-5	0,87
Ilium l. ri	5	38,6	36-43	2,74
le	7	38,7	32-48	5,94
Ilium b. ri	6	36,7	32-54	7,29
le	7	36,3	32-44	4,80
Gsn. d. ri	5	3,7	2,2-6,0	1,36
le	7	3,7	2,5-4,5	0,69
Gsn. w. ri	5	11,4	8-19	4,18
le	7	11,0	9-13	1,51

tab. 75. Measurement sections of the upper limbs, shoulder, spine and pelvis for the age categories infans I and infans II

age	1-3				4-6				7-10			
measure	n	x	range	s	n	x	range	s	n	x	range	s
Hu1 ri	4	118,0	106-126	7,65	11	149,7	125-172	13,38	8	191,1	159-208	15,06
le	4	118,5	107-129	8,08	10	155,1	135-169	10,64	5	186,0	159-207	16,22
Hu4 ri	2	26,0			7	33,3	30-37	2,43	6	40,5	35-46	3,40
le	2	26,5			6	33,2	30-36	2,41	5	39,6	35-45	3,32
Hu5 ri	4	10,3	10-11	0,43	12	12,4	10-15	1,84	9	14,2	11-16	1,55
le	4	9,7	9-11	0,83	11	12,2	10-15	1,53	6	13,3	12-14	0,74
Hu6 ri	4	8,0			13	10,1	8-13	1,38	8	11,7	10-13	1,10
le	4	8,3	8-9	0,43	12	10,1	8-12	1,25	6	11,0	10-13	1,15
Hu7 ri	4	31,0	29-33	1,58	10	36,6	30-42	3,83	9	42,1	36-46	3,18
le	4	30,5	28-34	2,29	11	36,6	32-42	3,65	7	41,8	39-45	2,10
Hu9 ri	0				1	24,0			1	29,0		
le	0				1	24,0			1	25,0		
HuW28 ri	1	2,9			2	1,7			3	2,7	2,3-3,2	0,37
le	0				0				3	3,1	2,5-4,2	0,78
Ra1 ri	2	84,0			9	115,9	101-135	12,10	8	142,0	121-161	11,3
le	5	88,2	76-99	8,47	7	113,7	104-127	7,85	4	131,0	121-137	6,16
Ra3 ri	2	12,5			6	17,5	17-19	1,12	7	19,6	17-22	1,59
le	2	14,5			8	17,0	14-19	1,50	3	19,7	16-23	2,87
Ra4 ri	1	6,0			7	8,3	7-9	0,88	3	10,7	10-11	0,47
le	4	7,0	6-8	0,71	7	8,1	7-9	0,83	2	9,5		
Ra5 ri	1	5,0			7	6,7	6-8	0,70	3	7,7	7-8	0,47
le	4	5,8	5-7	0,83	7	6,6	6-9	1,05	2	7,5		
Ra5(6) ri	3	13,7			6	17,3	15,1-19,0	1,23	3	19,9	18,1-21,8	1,51
le	0				7	16,7	14,5-18,7	1,47	2	20,3		
RaW33 ri	1	1,2			0				1	1,6		
le	0				1	2,0			2	2,0		
Ul1 ri	3	95,3	89-99	4,50	7	127,4	115-145	11,11	8	160,1	134-175	12,21
le	3	90,7	76-108	13,20	9	124,0	102-143	12,30	8	151,7	133-171	13,18
Ul11 ri	2	7,0			8	8,0	7-9	0,71	6	11,2	11-12	0,37
le	3	6,3	6-7	0,47	8	7,8	6-9	0,97	3	10,3	9-11	0,94
Ul12 ri	2	5,5			8	6,8	6-8	0,66	6	8,5	7-10	1,12
le	3	5,0			8	7,0	6-9	1,00	3	7,7	7-8	0,47
Cl1 ri	6	58,8	42-66	7,82	11	79,6	68-89	6,12	6	93,3	86-98	3,90
le	2	60,5			10	79,7	66-92	8,60	5	92,2	89-98	3,65

(tab. 75. continued)

age	1-3				4-6				7-10			
measure	n	x	range	s	n	x	range	s	n	x	range	s
Cl4 ri	4	3,7	3-4	0,43	9	4,7	4-6	0,67	3	6,3	6-7	0,47
le	3	4,7	4-6	0,92	7	5,0	4-6	0,75	5	6,2	6-7	0,40
Cl5 ri	4	6,2	5-7	0,83	9	6,8	5-8	0,92	3	8,3	7-10	1,25
le	3	6,3	6-7	0,47	6	7,0	6-8	0,82	5	7,8	6-9	1,17
Cl6 ri	1	17,0			6	20,7	18-23	1,79	2	25,5		
le	1	17,0			4	21,0	19-22	1,22	4	23,0	21-26	1,87
SaW24 ri	0				1	26,0			1	19,0		
le	0				1	24,0			1	19,0		
Ilium l. ri	5	59,8	52-68	5,38	11	79,3	68-89	5,83	5	96,0	80-105	8,65
le	2	61,0			10	79,0	72-86	4,19	6	95,3	79-105	8,38
Ilium b. ri	4	53,5	48-61	5,13	8	73,1	66-90	7,11	4	86,0	75-90	6,44
le	3	55,0	49-60	4,54	11	71,5	58-84	6,47	5	88,0	76-97	7,61
Gsn. d. ri	5	4,6	3,6-5,5	0,75	11	7,3	4,5-8,8	1,39	7	9,9	8,5-11,9	1,22
le	6	4,6	4,1-5,6	0,64	12	7,4	5,2-9,2	1,24	6	9,4	7,3-11,6	1,33
Gsn. w. ri	5	14,6	11-18	2,42	10	20,4	16-26	2,90	7	25,7	22-29	2,25
le	6	14,8	12-17	2,03	11	19,8	16-23	2,04	6	24,0	21-27	2,31

tab. 76. Measurement sections of the upper limbs, shoulder, spine and pelvis for the age categories infans II and juvenis

age	11-14				15-17		18-20			
measure	n	x	range	s	n	x	n	x	range	s
Hu1 ri	5	232,4	215-249	13,12	1	334,0	4	298,5	276-131	14,22
le	6	230,8	204-255	19,52	1	288,0	3	291,3	270-307	15,62
Hu4 ri	7	42,1	34-46	3,76	1	66,0	4	57,0	51-65	5,24
le	5	43,0	40-46	2,00	1	57,0	3	58,0	53-64	4,54
Hu5 ri	6	15,8	14-19	1,67	2	19,5	4	18,2	16-22	2,28
le	9	16,5	14-22	2,45	2	20,0	4	17,2	16-20	1,64
Hu6 ri	6	13,2	11-15	1,34	2	17,0	4	14,5	14-16	0,87
le	7	12,6	11-15	1,50	2	16,5	4	14,7	14-15	0,43
Hu7 ri	6	47,2	42-56	4,49	2	58,0	4	54,7	51-59	3,03
le	9	48,5	41-63	6,52	2	55,5	4	54,0	50-59	3,24
Hu9 ri	2	30,5			1	47,0	4	39,0	34-45	4,30
le	2	32,5			2	38,0	3	39,0	35-46	4,97
HuW28 ri	2	2,7			0		1	2,6		
le	2	3,0			1	4,6	0			
Ra1 ri	5	184,0	158-216	21,62	1	268,0	4	214,5	204-224	7,40
le	6	184,8	152-213	22,03	1	221,0	3	210,3	201-220	7,76
Ra3 ri	5	21,6	19-24	2,24	0		3	24,7	23-27	1,70
le	5	21,6	19-25	2,15	1	28,0	4	25,2	23-29	2,49
Ra4 ri	4	11,5	10-14	1,50	2	15,0	3	13,3	12-15	1,25
le	5	10,4	9-12	1,02	1	14,0	3	12,7	12-13	0,47
Ra5 ri	5	10,4	7-12	2,15	2	14,0	4	10,0	9-11	1,00
le	5	9,2	7-11	1,33	1	12,0	4	10,2	9-12	1,30
Ra5(6) ri	6	22,7	19,0-27,3	2,89	2	28,4	3	26,5	23,0-29,7	2,75
le	4	22,4	18,8-23,7	2,71	0		4	25,4	23,0-28,8	2,19
RaW33 ri	2	2,7			2	3,1	0			
le	2	2,2			1	3,9	0			
Ul1 ri	4	202,0	172-244	28,50	1	291,0	4	231,2	228-243	6,83
le	7	196,6	170-241	24,21	0		3	233,3	222-251	12,66
Ul11 ri	4	12,0	10-14	1,58	1	16,0	4	13,2	12-15	1,09
le	6	10,7	9-12	1,10	1	15,0	4	12,7	12-14	0,83
Ul12 ri	4	10,2	8-12	1,78	1	15,0	4	11,5	10-13	1,12
le	6	8,8	7-10	1,07	1	20,0	4	11,0	10-13	1,22
Cl1 ri	5	101,6	94-111	6,65	1	125,0	3	123,7	118-128	4,19
le	5	110,6	100-116	5,92	3	119,0	4	127,0	119-132	4,85

(tab. 76. continued)

age	11-14				15-17		18-20			
measure	n	x	range	s	n	x	n	x	range	s
Cl4 ri	3	6,7	6-7	0,47	1	7,0	3	8,0	7-9	0,82
le	5	8,2	7-9	0,98	2	9,5	4	8,7	7-10	1,09
Cl5 ri	3	8,3	8-9	0,47	1	11,0	3	9,7	9-10	0,47
le	5	9,2	8-10	0,75	2	10,0	4	10,2	7-12	2,05
Cl6 ri	3	26,0	25-27	0,82	1	28,0	3	30,0	26-35	3,74
le	5	27,2	25-20	1,72	2	32,0	4	33,0	28-37	3,39
SaW24 ri	4	34,7	33-37	1,48	1	36,0	4	35,0	21-40	8,09
le	4	35,7	32-39	2,86	1	35,0	4	38,5	36-42	2,29
Ilium l. ri	5	110,6	104-126	8,48	2	134,5				
le	3	113,7	103-126	9,46	0					
Ilium b. ri	5	105,4	92-121	10,85	2	122,5				
le	5	105,4	91-121	11,29	0					
Gsn. d. ri	6	12,9	10,0-15,1	1,87	1	13,5				
le	7	13,2	9,0-20,0	3,25	0					
Gsn. w. ri	6	31,2	25-35	3,80	1	28,0				
le	7	30,1	27-34	2,36	0					

Measurements of the lower limbs

Tables 77-79 show the 26 measurements of the lower limbs with the respective amount of individuals (n), average values (x), ranges and standard deviation (s) for the right (ri) and left (le) body side for all age categories.

tab. 77. Measurement sections of the lower limbs of the neonate individuals, age 0-1 year

age	**0-1**			
measure	n	x	range	s
Fe1 ri	8	79,6	75-89	5,17
le	8	92,6	75-128	18,06
Fe6 ri	7	10,0	5-10	1,79
le	7	7,6	5-10	1,82
Fe7 ri	10	7,7	6-11	1,75
le	7	8,3	6-11	1,74
Fe8 ri	7	27,0	20-36	4,95
le	4	31,3	26-35	3,27
Fe9 ri	9	10,0	8-13	1,66
le	6	11,3	8-14	1,88
Fe10 ri	9	8,7	7-12	1,76
le	6	9,5	7-11	1,26
Fe19 ri	0			
le	0			
Fe21 ri	0			
le	0			
FeW43 ri	7	1,8	1,0-2,5	0,50
le	6	2,0	1,3-2,4	0,43
FeW44 ri	0			
le	0			
Ti1 ri	8	73,1	66-92	8,82
le	10	72,6	65-92	8,39
Ti8 ri	9	7,3	5-10	1,65
le	10	7,5	5-10	1,63
Ti8a ri	8	8,6	7-11	1,46
le	9	8,9	7-12	1,61
Ti9 ri	9	6,3	5-9	1,41
le	10	6,6	5-9	1,33
Ti9a ri	8	7,8	6-10	1,36
le	9	8,0	6-11	1,45

(tab. 77. continued)

age	**0-1**			
measure	n	x	range	s
Ti10 ri	8	23,5	19-27	4,01
le	9	24,1	18-31	3,87
Ti10a ri	7	26,3	21-34	4,41
le	8	26,5	20-34	4,12
Ti10b ri	2	26,5	22-31	4,50
le	2	27,0	22-32	5,00
Fi1 ri	1	60,0		
le	1	61,0		

tab. 78. Measurement sections of the lower limb for the age categories infans I and infans II

age	1-3				4-6				7-10			
measure	n	x	range	s	n	x	range	s	n	x	range	s
Fe1 ri	5	143,6	123-157	17,96	10	207,9	169-230	20,54	7	255,4	218-286	19,81
le	6	151,8	122-185	25,07	7	201,6	174-234	21,28	5	256,8	216-290	24,28
Fe6 ri	6	11,0	10-13	1,15	11	14,0	12-16	1,28	8	17,1	15-19	1,16
le	7	11,3	10-14	1,38	12	13,5	12-16	1,44	9	16,0	14-18	1,41
Fe7 ri	6	11,0	10-12	0,82	11	13,6	12-15	0,77	8	16,4	15-18	1,22
le	7	11,0	10-12	0,76	12	13,2	10-15	1,28	9	16,2	14-19	1,47
Fe8 ri	6	38,2	34-43	3,18	11	44,8	42-48	2,59	8	53,0	48-59	3,32
le	6	38,2	36-43	2,41	12	44,2	41-49	3,51	9	52,8	48-57	3,36
Fe9 ri	6	15,0	13-18	1,63	11	16,9	16-19	0,99	9	21,1	17-25	2,47
le	6	14,2	12-18	1,95	11	16,8	15-20	2,08	10	20,8	18-24	2,13
Fe10 ri	6	12,0	10-14	1,53	11	14,5	12-17	1,23	9	16,9	15-19	1,10
le	6	12,0	10-14	1,53	11	14,4	12-16	1,30	10	16,4	14-18	1,11
Fe19 ri	0				1	27,0			4	30,0	29-33	1,73
le	0				0				4	29,2	26-33	2,59
Fe21 ri	1	34,0			5	47,2	46-51	3,97	3	58,3	54-67	6,13
le	3	37,7	28-44	6,94	6	46,3	42-52	4,23	5	57,6	54-67	5,08
FeW43 ri	4	2,0	1,8-2,6	0,33	9	2,6	1,5-3,5	0,62	6	2,8	1,8-4,6	0,86
le	5	2,3	1,7-3,0	0,44	9	2,6	1,4-3,6	0,82	8	2,9	1,4-5,1	1,05
FeW4 ri	1	1,5			2	1,7			3	3,6	2,9-4,4	0,61
le	2	2,0			6	2,2	1,8-2,6	0,28	5	3,3	2,6-4,2	0,62
Pat1 ri	0				0				0			
le	0				0				0			
Pat2 ri	0				0				0			
le	0				0				0			
Pat3 ri	0				0				0			
le	0				0				0			
Ti1 ri	4	155,0	102-136	13,15	7	167,7	134-185	17,32	8	206,2	174-230	16,36
le	7	115,0	101-137	13,30	7	161,8	136-185	16,49	8	212,2	175-235	19,29
Ti3 ri	3	29,3	26-32	2,49	5	39,0	37-40	1,09	6	45,2	40-50	3,43
le	4	28,5	25-32	2,50	7	39,1	33-43	2,90	4	46,7	40-51	4,14
Ti6 ri	1	12,0			1	16,0			1	17,0		
le	1	13,0			1	17,0			1	18,0		
Ti8 ri	4	11,2	11-12	0,43	8	14,1	13-15	0,78	9	16,3	13-20	3,12
le	7	11,1	10-13	0,99	8	13,8	12-16	1,36	9	17,8	13-21	2,48
Ti8a ri	4	13,0	12-14	1,00	10	16,0	14-18	1,34	10	19,9	16-21	1,81
le	7	13,0	12-15	1,17	9	16,5	15-20	1,71	10	20,5	18-23	1,50

(tab. 78. continued)

age	1-3				4-6				7-10			
measure	n	x	range	s	n	x	range	s	n	x	range	s
Ti9 ri	3	10,0			7	12,4	10-15	1,40	8	14,9	13-16	1,05
le	6	9,7	9-10	0,47	7	12,3	11-13	0,88	8	15,1	13-16	1,05
Ti9a ri	4	11,7	11-13	0,83	10	14,6	11-17	0,62	10	17,2	15-20	1,47
le	7	11,8	10-13	0,99	9	14,8	13-17	1,13	10	17,1	15-19	1,30
Ti10 ri	4	34,7	33-38	1,92	8	42,1	38-46	2,47	9	51,9	44-58	4,63
le	7	33,8	29-38	2,80	8	42,8	38-46	2,76	9	53,0	44-59	5,16
Ti10a ri	4	37,7	35-41	2,16	8	47,7	44-55	3,38	9	58,2	51-66	4,92
le	7	37,4	33-43	3,42	8	48,0	43-56	3,87	9	58,2	52-64	4,47
Ti10b ri	4	36,5	34-42	3,20	9	43,4	37-48	3,37	8	50,4	46-54	3,83
le	7	35,4	32-40	2,38	8	43,2	39-47	2,99	7	52,3	46-67	7,02
Fi1 ri	0				4	162,7	145-180	15,42	5	203,4	170-221	17,46
le	2	135,5			6	155,8	138-177	12,74	7	203,1	170-225	16,35
Ca1 ri	0				0				1	42,0		
le	0				1	43,0			1	49,0		
Ta1 ri	0				0				2	35,5		
le	0				1	33,0			2	39,0		

tab. 79. Measurement sections of the lower limbs for the age categories infans II and juvenile

age	11-14				15-17		18-20			
measure	n	x	range	s	n	x	n	x	range	s
Fe1 ri	6	330,0	290-404	40,38	1	465,0	4	402,0	374-426	18,55
le	7	335,8	285-409	40,59	0		4	410,0	381-423	18,88
Fe6 ri	8	20,9	17-28	3,62	2	30,5	5	24,2	23-26	0,98
le	9	20,9	17-28	3,51	2	28,0	5	24,8	23-28	1,72
Fe7 ri	8	19,2	16-23	2,43	2	27,0	5	23,4	22-26	1,50
le	9	19,3	16-23	2,11	2	26,5	5	24,0	22-26	1,41
Fe8 ri	8	63,7	54-80	8,68	2	89,0	5	76,8	72-87	5,38
le	9	64,0	54-79	8,23	2	87,5	5	77,6	74-87	4,92
Fe9 ri	8	24,4	20-32	3,90	1	38,0	5	27,6	25-31	2,15
le	9	24,4	21-30	2,75	0		5	27,6	24-32	2,87
Fe10 ri	8	19,0	17-24	2,23	1	25,0	5	22,0	21-24	1,09
le	9	19,3	17-24	2,21	1	25,0	5	22,8	22-26	1,60
Fe19 ri	5	35,2	31-41	3,76	1	25,0	5	42,8	39-48	3,06
le	4	36,2	33-41	2,95	0		4	42,2	38-48	3,77
Fe21 ri	4	68,5	64-73	3,64	1	83,0	3	70,3	64-75	4,62
le	5	69,8	64-74	3,71	1	84,0	4	72,7	64-83	6,79
FeW43 ri	8	3,9	2,1-6,4	1,28	2	5,7	5	6,4	5,2-7,4	0,71
le	9	3,9	2,1-6,6	1,50	1	4,5	5	6,2	5,4-6,7	0,54
FeW44 ri	0				1	6,1	2	4,6		
le	4	4,0	2,4-5,9	1,24	1	6,6	2	4,2		
Pat1 ri	1	42,0			1	47,0	2	40,5		
le	1	42,0			1	48,0	1	42,0		
Pat2 ri	1	36,0			1	47,0	2	48,5		
le	1	36,0			1	47,0	1	41,0		
Pat3 ri	1	20,0			1	21,0	2	18,5		
le	1	19,0			1	21,0	1	18,0		
Ti1 ri	5	247,2	227-288	21,28	1	417,0	4	349,7	338-362	10,01
le	5	268,2	242-328	34,39	1	416,0	4	344,5	322-363	16,41
Ti3 ri	3	50,0	42-57	6,16	1	80,0	4	68,5	62-76	5,02
le	5	54,8	44-72	9,76	0		4	69,5	62-77	5,59
Ti6 ri	2	41,0			0		4	44,7	41-51	3,89
le	3	44,0	42-47	2,16	0		3	46,7	45-50	2,36
Ti8 ri	5	20,4	19-22	1,02	1	32,0	4	26,0	25-28	1,22
le	5	19,4	12-28	5,85	1	30,0	5	25,8	24-28	1,47
Ti8a ri	5	21,6	21-23	0,80	1	37,0	4	29,2	28-31	1,09
le	5	23,6	21-31	3,93	1	38,0	5	30,2	29-31	0,75

(tab. 79. continued)

age	11-14				15-17		18-20			
measure	n	x	range	s	n	x	n	x	range	s
Ti9 ri	5	16,6	15-19	1,62	1	25,0	4	21,0	10-26	2,91
le	5	16,0	14-19	1,67	1	27,0	5	19,6	18-22	1,49
Ti9a ri	5	19,2	17-25	2,99	1	27,0	4	21,7	20-25	1,92
le	5	20,0	17-24	2,61	1	28,0	5	21,8	10-24	19,40
Ti10 ri	5	58,0	53-67	5,29	1	92,0	4	73,2	71-75	1,48
le	5	61,8	53-76	8,13	1	94,0	5	73,6	70-77	2,58
Ti10a ri	5	64,6	61-72	4,08	1	98,0	4	83,5	80-90	4,09
le	5	68,2	60-84	8,49	1	101,0	5	82,0	78-86	3,85
Ti10b ri	5	58,2	53-64	3,65	1	86,0	5	69,4	66-76	3,77
le	5	61,2	55-76	7,83	1	83,0	5	70,8	67-77	5,07
Fi1 ri	4	258,0	227-280	24,04	1	390,0	3	320,3	303-334	12,92
le	5	260,8	227-332	40,46	1	383,0	3	319,7	300-336	14,88
Ca1 ri	2	66,0			0		4	74,5	72-78	2,29
le	3	65,7	60-75	6,65	0		3	74,7	71-77	2,62
Ta1 ri	3	47,0	42-54	5,10	1	59,0	4	49,7	49-52	1,29
le	2	46,0			0		3	51,3	49-54	2,05

Indices of the infra-cranium

tab. 80. Indices of the infra-cranium for the age category infans I

	0-1				1-3				4-6			
index	n	x	range	s	n	x	range	s	n	x	range	s
Hu length-thickness ri	1	22,2			5	27,2	23,8-30,7	2,19	8	24,4	20,7-30,6	3,07
le	1	25,1			4	28,0	26,7-30,3	1,39	9	24,2	20,4-31,8	3,28
Humero-radial ri	5	80,2	78,5-83,3	1,63	1	76,4			5	76,7	73,1-84,8	4,15
le	7	80,3	77,2-81,8	1,49	3	77,0	74,6-80,8	2,70	4	75,6	71,4-80,9	3,53
Femoro-humeral ri	6	87,9	85,5-89,5	1,39	2	83,2			6	74,1	67,9-79,3	3,51
le	5	87,1	84,2-91,1	2,37	4	81,0	77,3-84,9	2,69	5	74,0	67,1-77,6	3,81
Fe length--thickness ri	2	31,8			4	26,7	24,1-28,4	1,60	9	21,8	18,9-29,0	2,85
le	2	33,4			3	29,0	27,3-30,1	1,20	6	22,6	20,0-28,2	2,80
Fe robustness ri	6	17,3	14,3-22,6	2,60	4	15,4	14,1-17,1	1,17	9	13,4	12,0-17,7	1,63
le	4	17,2	14,4-21,2	2,49	3	15,8	15,2-16,4	0,49	6	13,5	12,0-17,2	1,81
Fe platymericus ri	7	85,4	72,4-96,4	7,42	6	82,4	71,4-92,3	6,83	11	86,0	75,0-94,4	5,07
le	5	90,7	90,4-90,7	0,20	6	86,1	78,6-93,3	5,14	10	86,5	75,0-108,3	9,17
Fe pilastricus ri	9	91,9	80,0-111,1	9,13	6	100,4	90,9-130,0	13,83	11	102,6	92,3-107,7	6,42
le	6	94,1	80,0-106,9	8,42	6	100,1	90,9-109,1	7,27	11	105,0	92,8-114,3	6,66
Femoro-tibial ri	4	89,6	86,8-94,7	3,04	2	81,4			7	79,3	76,6-80,8	1,44
le	4	87,1	84,3-89,1	1,82	2	81,4			5	80,4	78,2-83,1	1,71
Ti cnemicus ri	9	93,9	86,1-110,4	9,02	5	90,7	85,7-92,8	2,57	10	91,5	73,3-114,3	9,88
le	10	95,8	80,0-116,4	11,08	5	90,5	83,3-100,0	5,80	9	89,6	83,3-100,0	4,85
Sacro-clavicular ri	0				0				1	32,5		
le	0				0				1	30,0		

tab. 81. Indices of the infra-cranium for the age categories infans II and juvenile

	7-10				11-14				15-17		18-20			
index	n	x	range	s	n	x	range	s	n	x	n	x	range	s
Hu length-thickness ri	3	21,6	20,3-23,9	1,61	4	20,4	19,0-22,5	1,43	1	19,2	4	18,4	16,9-19,9	1,07
le	5	22,7	20,3-24,7	1,86	5	20,2	18,4-22,5	1,47	1	21,2	3	18,6	17,3-19,9	1,06
Humero-radial ri	2	76,7			3	73,0	70,2-74,4	1,96	1	80,2	4	72,0	66,2-76,8	4,30
le	3	73,7	72,4-76,1	1,70	4	73,7	70,7-75,7	1,83	1	76,7	2	75,9		
Femoro-humeral ri	2	72,8			1	71,8			1	71,8	4	72,6	71,7-73,5	0,90
le	4	71,9	70,2-73,6	1,24	3	70,2	69,2-71,2	0,82	0		3	69,5	67,3-72,6	2,24
Fe length--thickness ri	4	19,9	19,7-20,6	0,42	5	19,0	18,0-19,9	0,70	1	18,9	4	18,4	17,4-19,9	0,96
le	2	20,0			6	18,9	17,6-20,1	0,94	0		4	18,6	17,7-19,8	0,81
Fe robustness ri	4	12,8	12,2-13,5	0,51	5	12,0	11,4-12,7	0,48	1	12,4	4	11,4	10,9-11,9	0,39
le	2	12,2			6	11,9	11,3-12,5	0,42	0		4	11,6	11,2-12,3	0,43
Fe platymericus ri	7	83,9	73,9-90,5	6,59	7	78,7	71,4-95,0	10,12	1	65,8	5	80,1	67,7-84,6	6,29
le	7	82,0	73,9-96,7	7,41	8	79,6	73,9-96,0	7,64	0		5	83,3	68,7-91,7	8,52
Fe pilastricus ri	7	105,6	94,4-113,3	5,96	7	108,6	90,0-121,7	10,28	1	114,8	5	103,6	100,0-109,1	3,39
le	7	104,1	93,3-121,4	9,36	8	109,3	90,0-121,7	9,27	1	107,7	5	103,4	95,8-109,1	4,92
Femoro-tibial ri	4	79,8	79,1-80,4	0,54	3	81,3	80,3-82,5	0,91	1	89,7	4	81,7	80,3-84,7	1,77
le	1	80,0			5	81,2	78,3-84,2	2,20	0		4	80,3	79,6-81,7	0,84
Ti cnemicus ri	9	86,2	78,9-95,2	5,41	4	89,9	77,3-119,0	16,88	1	73,0	5	74,5	64,5-80,5	5,85
le	8	83,6	83,3-87,6	3,75	5	86,6	71,0-120,0	17,14	1	73,7	4	71,0	61,3-80,4	6,81
Sacro-clavicular ri	1	19,6			2	37,2			0		3	29,8	24,2-33,1	3,96
le	1	20,2			0				1	28,2	4	30,4	27,3-32,6	1,93

tab. 82. Direct comparison of the indices of the infra-cranium of non-adults and adults

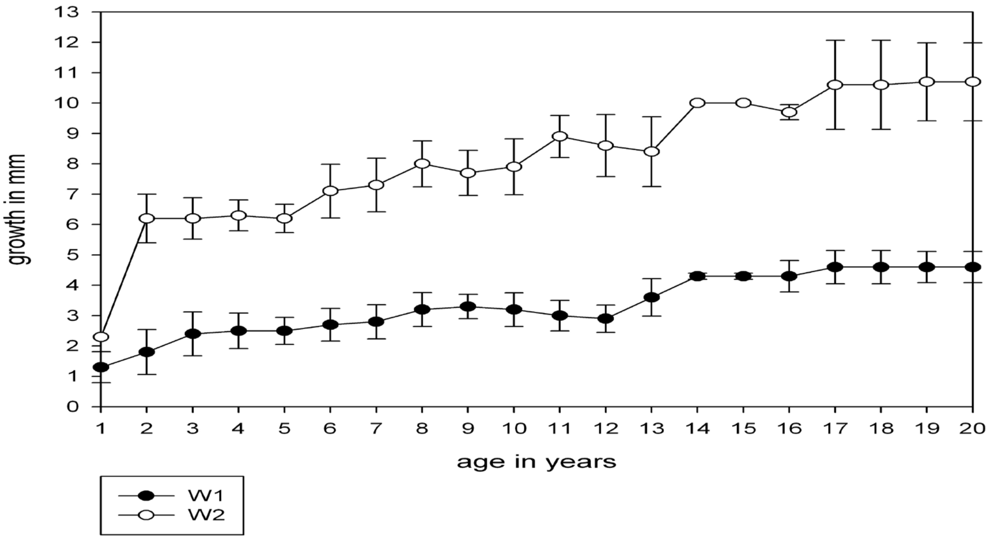
	0-1		1-3		4-6		7-10		11-14		15-17		18-20		adult♂		adult♀	
Index	n	x	n	x	n	x	n	x	n	x	n	x	n	x	n	x	n	x
Hu len.-thick. ri	1	22,2	5	27,2	8	24,4	3	21,6	4	20,4	1	19,2	4	18,4	46	20,3	48	19,2
le	1	25,1	4	28,0	9	24,2	5	22,7	5	20,2	1	21,2	3	18,6	49	20,2	55	19,2
Hum.-rad. ri	5	80,2	1	76,4	5	76,7	2	76,7	3	73,0	1	80,2	4	72,0	39	75,4	36	74,8
le	7	80,3	3	77,0	4	75,6	3	73,7	4	73,7	1	76,7	2	75,9	39	75,6	41	74,6
Fem.-hum. ri	6	87,9	2	83,2	6	74,1	2	72,8	1	71,8	1	71,8	4	72,6	39	71,2	36	71,5
le	5	87,1	4	81,0	5	74,0	4	71,9	3	70,2	0		3	69,5	37	70,1	43	70,2
Fe len.-thick. ri	2	31,8	4	26,7	9	21,8	4	19,9	5	19,0	1	18,9	4	18,4	56	20,2	52	19,6
le	2	33,4	3	29,0	6	22,6	2	20,0	6	18,9	0		4	18,6	52	20,2	63	19,7
Fe rob. ri	6	17,3	4	15,4	9	13,4	4	12,8	5	12,0	1	12,4	4	11,4	56	12,7	52	12,5
le	4	17,2	3	15,8	6	13,5	2	12,2	6	11,9	0		4	11,6	54	12,9	63	12,5
Fe platym. ri	7	85,4	6	82,4	11	86,0	7	83,9	7	78,7	1	65,8	5	80,1	69	83,2	65	81,3
le	5	90,7	6	86,1	10	86,5	7	82,0	8	79,6	0		5	83,3	70	81,0	71	79,1
Fe pilast. ri	9	91,9	6	100,4	11	102,6	7	105,6	7	108,6	1	114,8	5	103,6	74	100,5	67	102,0
le	6	94,1	6	100,1	11	105,0	7	104,1	8	109,3	1	107,7	5	103,4	73	100,2	71	100,0
Fem.-tib. ri	4	89,6	2	81,4	7	79,3	4	79,8	3	81,3	1	89,7	4	81,7	41	82,4	45	83,0
le	4	87,1	2	81,4	5	80,4	1	80,0	5	81,2	0		4	80,3	44	82,1	52	82,5
Ti cnem. ri	9	93,9	5	90,7	10	91,5	9	86,2	4	89,9	1	73,0	5	74,5	68	71,3	66	70,5
le	10	95,8	5	90,5	9	89,6	8	83,6	5	86,6	1	73,7	4	71,0	68	71,2	65	69,7
Sacro-clav. ri	0		0		1	32,5	1	19,6	2	37,2	0		3	29,8	30	28,9	27	31,9
le	0		0		1	30,0	1	20,2	0		1	28,2	4	30,4	31	29,9	29	31,6

The comparison of indices between non-adults of different age categories and adults show significant differences especially in the lower age classes. The youngest categories neonatus and infans I show the biggest discrepancies. In the process of development, different phases of accelerated growth lead to adaptation of body proportions represented by the values of male and female adults. However, the comparison of indices divided by age classes just gives a simplistic picture of growth and development of the Grevenmacher non-adults. Therefore, a detailed analysis of growth is carried out in the next section (detailed list of indices see tables 95-97).

10.3. Growth studies

Growth and maturation characterizes human development from the moment of procreation till adulthood. Bogin (2001) divides this time span in five phases where different velocities of growth are visible. The infancy stage comprises the time from birth to about three years of age. This phase is characterized by a rapid velocity of growth directly after birth, as well as, a deceleration a little after. The following childhood stage spans the age from about three to seven years. The growth acceleration of infancy ends and a rate of growth about 5 cm a year occurs. At the age of six to eight years the so called mid-growth spurt leads to a modest acceleration in growth velocity whereas the lower extremities grow a bit faster than the upper extremities. The juvenile stage begins at about 7 years of age and is characterized by the slowest rate of growth since birth. The end of the juvenile period differs in boys and girls. In girls it ends on average at the age of ten, in boys on average at the age of twelve years. In general this mirrors the earlier onset of adolescence in girls. In the adolescence stage, a rapid acceleration in growth velocity occur in all bones of the body in boys and girls. This is called the adolescent growth spurt. Also a social and sexual maturation occurs in this phase. The completion of the growth spurt marks the beginning of adulthood. An adult stature and full reproductive maturity is achieved. In this stage fusion of the epi- and apohysis of the long bones (humerus, femur, tibia) and thereby height growth is more or less complete (Welte and Wahl 2010, Grupe et al. 2005, Bogin, 2001).
For numerical expression of this kind of growth, a collection of metrical data is necessary from individuals of all age categories from neonatus to adultus. With the help of this data, different questions can be solved concerning the developmental status of individuals, as well as, within populations. For example, the individual determination of age at death in skeletal samples can be supported by metrical data of the long bones in addition to tooth development and eruption. Comparison of metrical data and the status of tooth development allows to estimate if an individuals body height corresponds to the average or if it is taller or smaller than its contemporaries. Further information can be gained with regard to sex, nutrition and living conditions in general. Individual development within the whole population can answer questions concerning the occurrence of phases of accelerated growth in infancy, as well as, in adolescence in comparison with populations from different times and geographical regions (Welte and Wahl 2010).
The recording and processing of the data was carried out according to Welte and Wahl (2010) including all non-adult individuals from the categories neonatus to juvenis where age determination with the help of tooth eruption was possible. Measurement sections from the skull, as well as, the upper and lower extremities were used for comparison. In addition, growth curves were created for the body height of the individuals. The results are shown in figures 113 to 117.

Thickness of the skullcap (W1) and thickness at the Cruciform eminence (W2)



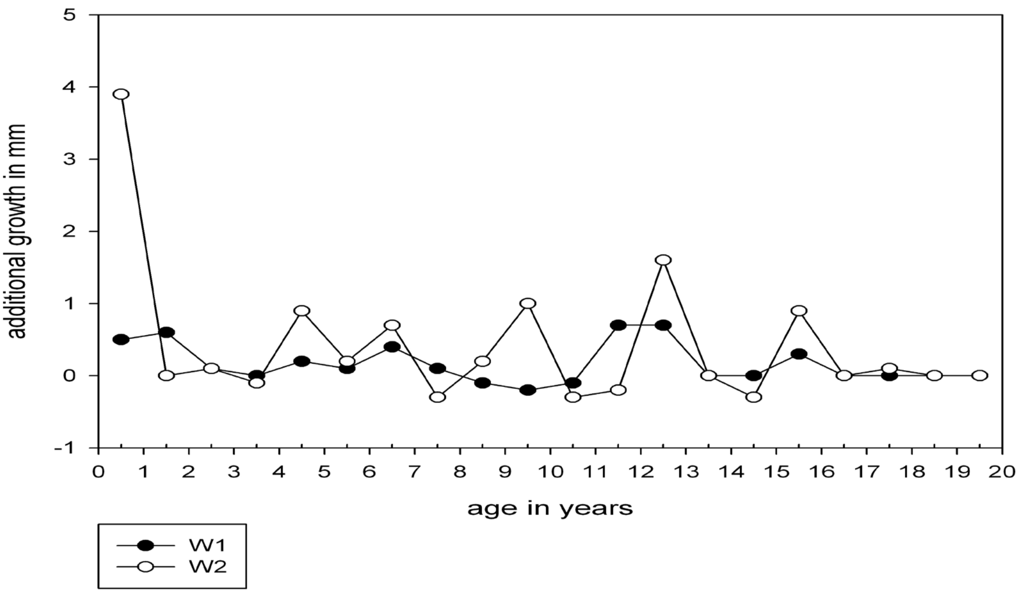
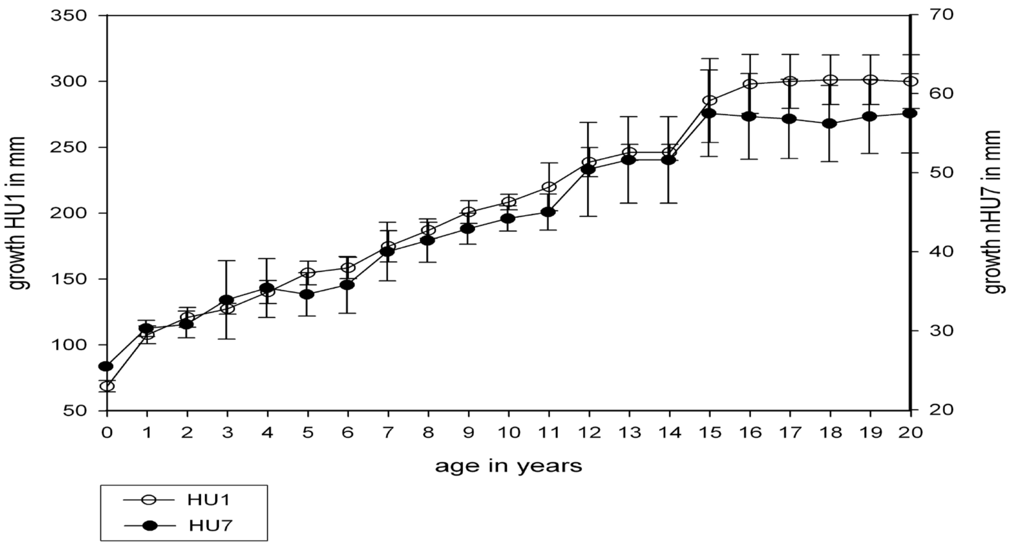


fig. 113. Measure (W1) thickness of the skull cap (black dots, n=148) and measure (W2) thickness of the skullcap at the Cruciform eminence (white dots n=91). Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

Humerus maximum length (Hu1) and least circumference of the mid-shaft (Hu7)



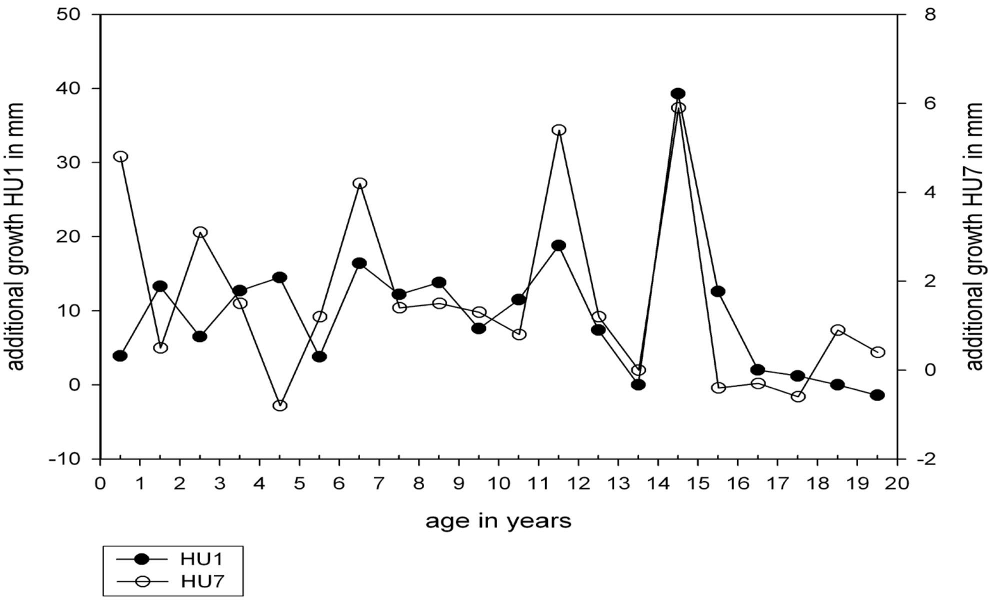
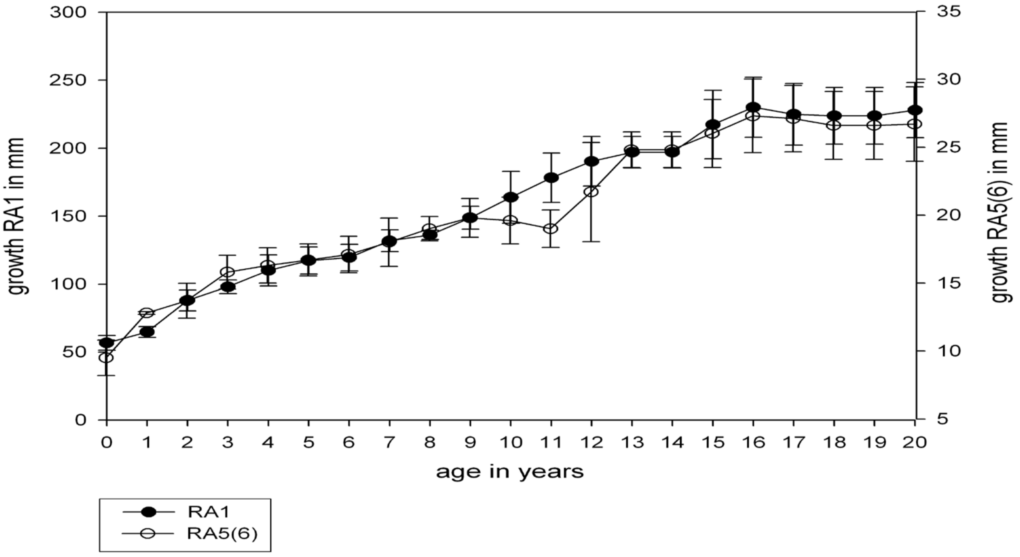


fig. 114. Measure (Hu1) maximum length of the humerus diaphysis (black dots, n=123) and measure (Hu7) least circumference of the humerus midshaft (white dots n=128). Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

Radius maximum length (Ra1) and distal maximum breath (Ra5(6))



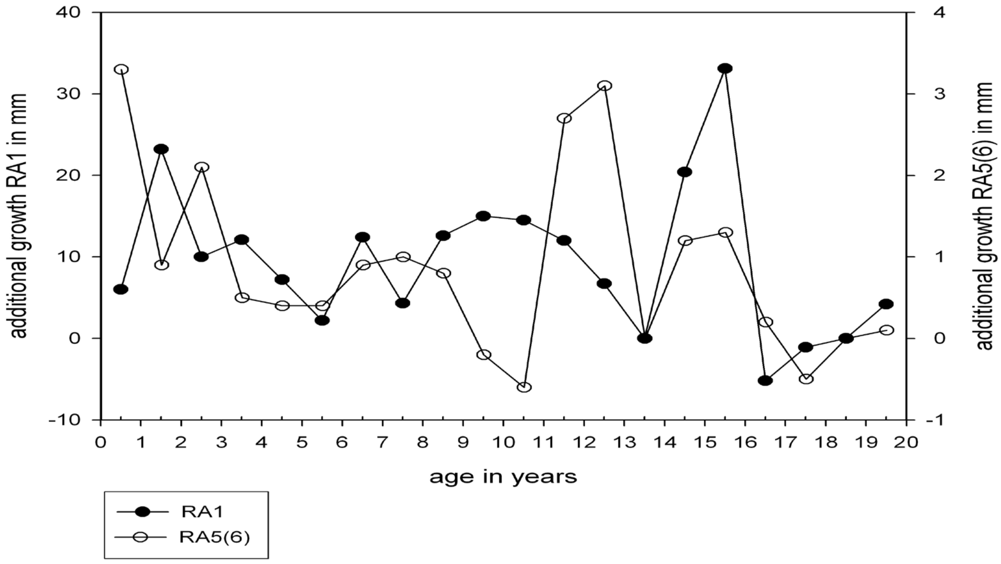
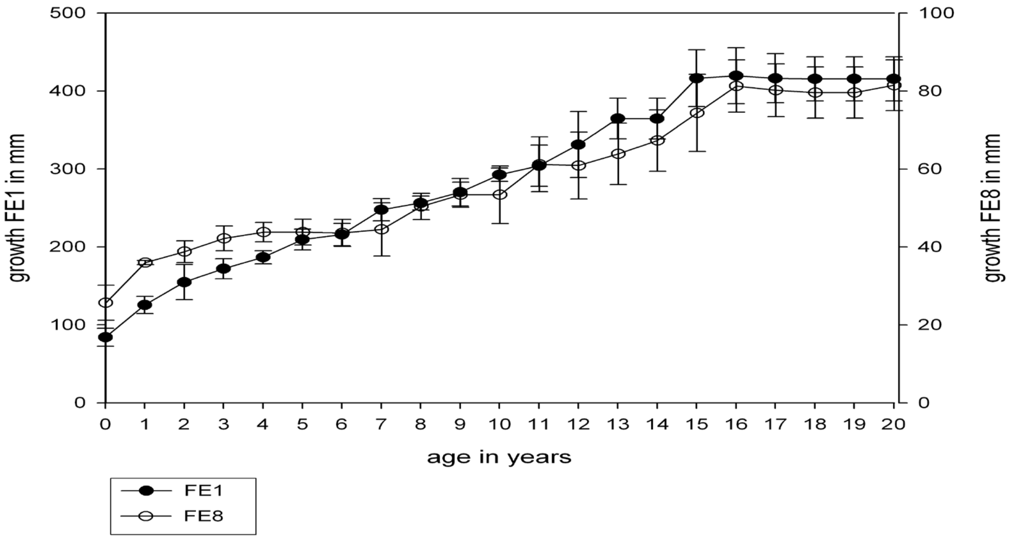


fig. 115. Measure (Ra1) maximum length of the radius diaphysis (black ldots, n=122) and measure (Ra5(6)) distal maximum breath of the radius diaphysis (white dots n=84). Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

Femur length of the diaphysis (Fe1) and circumference of the mid-shaft (Fe8)



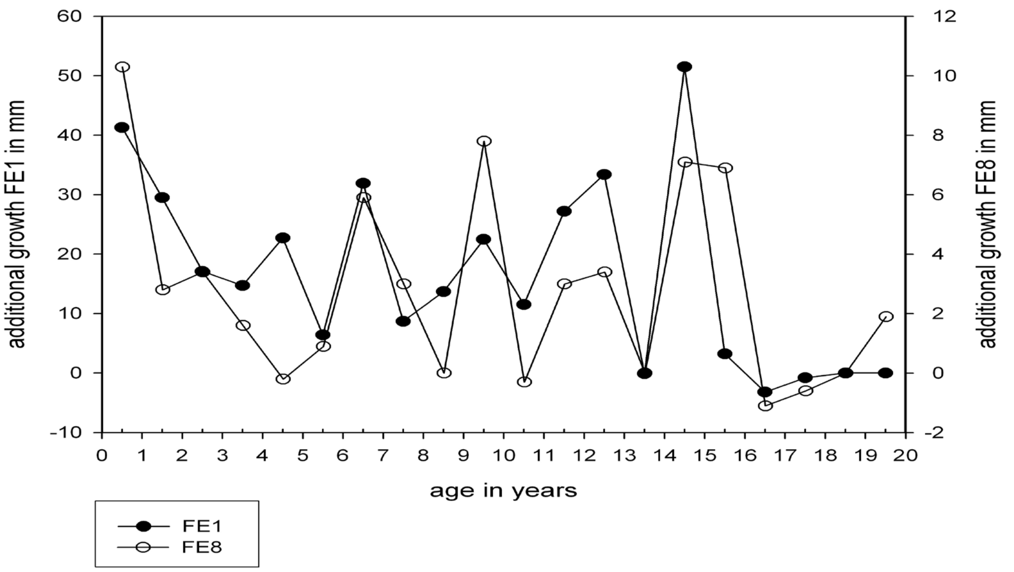
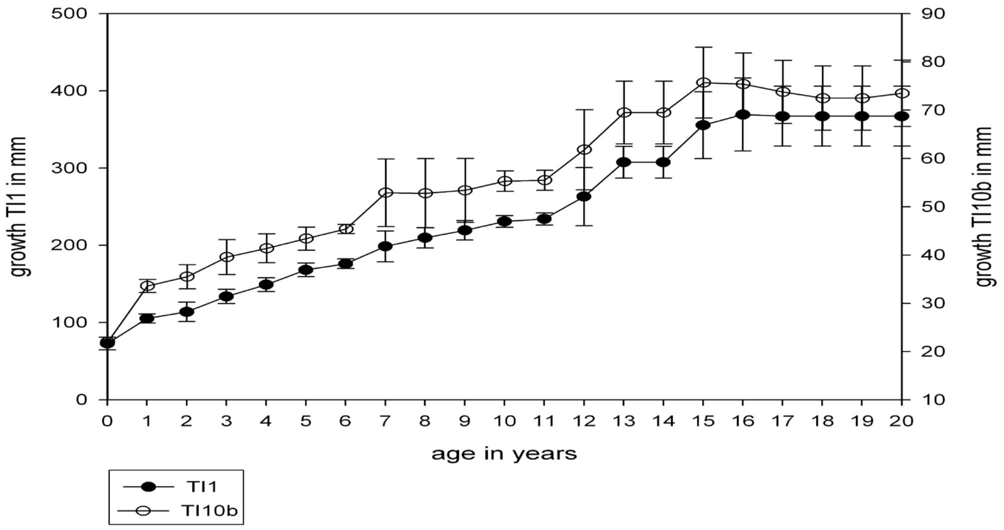


fig. 116. Measure (Fe1) maximum length of the femur diaphysis (black dots, n=118) and measure (Fe8) circumference of the femurmid-shaft (white dots n=150). Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

Tibia length of the diaphysis (Ti1) and least circumference (Ti10b)



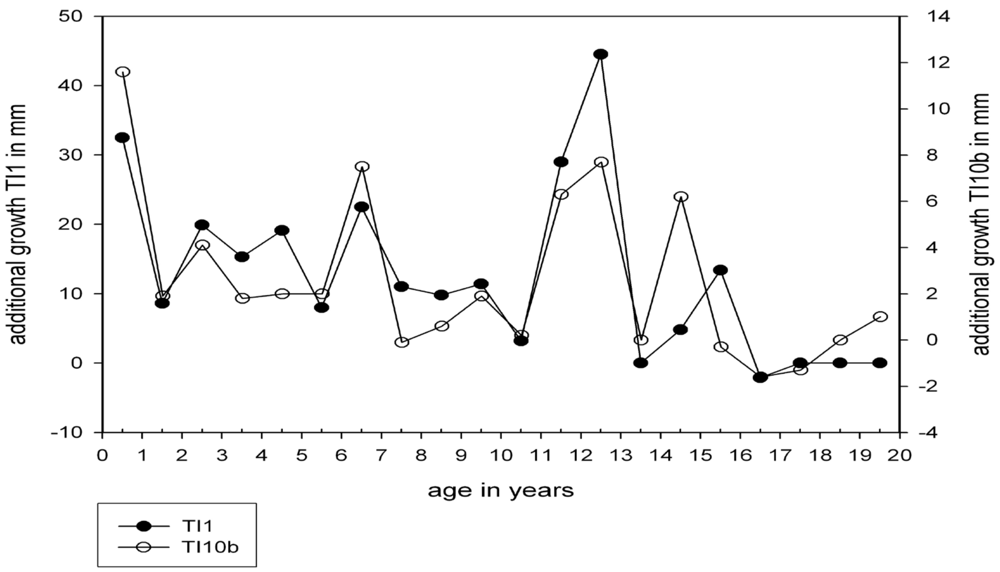


fig. 117. Measure (Ti1) maximum length of the tibia diaphysis (black dots, n=104) and measure (Ti10b) least circumference of the tibia diaphysis (white dots n=102). Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

Results

As expected all of the growth curves show a more or less constant increase from the neonate to adult age. This is visible in the single measurements, as well as, in the body height (figure 118). In the velocity curves several peaks can be identified. They correlate more or less around the same ages and mark different phases of increased velocity in growth. All velocity curves show a first little peak around the age of two years. This most likely mirrors the first rapid velocity of infant growth according to Bogin (2001). This peak is very pronounced in the upper limbs and the body height. Lower limbs and the skull show just a slight maximum whereas at the skull thickness the peak is shifted by two years. A deceleration of growth follows until the next peak around six years of age. At this point an increased velocity of growth is visible in all linear measurements, as well as, in the circumferences and width and can be correlated with the mid-growth spurt. The next maximum in the velocity curves that is visible in all measurements occurs around the age of twelve to thirteen and around fourteen to fifteen years of age. Reasons for the occurrence of two maxima are not quite clear. The second peak around fourteen to fifteen years most likely mirrors the adolescent growth spurt. The first peak is shifted to the younger ages by around two years. Here it is possible that in some of the children the growth spurt occurs earlier. One reason for that could be the affiliation to a higher social class and an associated better nutritional status. A possible earlier growth spurt concerning female individuals due to an earlier onset of puberty can not be confirmed because the sex distribution in both age categories is almost balanced. Differences are also visible in the way of growth in the earlier and the later maximum. With regard to the first maximum in the upper extremities the width growth dominates the linear growth whereas in the lower limbs vice versa the linear growth overlies the width growth. In the second maximum the humerus shows a simultaneous growth in length, as well as, in width. In the radius and femur linear growth dominates whereas in the tibia the maxima of both measures are shifted. These differences point to the fact that growth does not occure the same way in all long bones and that there are differences not just between upper and lower extremities but between single bones as well. After the age of sixteen almost all measurements show just a slight or no growth till the age of around 20 years when height growth is more or less finished with the adhesion of the long bone epiphysis.

10.4. Body height

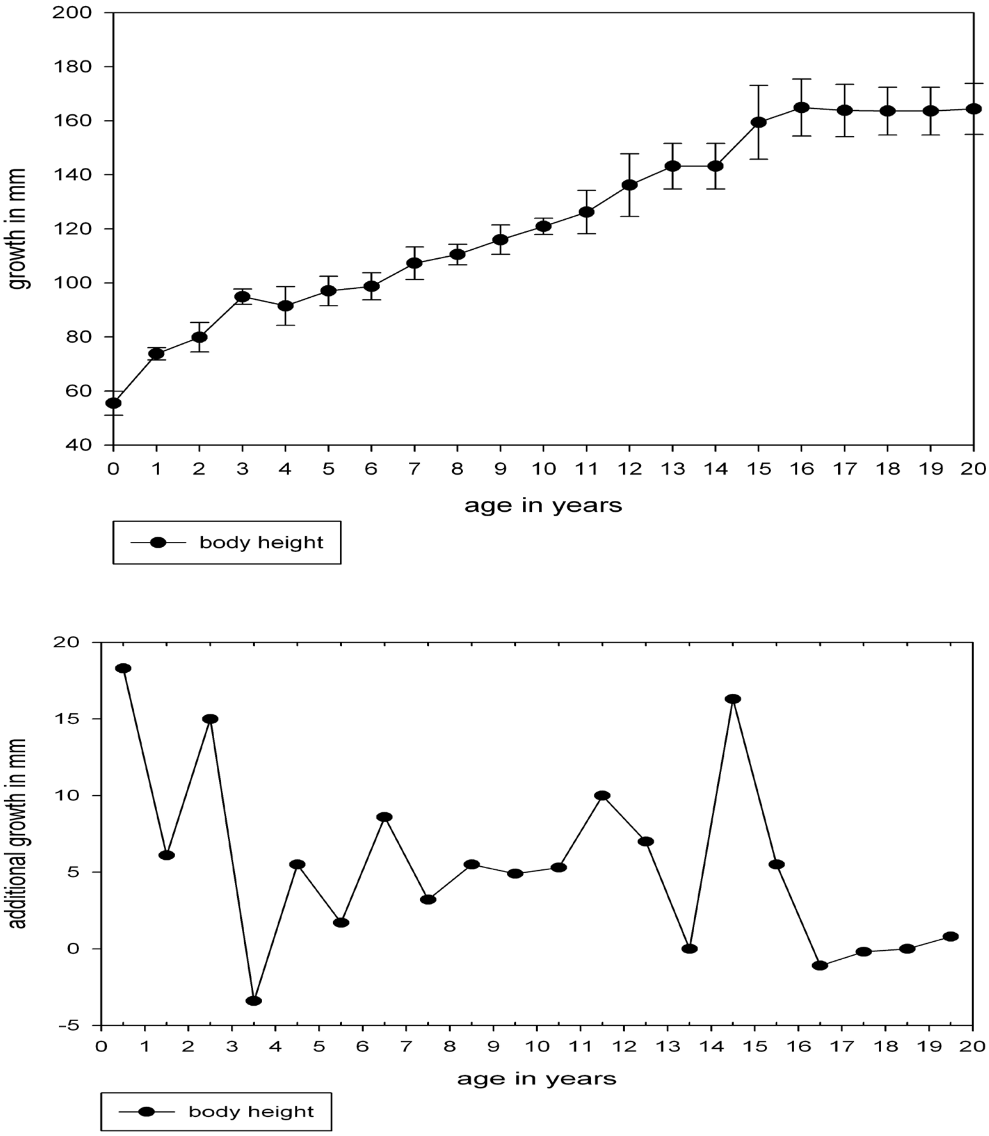


fig. 118. Body height combined for both sexes. Above: growth in annual steps. The curve connects the mean values of the respective age classes. Below: additional growth in annual steps

As expected a linear growth of body height is visible from the lowest age class to the adolescent individuals (fig. 118). In the velocity curve the same maxima occur at the age of two, six, eleven and fourteen years. This is also to be expected because every increase in bone growth especially in the lower limbs precipitates in an increase of body height. Tables 83 and 84 show the average body height of non-adults separated by age categories. Body height was calculated according to Telkkä et al. (1962) in Herrmann et al. (1990) for the age classes neonatus to infans II (see also table 94). For juveniles body height was calculated on one hand after Telkkä et al. (1962) on the other hand by formulas already used for adult individuals (see chapter 6) and separated for both sexes.

tab. 83. Body height according to age class with the respective amount of individuals (n), average values (x), ranges, standard of deviation (s) and variance (v)

age	n	x	range	s	v
7-9LM	2	42,4			
0-1	13	55,4	51,4-64,3	4,46	12,9
1-2	8	76,0	71,6-84,3	4,36	12,7
3-4	8	86,3	80,5-91,2	3,33	11,6
5-6	9	97,3	89,3-110,0	5,65	20,7
7-8	8	105,8	98,4-112,6	4,77	14,2
9-10	12	116,6	107,2-122,9	4,97	15,7
11-12	4	132,0	122,4-153,9	12,78	31,5
13-14	6	143,2	134,9-160,0	8,45	25,1
15-20 m	3	168,2	160,1-182,4	10,09	22,3
15-20 f	3	158,7	154,4-162,3	3,27	7,9

(LM=lunar months; m=males, f=females)

tab. 84. Body height of uveniles 15-20 years, using formulas for adult individuals

	♂				♀						
formula	n	x	range	s	n	x	range	s	f/m%	dif. m-f	t-test
Breitinger (1938)	3	165,8	159,4-173,7	2,40							
Bach (1965)					3	159,3	156,0-161,5	0,55	96,08	6,5	4,572hs
Pearson (1899)	3	161,6	155,2-171,4	4,80	3	153,5	149,3-155,7	0,10	94,99	8,1	2,922s
TG-AW (1952)	3	167,3	161,5-177,9	0,50	3	158,1	153,4-161,8	1,40	94,50	9,2	10,719hs
TG-AN (1952)	3	162,8	157,1-172,4	0,95	3	154,8	150,6-158,2	1,25	95,08	8,0	8,826hs
Sieg. Kombi. (2010)	3	163,9	158,3-173,9	0,67	3	155,5	151,1-158,6	0,92	94,87	8,4	12,784hs

(TG-AW=Trotter and Gleser 'American White'; TG-AN=Trotter and Gleser 'American Negro'; Sieg.Kombi.=Siegmund Kombinierte Methode; s=significant, hs=highly significant)

The results for the juvenile individuals according to Telkkä et al. (1962) are on average higher in both sexes compared to the results gained by the formulas used for the adults. When the results of all calculations in table 83 are summarized an average body height of 164,3 cm for males and 156,2 cm for females is given. Compared with the results by Telkkä et al. (1962) this means a difference of 4,2 cm in males and 2,2 cm in females. However, the results have to be treated with caution because of the low rate of juvenile individuals with just three males and three females included.

Compared with the results of the adult individuals (mean values males 166,2; females 156,4) the values of the juveniles reach almost the values of the adults. On average males show a difference of 3,8 cm, females of 2,7 cm. However, the results by Telkkä et al. (1962) correspond already with the adult values in both sexes. In general comparisons between results gained from different formulas have to be treated with caution. So the values gained from the same formulas are considered more meaningful. A slight discrepancy in body height between juveniles and adults is expected because in juveniles the growth of the long bones is not finished completely and therefore the definite body height is not fully achieved.

10.5. Non-metric traits

tab. 85. Frequencies of non-metric traits in comparison of non-adults and adults

		non-adults			adults (males+females)		
trait	variation	reg. pres.	trait pres.	%	reg. pres.	trait pres.	%
Sut. front. (metopica)	present	35	4	11,4	134	16	11,9
Sut. mendosa pers.	present	37	0	0,0	136	1	0,7
For. (Inc.) supraorb. ri.	present	34	11	32,3	118	60	50,8
le.	present	32	11	34,4	118	60	50,8
For. frontale ri.	present	32	15	46,9	119	57	47,9
le.	present	32	12	37,5	118	45	38,1
Oss. coronalia ri.	present	34	0	0,0	128	1	0,8
le.	present	34	0	0,0	128	1	0,8
Oss. sagittalia	present	34	2	5,9	129	5	3,9
Oss. apicis lambdae	present	34	1	2,9	129	3	2,3
Oss. lambdoidea ri.	present	34	11	32,3	130	24	18,5
le.	present	33	13	39,4	129	33	25,6
Oss. astericum ri.	present	33	0	0,0	129	1	0,8
le.	present	33	0	0,0	129	2	1,5
Os epiptericum ri.	present	34	0	0,0	124	4	3,2
le.	present	34	0	0,0	124	3	2,4
For. parietale ri.	present	33	9	27,3	126	75	59,5
le.	present	33	8	24,2	127	66	52,0
For. Huschke ri.	present	27	5	18,5	112	27	24,1
le.	present	28	6	21,4	116	29	25,0
For. ovale ri.	double	14	0	0,0	83	3	3,6
le.	double	14	0	0,0	87	1	1,1
For. ovale ri.	open	13	1	7,6	84	5	5,9
le.	open	14	0	0,0	87	1	1,1
Fac. condyl. ri.	double	31	1	3,2	117	3	2,6
le.	double	32	1	3,1	117	1	0,8
For. zygomaticof. ri.	double	29	9	31,0	106	50	47,2
le.	double	26	4	15,4	103	38	36,9
For. zygomaticof. ri.	missing	29	7	24,1	106	13	12,2
le.	missing	26	1	3,8	103	7	6,8
Torus palatinus	present	30	1	3,3	107	11	10,2
For. palat. minor ri.	present	19	5	26,3	76	29	38,1
le.	present	23	5	21,7	77	29	37,7

(tab. 85. continued)

		non-adults			adults (males+females)		
trait	var.	reg. pr.	trait pr.	%	reg. pr.	trait pr.	%
Torus mandibularis ri.	present	31	0	0,0	112	20	17,8
le.	present	32	0	0,0	107	19	17,7
For. mentale ri.	double	32	3	9,4	110	10	9,1
le.	double	32	2	6,2	108	15	13,9
For. trans. part. (CW) ri.	double	30	3	10,0	120	11	9,2
le.	double	31	3	9,7	120	10	8,3
Fenestratio sternalis (St)	present	20	0	0,0	117	3	2,5
For. suprascapulare (Sc) ri.	present	19	0	0,0	106	3	2,8
le.	present	24	0	0,0	100	3	3,0
For. supratrochlear. (Hu) ri.	present	28	0	0,0	121	13	10,7
le.	present	27	0	0,0	126	22	17,5
Proc. supracondyl. (Hu) ri.	present	29	0	0,0	133	0	0,0
le.	present	27	0	0,0	135	2	1,4
Fac. art. talaris (Ca) ri.	double	10	4	40,0	106	42	39,6
le.	double	12	4	33,3	106	41	38,7
Trochanter tertius (Fe) ri.	present	31	3	9,7	127	31	24,4
le.	present	30	3	10,0	121	31	25,6

(Sut.=Sutura, For.=Foramen, Inc.=Incisura, Oss.=Ossiculum, Can.=Canalis; ri.=right body side, le.=left body side; pres.= trait present; doub.= trait is double; miss.= trait missing, complete list of traits see chapter 7)

The comparison of occurrence of non-metric traits shows a great similarity between non-adult and adult individuals. Traits commonly found in adults are also present to a great extent in the non-adults, rarely occurring traits are also rare in non-adults. This fact was to be expected because homogeneity within a population is not related to age. This circumstance is also visible in the section about the comparison of morphognostic features. To what extent differences in trait occurrence between non-adults and adults is related to age is still under discussion (Hauser and De Stefano 1989).

10.6. Paleopathology

The examination of pathological changes in non-adult skeletal material indicates in general the same kinds of diseases diagnosed in adult individuals. Specific and unspecific infections, metabolic disease, indicators of stress and trauma, as well as, dental disease can be recorded (Carli-Thiele 1996, Kreutz 1997, Lewis 2000, Jungklaus 2010). However some limitations complicate diagnoses in bone remains of non-adults like the limited preservation of bones, as well as, the greater susceptibility to taphonomic influences (Bello and Andrews 2006, Bello et al. 2006, Lewis 2000). Reasons for this fact were already discussed in chapters 2 and 3. High rates of bone-remodelling during growth inhibit clear diagnoses of inflammation of bone or periosteum. In long bones, deposition of disorganized bone on the periosteal surface is a normal process in growing bone, especially in neonate and infant ages. However, this new bone is macroscopically identical to the woven bone forming during infection or after trauma (Lewis 2000). Children die more often in an acute phase of a disease due to weaker immune status. Therefore, they often do not reach the chronic stage of a disease in which skeletal lesions develop (Lewis 2007). In spite of these limiting factors some pathological changes could be diagnosed in the skeletal remains of non-adults in the Grevenmacher sample. In adult individuals degenerative changes are the most common pathological features. Children in contrast show mainly illness-related changes.

Periostitis

The formation and deposition of new bone on the periosteum as a reaction to inflammation or trauma is a process also occurring in children. However the diagnosis of periostitis in non-adults is much more problematic. Growth related bone remodelling especially in neonates and infants make it almost impossible to distinguish between new bone formation due to growth or infection (Lewis 2000, 2007). In the Grevenmacher sample six individuals (5,2%) show new bone formation mainly on long bones that is not connected to growth. The youngest individual (SA6; 417/88), three to four years of age shows depositions of greyish coloured woven bone lateral on the left femur and posterior on the left tibia. The posterior surface of both Ossa ilii are also involved. Four individuals that are also affected are much older and therefore the diagnosis is much more reliable in these cases (SA14; 136/34), (SA15; 112/53) and (ID 351; 875/no No.). All three are 15-20 years old, (SA16; 587/250) is 18-20 years of age. They all show greyish coloured depositions mainly on the lower extremities especially the tibia and femur. Although the bone deposits are of variable size and reach dimensions up to several square centimeters. As main causes for this kind of manifestations, in all cases mentioned above, we can consider most likely unspecific infections or traumatic injuries. Whereas traces for the latter are not detectable, as well as, other symptoms are missing to enclose the differential diagnosis.

An extreme case of periostitis is present in the 15-17 years old individual (SA15; 112/53) (fig. 119). Every bone of the upper and lower limbs including the preserved metacarpals are covered with a layer of ossified periosteum. In some areas the surface is thickened and in the case of the metacarpals lead to the deformation of the bones. However, the meta- and epiphysis are not affected. Bones of the pelvis, the scapulae and clavicles, as well as, some of the ribs show also extensive depositions of new bone formation. The vertebrae, as well as, the skull bones including the mandible are not affected. Further symptoms are absent. Also in this case an exact diagnosis is very difficult. A generalized periostitis is most likely caused by non-specific and specific infection (Schultz 2003, Ortner 2003). As further causes for the listed symptoms syndromes like infantile cortical hyperostosis (Caffey-syndrome) or Hyperostosis generalisata (Camurati-Engelmann-syndrome) are reasonably possible (Witkowski et al. 2003).

fig. 119. Periostitis on the tibia shaft of a 15-17 years old individual (SA15; 112/53)

fig. 120. Endocranial lesions at the Os occipitale of a 3-4 years old individual (SA6; 417/88)

Endocranial lesions

Nine individuals (7,9%) show lesions located on the endocranial surface (fig. 120). The age of the affected children spans from neonate (up to six months) to infans II (around 10 years). In four individuals of neonate age it cannot be determined for certain if these lesions are pathological. In these cases it is very likely that the bone changes are part of the remodelling processes during growth (Lewis 2000, 2004). For the same reason no pathological changes can be discovered on any other part of the skeleton that would support an infection. From the remaining five individuals (4,3%), four show lesions on the occipital bones, in two both parietal bones are also affected. In one individual the lesions are present only in the parietal bones. Frontal bones are not affected at all. This corroborates with the distribution described by Lewis (2004). According to her study about endocranial lesions in non-adult skeletal remains from different cemeteries from England, she states that the occipital bones are most affected followed by the parietal and frontal bones. The characteristic of the lesions in the Grevenmacher sample correspond mostly to the so called "hair-on-end" lesions also described by Lewis (2004, 2007). In one individual around ten years of age a characteristic "pitting" had manifested (SA34; 739/291a). A combination of endocranial lesions with other pathological changes was noticed in four cases. In two cases only a combination with Cribra orbitalia could be diagnosed because no elements of the infra-cranium are present (SA48; 1061/no No.); (SA36; 769/299c). One individual shows endocranial lesions, Cribra orbitalia and additional bone formation at the posterior side of the right Os ilium (ID 314, 841/314). In one case (SA15; 112/53) 15-20 years of age, additional bone formation was discovered at the femora, tibiae and also the posterior areas of both Ossa ilii, but no Cribra orbitalia is present. To what extend pathological changes visible in the infra-cranium are connected to endocranial lesions cannot be determined with absolute certainty. A combination of additional bone formation on long-bones manifest in periostitis and endocranial lesions would indicate a generalized infection that affects the periosteum of the long bones, as well as, the meninges. Whereas a combination of Cribra orbitalia and endocranial lesions would indicate haemorrhages caused by anemia. Both cases are listed as possible aetiology for endocranial lesions in non-adults. Furthermore, this kind of lesions were detected also in chronic meningitis, trauma, neoplasia, scurvy, rickets, congenital syphilis, venous drainage disorders and tuberculosis (Lewis 2004, Schultz 2003). Due to this variety of aetiology it is very difficult to retrace the occurrence of endocranial lesions in dry bone. Noticeable is the very low rate of endocranial lesions (4,3%) in Grevenmacher in comparison to other series from medieval and modern times. Jungklaus (2010) compared rates of affection of six different series in Germany with rates ranging from 39,8% in Tasdorf (Brandenburg) to 86,4% in Harting (Bavaria).

Cribra orbitalia

As mentioned in the chapter about pathological changes in the adults, traces for metabolic disease in form of porotic lesions of the orbital roof (Cribra orbitalia) are also visible in non-adults (fig. 121). The aetiology of Cribra orbitalia is already described in this chapter. Altogether 20 non-adult individuals (17,5%) show traces of Cribra orbitalia in different stages. The age of the affected individuals range from around one year to 20 years with most cases between two and seven years (n=13). In most of the individuals this feature is singular and no other lesions are found on the skeleton. However, four individuals show a combination with endocranial lesions which confirms an infection as the main cause. In two cases lesions on the outer surface of the cranium are visible. One is present in form of Cribra cranii (SA21; 1011/415), another individual shows porotic hyperostosis on the left Os parietale (ID 368; 379/151). These features are described as characeristics for a more severe form of anemia (Roberts and Manchester 2007). The comparisons of rates of Cribra orbitalia between different series emphasise again an unusual low level in the Grevenmacher sample. Different series from Germany show rates between 40,6% in Diepensee (Brandenburg) and 87,9% in Schleswig (Schleswig-Holstein) (Jungklaus 2010).

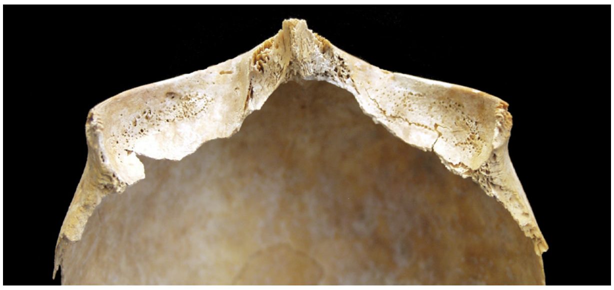


fig. 121. Porotic lesions of the orbira roof (Cribra orbitalia) in a 2-3 years old individual (SA13; 302/83)

Congenital changes

A juvenile individual (SA16; 587/250), 18-20 years of age shows an incomplete fusion of the Crista sacralis mediana. Fusion occurred just in the area of the first and the third vertebra the rest of the Canalis sacralis is exposed. Similar cases are already discussed in a previous chapter. Fused vertebral arches of the third and fourth thoracic vertebrae were found in the spine of a two to three year old individual (SA27; 821/304) (fig. 122). In both cases the lesions seem to be singular congenital features because no further symptoms were present.

fig. 122. Fused vertebral arches of the third and fourth thoracic vertebrae in a 2-3 years old individual (SA27; 821/304)

Trauma

The only trace of a traumatic injury is found in an infant around two years of age (SA31; 725/298). A lesion is present at the distal end of the left ulna shaft. It shows the rest of a fracture line on the medial, but not on the lateral surface. The fracture is surrounded by a slight callus of newly developed bone. At the associated radius no trace of fracture is visible. The most likely explanation for this kind of lesion is a so called greenstick fracture (Wessel et al. 2007, Lewis 2007). Thereby the compressed side of the bone is bowed whereas a fracture occurs at the tensile side. This kind of fracture is very common in non-adult bone because of the highly plastic nature of the infant bone. The main cause for fractures in this position is a fall on the outstretched arm (Lewis 2007).

Dental disease

As soon as deciduous, and subsequently, permanent teeth are developed and in use, they are exposed to all the corrosive factors like wear or dental plaque, that can lead to diseases like dental calculus, caries or periodontal changes. Therefore, it is not unexpected that even young children show traces of dental disease (fig. 123). All lesions found in the dentition of non-adults are recorded as described in chapter 9. Teeth were preserved for evaluation in 53 out of 114 non-adult individuals, that means a percentage of 46,5%.

fig. 123. Carious lesion and deposition of dental calculus on teeth of a 15-20 yeras old individual (SA20; 772/291b)

Dental calculus

The mineralized form of dental plaque, referred to as dental calculus is a feature already found in infant and juvenile teeth. In the Grevenmacher sample 26 out of 53 individuals (49,1%) show formation of calculus in different stages of manifestation. Slight calculus formation is already visible in infants of two to four years of age. Distributed over the single age classes it results in percentages of 20,0% (2 out of 10 individuals) for infans I, 84,2% (16 out of 19 individuals) in infans II and juveniles are affected to 100% (8 out of 8 individuals).

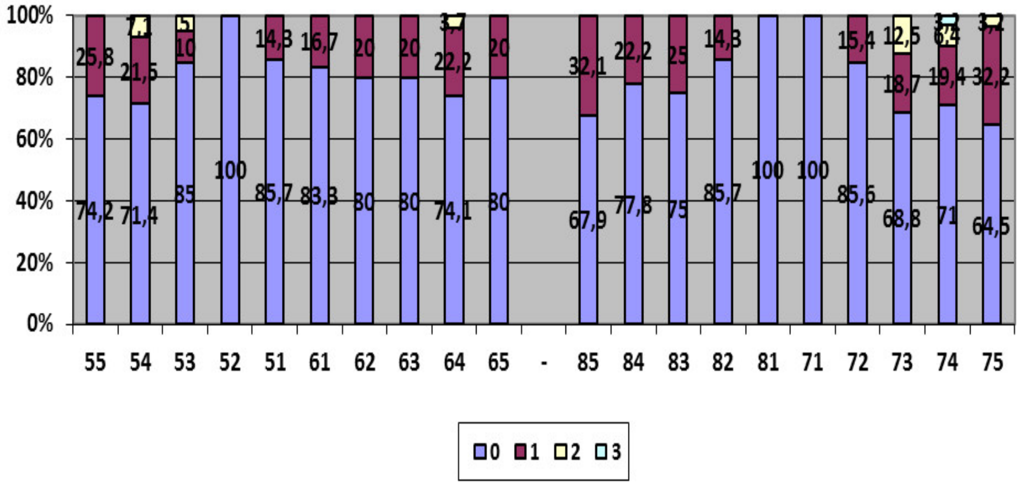


fig. 124. Rates of dental calculus in deciduous teeth

In deciduous teeth rates of calculus manifestation are overall low (fig. 124). Molars and canines of both jaws are mostly affected, incisors show just slight calculus formation.

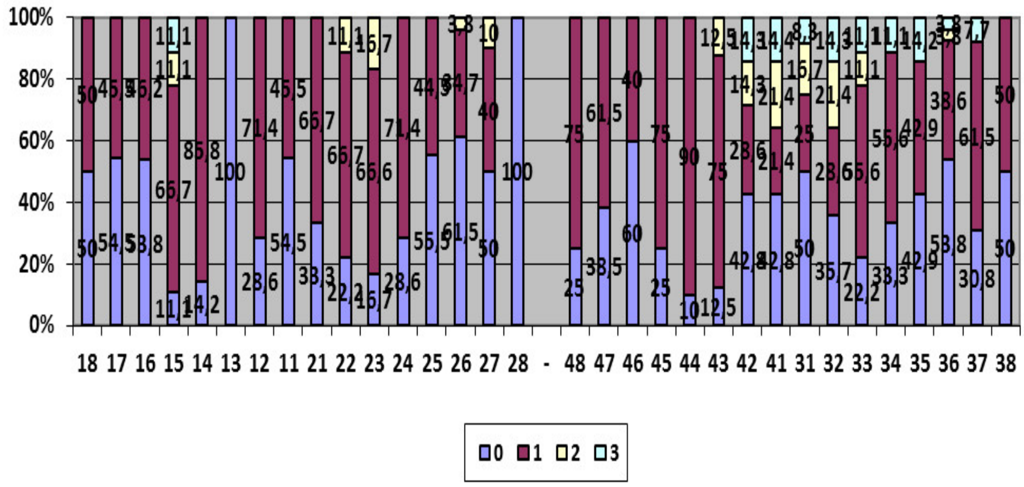


fig. 125. Rates of dental calculus in permanent teeth

Rates of calculus formation in permanent teeth of non-adults show similar distribution as visible in the adults (fig. 125). Teeth in the lower jaw are in general more affected. Especially front teeth of the lower jaw show an increased calculus formation due to their proximity to the salivary glands at the tongue side of the lower incisors (Roberts and Manchester 2007, Hillson 2005).

Dental caries

A total of 19 out of 53 individuals with teeth preserved for evaluation show carious lesions in different stages which results in a caries frequency of 35,8%. The caries intensity (percentage of affected teeth) is 4,8%. A separation in different age classes result in the following caries frequencies:
infans I 13,8% (4 out of 29 individuals), infans II 68,8% (11 out of 16 individuals), juvenile 50% (4 out of 8 individuals)

tab. 86. Proportion of affected teeth in deciduous dentition

position	55	54	53	52	51	61	62	63	64	65
n aff.	3	2	1	0	0	0	0	0	5	1
% aff.	13,6	9,2	4,5	0,0	0,0	0,0	0,0	0,0	22,8	4,5
position	**85**	**84**	**83**	**82**	**81**	**71**	**72**	**73**	**74**	**75**
n aff.	3	2	1	0	0	0	0	0	3	1
% aff.	13,6	9,2	4,5	0,0	0,0	0,0	0,0	0,0	13,6	4,5

In the deciduous dentition molars are most affected in both jaws. Whereas on the right side the second molars are more affected, on the left side infestations are present to a higher degree in the first molars. Lesions in the canines are rare and visible only in two teeth of the right side. The incisors are affected not at all. However, for detailed statements about differences of left and right side the sample is too small.

tab. 87. Severity code of caries in deciduous dentition

position and severity	1oc	2oc	3oc	1ap	2ap	3ap	root
n	2	1	1	6	7	2	3
%	9,1	4,5	4,5	27,3	31,8	9,1	13,7

Most of the lesions occur in an apical position of the tooth crown with a severity stage of 1 (superficialis) and 2 (media). Severe lesions of stage 3 (profunda) are visible only in two teeth. Infestations on the occlusal surface are less frequent. Three individuals show lesions on the tooth root.

Dental caries in permanent teeth

Permanent dentition shows most of its lesions in the molars and premolars (tab. 88). Canines and incisors are not affected.

tab. 88. Proportion of affected teeth in permanent dentition

position	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
n aff.	1	3	2	1	0	0	0	0	0	0	0	0	0	3	2	1
% aff.	4,8	14,3	9,5	4,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	14,3	9,5	4,8
position	**48**	**47**	**46**	**45**	**44**	**43**	**42**	**41**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
n aff.	0	4	1	0	0	0	0	0	0	0	0	0	0	1	2	0
% aff.	0,0	18,9	4,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,8	9,5	0,0

tab. 89. Severity code of caries in permanent dentition

position and severity	1oc	2oc	3oc	1ap	2ap	3ap	root
n	17	0	0	1	2	1	0
%	81,0	0,0	0,0	4,8	9,4	4,8	0,0

In contrast to the deciduous dentition, permanent teeth show a high rate of mild occlusal infestation. The apical positions are just rarely affected.

Dental attrition

Attrition is a feature occurring also very early in life. Individuals around two to three years show first traces of abrasion of the tooth crown especially on the molars. The proportions of affected individuals in the single age categories are very high. In the category infans I 82,8% (24 out of 29 individuals) show attrition. Values in the category infans II is even higher with 93,8% (15 out of 16 individuals). In juveniles all eight individuals examined are affected (100%).

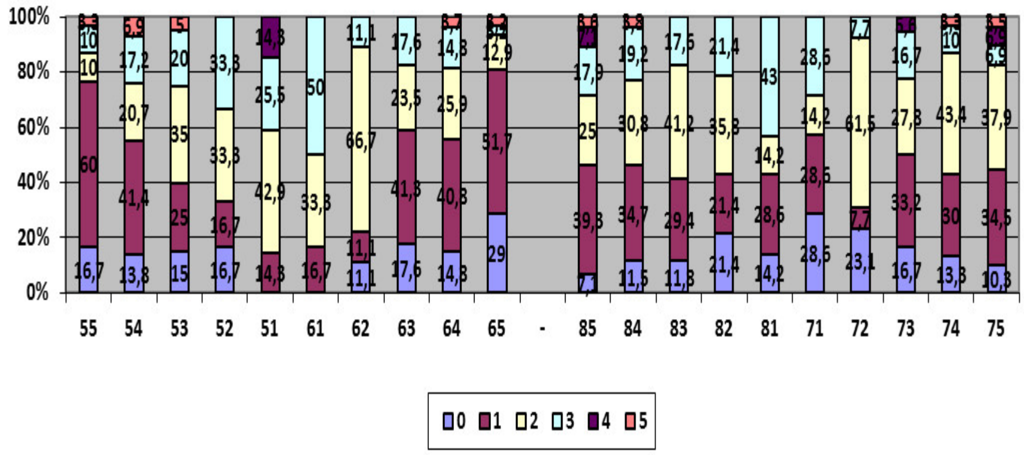


fig. 126. Severity code of attrition in deciduous teeth

The early occurrence of attrition in the Grevenmacher sample points out that infants were introduced to solid food around this age. This lead to the conclusion that weaning of the infants must have happened around the age of two to three years. Increasing dental attrition can be linked to an increased part of solid food in the dietary of the infants (Kreutz 1997). Molars and canines show the highest values of wear. That is to be expected because they are the kind of teeth that are in use for the longest time, moreover molars are normally most involved in the chewing process. Incisors in contrast erupt at first in the deciduous dentition, but are not directly used for chewing. Therefore, they show in general high values, but they do not reach the highest stages.

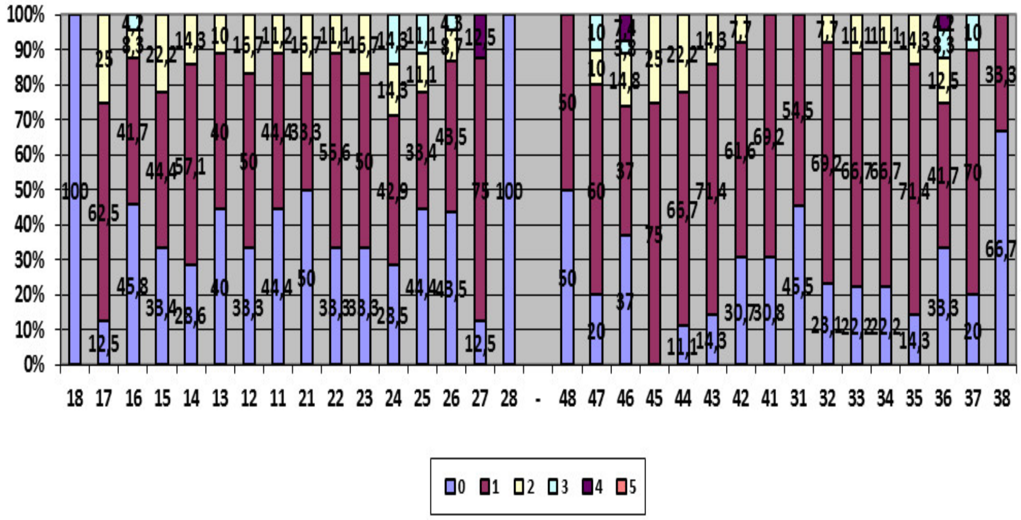


fig. 127. Dental attrition in permanent teeth

In permanent dentition attrition is in general less pronounced (fig. 127). Most of the studied individuals show a mixed dentition of deciduous and permanent teeth. Most of the permanent teeth are often not long in use, especially the incisors and canines and therefore, show no marked attrition. The first permanent molars erupt at the age of around six years (Ubelaker 1979) and are therefore teeth that are in use for the longest period of time. Already in younger age categories these first molars show the highest rates of attrition and this fact continues into adulthood (c.f. chapter 9).

Enamel hypoplasia

In seven out of 54 individuals with preserved teeth transverse enamel hypoplasia is visible. This means a percentage of 12,9%. This value is very low compared to other medieval series where rates from 40% to over 90% are a common occurrence (Kreutz 1997, Jungklaus 2010). The defects are present in form of transversal grooves at the vertical surface of the permanent teeth. The localization of hypoplasia on the tooth mirrors the time period of its occurrence. In the Grevenmacher individuals, most of the defects developed within the age of two to four years. A few show a formation in later years from four to six. This corroborates with outcomes from other studies (Kreutz 1997, Jungklaus 2010) and is often associated with the weaning of children. In this phase the infant is exposed to a variety of new pathogens, as well as, nutrients the child is not yet able to metabolise. This leads to an extremly stressful situation for the organism resulting in manifestations like enamel hypoplasia (Lewis 2007). Most of the affected teeth show only one clear groove and therefore, it can be assumed that this mirrors one phase of stress. More than one sign of hypoplasia has manifested in the teeth of two individuals, (ID 318; 955/360) 14-15 years old and (SA17; 939/357) 15-20 years of age (fig. 128). In these two cases a recurring exposure to stress in earlier life can be assumed. The causes for the development of hypoplasia apart from weaning stress are more variable. As etiology stress due to illness or hereditary and metabolic anomalies are also mentioned (Neiburger 1990, Palubeckaité et al. 2002, Roberts and Manchester 2007, Ogden et al. 2007).

fig. 128. Linear enamel hypoplasia on teeth of a 15-20 years old individual (SA17; 939/357)

Periapical lesions

Three individuals show lesions around the apex of the tooth root. One three to four year old individual (SA6; 417/88) shows a lesion 3,2 mm in diameter, around the root of the second left milk incisor (62). The second individual (ID 356; 371/138) (fig. 129), five to seven years of age shows severe lesions around the first and second upper molar of the left side (64, 65). Above the first molar a cavity of around 6 mm in diameter is visible. The inflammation concerned the root area of the first molar, as well as, the area around the first premolar (24) that is still in its cavity. In direct relation with that lesion is most probably the inflammation around the second molar (65). Here a cavity of 5 mm in diameter is visible in the alveolar bone. Inflammation occured in the bone around the tooth and lead to the partial dissolution of bone matrix around the tooth. Signs of inflammation are also visible on the outer surface of the maxilla in the area around the affected teeth. This inflammation of the facial bone is initiated by the discharge of puss from the tooth cavity that lead to inflammation of surrounding soft tissue and finally of the underlying bone.
The third case concerns a juvenile individual 15 to 20 years of age (SA20; 665/267). The first permanent upper molar of the left side (26) shows a severe caries lesion that lead to destruction of the tooth crown and exposure of the pulp cavity. An inflammation around the tooth apex occurred and left cavities of 3 and 4 mm in diameter.

fig. 129. Periapical lesion at a 5-7 years old individual (ID 356, 371/138)

10.7. Summary

The study of the non-adult human remains from Grevenmacher confirmed a close relationship between non-adults and adults within the population. This is visible on one hand in the morphognostic indices, where with increasing age a considerable approach to adult values is visible. On the other hand the non-metric traits show a great similarity in values and distributions in both groups.

The pathological changes diagnosed in non-adults differ from lesions found in adults. In contrast to degenerative features mainly found in the adult individuals, non-adults show illness related symptoms. Striking in the Grevenmacher sample, is the overall low rate of different symptoms in comparison to other series of non-adults from medieval times. This concerns the unspecific stress markers like Cribra orbitalia and enamel hypoplasia, and traces that are assigned to infectious diseases like endocranial lesions and periostitis. Bias of the results due to small sample size or insufficient preservation of the bones can be excluded. The results lead to the conclusion that the living conditions at Grevenmacher were overall good. Signs of malnutrition and an increase in infectious diseases are present, but were not as wide-spread as in other series (Jungklaus 2010). This is also the case in the adult individuals (see chapter 9). In spite of the low rates of different symptoms, almost 30% of the individuals show traces connected with infectious diseases. Most of these individuals are found in the age class infans I, that is also the category with the highest rate of death. It can be assumed that infectious diseases were the main cause of death, among many others, for non-adults in medieval times (Lewis 2007). This can also be assumed for Grevenmacher. However, only a few of the affected individuals survived long enough to develop manifestations visible on bones. Most of them died in the acute phase of the disease. Other causes of death do not leave traces on the bones.

The recorded measurement sections of the non adults divided by skeletal segments. The respective measurement sections are listed with their abbreviation, an English and German definition and citation.

tab. 90. Measurement sections of the skull

abbr.	definition English	definition German	author
M1	maximum cranial length	größte Schädellänge	Bräuer 1988
M5	basion-nasion length	Schädelbasislänge	Bräuer 1988
M8	maximum breadth	größte Schädelbreite	Bräuer 1988
M9	least frontal breadth	kleinste Stirnbreite	Bräuer 1988
M10	maximum frontal breadth	größte Stirnbreite	Bräuer 1988
M11	biauricular breadth	Biauricularbreite	Bräuer 1988
M12	biasterionic breadth	größte Hinterhauptsbreite	Bräuer 1988
M13	bimastoid breadth	Mastoidealbreite	Bräuer 1988
M17	basion-bregmatic height	Basion-Bregma-Höhe	Bräuer 1988
M20	auriculo-bregmatic height	Ohr-Bregma-Höhe	Bräuer 1988
W1	thickness of the skullcap	Kalottendicke	Gejvall 1963
W2	thickness of the skullcap at the Cruciform eminence	Kalottendicke im Bereich der Eminentia cruciformis	Gejvall 1963
M23	horizontal circumference	Horizontalumfang	Bräuer 1988
M24	transverse arc	Transversalbogen	Bräuer 1988
M25	total sagittal arc	Mediansagittalbogen	Bräuer 1988
M26	frontal sagittal arc	Mediansagittaler Frontalbogen	Bräuer 1988
M27	parietal sagittal arc	Mediansagittaler Parietalbogen	Bräuer 1988
M28	occipital sagittal arc	Mediansagittaler Occipitalbogen	Bräuer 1988
M29	frontal sagittal chord	Mediansagittaler Frontalsehne	Bräuer 1988
M30	parietal sagittal chord	Mediansagittaler Parietalsehne	Bräuer 1988
M31	occipital sagittal chord	Mediansagittaler Occipitalsehne	Bräuer 1988
M38	cranial capacity (Lee-Pearson 1901)	Schädelkapazität (Lee-Pearson 1901)	Bräuer 1988
M40	basion-prostion length	Gesichtslänge	Bräuer 1988
M42	gnathion-basion length	untere Gesichtslänge	Bräuer 1988
M43	outer biorbital breadth	Obergesichtsbreite	Bräuer 1988
M44	biorbital breadth	Biorbitalbreite	Bräuer 1988
M45	bizygomatic breadth	Jochbogenbreite	Bräuer 1988
M47	total facial height	Gesichtshöhe	Bräuer 1988
M48	upper facial height	Obergesichtshöhe	Bräuer 1988
M50	anterior interorbital breadth	vord. Interorbitalbreite	Bräuer 1988
M51	orbital breadth	Orbitalbreite	Bräuer 1988

(tab. 90. continued)

abbr.	definition English	definition German	author
M52	orbital height	Orbitalhöhe	Bräuer 1988
M54	nasal breadth	Nasenbreite	Bräuer 1988
M55	nasal height	Nasenhöhe	Bräuer 1988
M60	maxillo-alveolar length	Maxilloalveolarlänge	Bräuer 1988
M61	maxillo-alveolar breadth	Maxilloalveolarbreite	Bräuer 1988
W17	transverse Breadth of Capitulum mandibulae	transversale Breite des Caput mandibulae	Wahl 1988
M65	bicondylar breadth	Kondylenbreite des Unterkiefers	Bräuer 1988
M66	bigonial breadth	Winkelbreite des Unterkiefers	Bräuer 1988
M68	projective length of the Corpus mandibulae	Unterkieferlänge	Bräuer 1988
M69	height of the mandibular symphysis	Kinnhöhe	Bräuer 1988
M70	condyloid height	Asthöhe	Bräuer 1988
M71	condyloid breadth	Astbreite	Bräuer 1988
M79	mandibular angle	Astwinkel UK	Bräuer 1988
f.l.	frontal length	Os frontale Länge	Kósa 1978
f.b.	frontal breadth	Os frontale Breite	Kósa 1978
t.h.	temporal height	Os temporale Höhe	Kósa 1978
t.b.	temporal breadth	Os temporale Breite	Kósa 1978
o.h.	occipital height	Os occipitale Höhe	Kósa 1978
o.b.	occipital breadth	Os occipitale Breite	Kósa 1978
s.b.	breadth of the Corpus ossis sphenoidalis	Corpus ossis sphenoidalis Breite	Kósa 1978
p.p.l.	length of the Pars petrosa	Pars petrosa Länge	Kósa 1978
p.b.l.	length of the Pars basilaris	Pars basilaris Länge	Kósa 1978

tab. 91. Measurement sections of the shoulder, spine and pelvis

abbr.	definition English	definition German	author
Cl1	maximum length of the clavicle	größte Länge der Clavicula	Bräuer 1988
Cl4	vertical mid-shaft diameter	vertikaler Durchmesser der Mitte	Bräuer 1988
Cl5	sagittal mid-shaft diameter	sagittaler Durchmesser der Mitte	Bräuer 1988
Cl6	circumference of the mid-shaft	Umfang der Mitte	Bräuer 1988
SaW24	transverse breadth of the Pars lateralis	transversale Breite der Pars lateralis im Bereich der Basis	Wahl 1988
Ilium l.	length of the Os ilium	Länge des Os ilium	Schutkowksi 1983
Ilium b.	breadth of the Os ilium	Breite des Os ilium	Schutkowksi 1983
Gsn. d.	depth of the Greater sciatic notch	Tiefe der Incisura ischiadica major	Schutkowksi 1983
Gsn. w.	with of the Greater sciatic notch	Weite der Incisura ischiadica major	Schutkowksi 1983

tab. 92. Measurement sections of the upper limbs

abbr.	definition English	definition German	author
Hu1	maximum length of the humerus	größte Länge der Humerusdiaphyse	Bräuer 1988
Hu4	bi-epicondylar width	Epicondylenbreite	Bräuer 1988
Hu5	maximum mid-shaft diameter	größter Durchmesser Diaphysenmitte	Bräuer 1988
Hu6	minimum mid-shaft diameter	kleinster Durchmesser Diaphysenmitte	Bräuer 1988
Hu7	least circumference of the mid-shaft	kleinster Umfang der Diaphyse	Bräuer 1988
Hu9	transverse head diameter	größter transversaler Durchmesser des Caput	Bräuer 1988
HuW28	wall thickness of the mid-shaft	Wanddicke	Gejvall 1963
Ra1	maximum length of the radius	größte Länge der Radiusdiaphyse	Bräuer 1988
Ra3	Minimal circumference	kleinster Umfang	Bräuer 1988
Ra4	maximum transverse shaft diameter	transveraler Durchmesser des Schaftes	Bräuer 1988
Ra5	minimum sagittal shaft diameter	sagittaler Durchmesser des Schaftes	Bräuer 1988
Ra5(6)	distal maximum breadth	untere Epiphysenbreite	Bräuer 1988
RaW33	wall thickness of mid-shaft	Wanddicke in der Diaphysenmitte	Gejvall 1963
Ul1	maximum length of the ulna	größte Länge der Ulnadiaphyse	Bräuer 1988
Ul11	dorso-ventral shaft diameter	dorso-volarer Durchmesser der Schaft-mitte	Bräuer 1988
Ul12	transverse shaft diameter	transversaler Durchmesser des Schaftes	Bräuer 1988

(maximum length of humerus (Hu1), radius (Ra1) and ulna (Ul1) means the diaphysal length without epiphysis) tab. 93. Measurement sections of the lower limbs

abbr.	definition English	definition German	author
Fe1	maximum length of the femur	größte Länge der Femurdiaphyse	Bräuer 1988
Fe6	sagittal mid-shaft diameter	sagittaler Durchmesser der Diaphysenmitte	Bräuer 1988
Fe7	transverse mid-shaft diameter	transversaler Durchmesser der Diaphysenmitte	Bräuer 1988
Fe8	circumference of the midshaft	Umfang der Diaphysenmitte	Bräuer 1988
Fe9	subtrochanteric sagittal diameter	oberer transversaler Diaphysendurchmesser	Bräuer 1988
Fe10	subtrochanteric transverse diameter	oberer sagittaler Diaphysendurchmesser	Bräuer 1988
Fe19	transverse diameter of the head	transversaler Durchmesser des Caput	Bräuer 1988
Fe21	bicondylar width	Epicondylenbreite	Bräuer 1988
FeW43	breath of the Linea aspera	Breite der Linea aspera	Wahl 1988
FeW44	wall thicknes of the midshaft	Wanddicke im mittleren Diaphysenbereich	Gejvall 1963
Ti1	maximum length of the tibia	Länge der Tibiadiaphyse	Bräuer 1988
Ti3	bicondylar breadth	größte proximale Epiphysenbreite	Bräuer 1988
Ti6	transverse diameter of distal epiphysis	größte distale Epiphysenbreite	Bräuer 1988
Ti8	sagittal mid-shaft diameter	größter Durchmesser der Schaftmitte	Bräuer 1988
Ti8a	sagittal diameter at nutrient foramen	sagittaler Durchmesser auf Höhe des Foramen nutritium	Bräuer 1988
Ti9	transverse mid-shaft diameter	transversaler Durchmesser der Schaftmitte	Bräuer 1988
Ti9a	transverse diameter at nutrient foramen	transversaler Durchmesser auf Höhe des Foramen nutritium	Bräuer 1988
Ti10	circumference of the mid-shaft	Umfang der Diaphyse	Bräuer 1988
Ti10a	circumference at nutrient foramen	Umfang der Diaphyse auf Höhe des Foramen nutritium	Bräuer 1988
Ti10b	minimum circumference of the shaft	kleinster Unfang der Diaphyse	Bräuer 1988
Fi1	maximum length of the fibula	größte Länge der Fibuladiaphyse	Bräuer 1988
Pat1	maximum height of the patella	Höhe der Patella	Bräuer 1988
Pat2	maximum breadth of the patella	transversale Breite der Patella	Bräuer 1988
Pat3	maximum thickness of the patella	maximale Dicke der Patella	Bräuer 1988
Ta1	talar length	Länge des Talus	Bräuer 1988
Ca1	maximum length of the calcaneus	größte Länge des Calcaneus	Bräuer 1988

(maximum length of femur (Fe1), tibia (Ti1) and fibula (Fi1) means the diaphysal length without epiphysis) tab. 94. Body height of non-adult individuals according to Telkkä et al. (1962)

ID. No.	Age	Sex	Body height	ID. No.	Age	Sex	Body height
SA1	12-14	(male)	135,3	302	10-12	indeterm.	122,4
SA2	9-11	(male)	122,9	304	5-7	(male)	97,2
SA3	5-7	(male)	101,1	308	0-6 months	(female)	51,5
SA4	10-12	(male)	124,7	318	11-14	(male)	145,2
SA5	5-8	(male)	102,3	326	7-10	(male)	110,0
SA6	3-4	(male)	89,3	330	10-15	indeterm.	153,9
SA7	13-15	(male)	143,7	332	6-7	(male)	101,1
SA8	3-5	(female)	86,1	334	12-14	indeterm.	134,9
SA10	5-6	(male)	97,3	337	2-4	(female)	86,1
SA11	4-5	(female)	92,1	338	~6 months	indeterm.	60,3
SA12	8-10	(male)	117,5	341	0-6 months	(male)	57,6
SA13	2-3	indeterm.	84,3	356	5-7	(female)	97,9
SA14	15-20	male	182,4	363	9-11	indeterm.	118,3
SA16	18-20	female	159,4	365	9-11	(male)	120,7
SA17	15-20	(male)	160,1	367	4-6	(male)	93,2
SA18	12-15	(male)	160,0	368	7-8	(male)	108,1
SA19	13-15	(female)	139,9	370	8-9	(female)	109,8
SA20	15-20	female	154,4	377	2-4	indeterm.	88,1
SA21	16-20	male	162,9	502	9-11	indeterm.	120,7
SA22	17-20	(female)	162,3	513	4-7	(female)	110,0
SA23	9-11	(male)	122,6	524	9-10	(male)	114,6
SA24	10-13	(male)	126,9	534	4-6	(male)	97,7
SA25	4-7	(male)	89,3	562	5-8	(male)	98,4
SA26	7-9	indeterm.	103,7	568	2-4	(female)	85,2
SA27	2-3	(male)	80,9	575	8-11	(male)	117,2
SA28	7-8	(male)	109,5	576	1-2	(male)	73,8
SA29	2-3	indeterm.	80,5	577	7-9	indeterm.	112,6
SA31	1-2	(male)	72,6	582	8-10	indeterm.	117,6
SA32	8-9	(male)	110,7	621	7-9	(male)	107,2
SA33	1-2	(female)	74,6	628	1-3	(female)	78,3
SA39	1-2	(male)	72,0	656	0-6 months	(female)	56,6
SA40	1-2	(female)	71,6	657	6-12 months	(male)	64,3
SA43	0-3 months	(male)	52,0	666	2-4	(female)	83,4
SA44	7-9 lunar m.	(male)	42,4	675	4-5	(female)	91,6
SA45	0-6 months	indeterm.	54,3				
SA46	7-9 lunar m.	(male)	42,5				

(tab. 94. continued)

ID. No.	Age	Sex	Body height	ID. No.	Age	Sex	Body height
SA47	0-3 months	indeterm.	52,1				
SA49	0-3 months	(male)	52,5				
SA50	6-12 months	(male)	63,6				
SA51	0-6 months	(female)	52,0				
SA52	0-1	indeterm.	51,4				
SA53	0-1	Indeterm.	52,7				

tab. 95. Indices of the skull of non-adults

ID	age	sex	l-w	l.-h	w-h	l-earh.	w-earh.	jugofr	jugo-mand.	face	upper face	orbi-tal	nasal
SA3	6-7	(m)	65,1			67,4	103,6	110,5	75,8	85,3	52,6	90,0	48,8
SA4	11-12	(m)	75,4			60,2	79,8						
SA5	5-8	(m)	66,1			64,6	97,6						
SA8	3-5	(f)	72,5			57,7	79,5	111,4	75,0	87,5	52,1	54,5	52,9
SA10	5-6	(m)	76,0			58,5	76,9						
SA15	15-17	(m)	77,8	74,1	94,1	65,5	84,2	98,2		81,6	47,7	87,9	51,2
SA16	18-20	f	76,3	68,4	89,6	56,5	74,1	95,6	80,0	88,7	53,9	91,9	50,0
SA17	15-20	(m)	72,8	72,8	100,0	59,8	82,1						
SA19	13-15	(f)	76,9	67,0	87,1	65,4	85,0	100,0	66,0	100,0	64,1	108,8	50,0
SA20	15-20	f					78,2						
SA21	16-20	m	75,1	67,3	89,6	57,0	75,9	97,5	77,9	91,0	56,6	89,7	42,8
SA22	17-20	(f)	75,9			58,5	77,0	97,4	79,3	90,5	56,0	84,2	47,9
SA24	10-13	(m)	64,6			68,0	105,3						
306	7-9	ind.	76,4	74,5	97,6	63,0	82,5						
310	5-7	ind.	74,5										47,5
314	4-5	(f)				67,7						90,9	53,1
326	7-10	(m)							71,8	91,3	51,4	93,9	52,5
356	5-7	(f)	81,4										48,7
370	8-9	(f)	59,4			58,3	98,2						
501	6-7	ind.	58,0										48,8
534	4-6	(m)	83,7			68,7	82,1	116,7	66,7	97,8	61,1	96,8	45,0
568	2-4	(f)	95,1										
569	2-4	(f)	67,0			50,0	74,6						
575	8-11	(m)	70,1	71,8	102,4	62,6	89,3	100,0	73,6	90,6	56,6	83,3	51,3
621	7-9	(m)	77,4			66,1	85,4						
628	1-3	(f)	77,9			63,8	81,9	114,9	72,4	85,0	50,6	87,5	53,5

Abbreviations: l-w=length-thickness; l-h=length-height; w-h=width-height; l-earh.=length-ear-height; w-earh.=width-earheight; jugofr=jugofrontal; jugomand.=jugomandibularis, cap.=skull capacity) tab. 96. Indices of the infra-cranium of non-adults

ID	age	sex	Hu leng-thick		Humero-radial		Femoro-humeral		Fe leng-thick		Fe robustness		Fe platy	
			ri	le	ri	le	ri	le	ri	le	ri	le	ri	le
SA1	12-14	(m)	19,2						18,0	18,2	11,4	11,2	81,8	78,3
SA2	9-11	(m)	20,7	20,7	77,4		72,7	71,4	19,5	19,3	12,5	11,7	90,5	73,9
SA3	5-7	(m)	26,7	26,7	84,8	80,9	67,9	67,1	20,8	20,5	12,5	12,0	88,9	84,2
SA4	10-12	(m)							18,5	18,4	11,6	11,5	77,3	80,9
SA5	5-8	(m)	22,7	23,7	76,2		76,8	75,4	20,5	21,0	12,9	12,5	88,2	83,3
SA6	3-4	(m)							22,7	22,2	12,9	13,0	75,0	75,0
SA7	13-15	(m)		18,4		75,7		71,2	19,1	17,6	12,1	11,7	71,4	74,1
SA8	3-5	(f)	30,6	31,8			79,3	77,6	29,0	28,2	17,7	17,1	78,9	75,0
SA10	5-6	(m)	22,5	22,9	73,1	76,4	73,7	73,0	19,3	20,0	12,0	12,1	87,5	87,5
SA11	4-5	(f)	24,3		75,0		73,5		21,4		12,7		82,3	
SA13	2-3	ind.							24,1		14,1		86,7	
SA14	15-20	m	19,2		80,2		71,8		18,9		12,4		65,8	
SA16	18-20	f	18,2		66,2		73,5		17,4	17,7	11,2	11,2	84,6	78,6
SA17	15-20	(m)		21,2		76,7								
SA18	12-15	(m)							19,9	19,4	12,7	12,5	88,9	96,0
SA19	13-15	(f)	22,5	22,5	74,3									
SA20	15-20	f	18,5	18,5	76,8	77,8	71,7	68,7	18,7	18,8	11,7	11,7	84,0	91,7
SA21	16-20	m	19,9	19,9	75,4	74,1	71,7	67,3	19,9	19,8	11,9	12,3	82,7	89,6
SA22	17-20	(f)	16,9	17,3	69,6		73,5	72,6	17,8	18,0	10,9	11,3	81,5	88,0
SA23	9-11	(m)	19,0	19,1	70,2	70,7								
SA24	10-13	(m)	21,0	21,2	74,4	74,2	71,8	70,2	19,6	20,1	12,4	12,3	73,9	73,9
SA25	4-7	(m)	26,1	25,5	74,6	73,7	73,4	77,0	22,9	24,0	14,4	14,2	87,5	81,2
SA26	7-9	ind.							19,8		12,2		93,0	96,7
SA27	2-3	(m)	26,8	27,9		74,6		80,8				15,2	81,2	93,3
SA28	7-8	(m)							19,7		13,5		77,3	85,0
SA29	2-3	ind.	30,7	30,3		80,8		77,3	27,4	27,3	14,6		92,3	84,6
SA40	1-2	(f)							28,4	29,5	17,1	16,4	76,9	84,6
SA43	0-3 m	(m)				81,8	88,0		26,7		17,3		72,4	
SA44	7-9 lm	(m)			80,2	79,6	89,5	91,1			16,4	16,2	96,4	90,7
SA46	7-9 lm	(m)			79,3	77,2								
SA49	0-3 m	(m)					88,3				15,7		84,4	
SA51	0-6 m	(f)			83,3	81,8	86,8	8,0			14,3	14,4	80,7	90,4
SA53	0-1	ind.									17,6		82,0	

(tab. 96. continued)

ID	age	sex	Hu leng-thick ri	Hu leng-thick le	Humero-radial ri	Humero-radial le	Femoro-humeral ri	Femoro-humeral le	Fe leng-thick ri	Fe leng-thick le	Fe robustness ri	Fe robustness le	Fe platy ri	Fe platy le
302	10-12	ind.								20,0		11,9	95,0	85,7
304	5-7	(m)		20,4					18,9		12,6		87,5	
308	0-6 m	(f)			78,5	81,2	85,5	84,2						
318	11-14	(m)		19,9		74,1		69,2						77,8
326	7-10	(m)		24,7		72,6		70,2	20,6	20,7	13,1	12,8	73,9	77,3
329	16-20	(m)											67,7	68,7
330	10-15	ind.											62,5	70,0
332	6-7	(m)		21,9					20,4		13,0		94,4	88,8
341	0-6 m	(m)				80,3		85,4		29,2		17,3		90,5
356	5-7	(f)	20,7	21,1		71,4								108,3
367	4-6	(m)	21,5										87,5	93,3
370	8-9	(f)											84,2	84,2
524	9-10	(m)	20,3	20,3										
534	4-6	(m)		23,9									88,2	88,9
562	5-8	(m)	23,9	24,5	76,1	76,1	72,9	72,6					88,2	83,6
568	2-4	(f)	23,8											92,3
576	1-2	(m)	27,3	27,1	76,5	75,7	84,1	84,9	27,0	30,1	15,9	15,9	71,4	83,3
621	7-9	(m)		23,2		72,4		72,3					80,8	73,9
628	1-3	(f)	27,3	26,7			82,4	81,1					85,7	78,6
656	0-6 m	(f)	22,2	25,1	80,0	80,0	89,3	87,0	36,9	37,6	22,6	21,2	90,9	90,9
657	6-12 m	(m)											90,9	90,9

(Abbreviations of the indices: Hu leng-thick= Humerus length-thickness; Fe leng-thick=Femur length-thickness; Fe platy= Femur platymericus) tab. 97. Indices of the infra-cranium of non-adults

ID	age	sex	Femur pilastricus ri	le	Femoro-tibial ri	le	Tibia cnemicus ri	le	Scaro-clavicular ri	le
SA1	12-14	(m)	111,1	111,1						
SA2	9-11	(m)	111,8	112,5	80,4	80,0	85,7	85,7	19,6	20,2
SA3	5-7	(m)	107,1	115,4	80,1	79,0	83,3	88,2	32,5	30,0
SA4	10-12	(m)	100,0	100,0	82,5	83,3	77,3	81,8	37,2	
SA5	5-8	(m)	107,1	100,0	80,8	80,8	94,1	83,3		
SA6	3-4	(m)	100,0	100,0		81,0	73,3	86,7		
SA7	13-15	(m)	104,8	110,0	81,1	79,9	119,0	120,0		
SA8	3-5	(f)	100,0	114,3	79,3	78,2	93,7	88,9		
SA10	5-6	(m)	100,0	100,0	77,9		114,3	87,5		
SA11	4-5	(f)	92,3	108,3			87,5	93,3		
SA12	8-10	(m)					85,7	85,7		
SA13	2-3	ind.	100,0		80,0		92,8	100,0		
SA14	15-20	m	114,8	107,7	89,7		73,0	73,7		
SA16	18-20	f	104,3	95,8	81,4	79,7	64,5	61,3		30,5
SA17	15-20	(m)								28,2
SA18	12-15	(m)	121,7	121,7		80,4		71,0		
SA20	15-20	f	104,5	109,1	84,7	79,6	75,0	72,4	33,1	31,1
SA21	16-20	m	100,0	10,7,7	80,5	80,4	80,5	80,4	16,4	27,3
SA22	17-20	(f)	109,1	104,3	80,3	81,7	72,4	70,0	32,0	32,6
SA24	10-13	(m)	90,0	90,0	80,3	78,3	82,6	79,2	37,2	
SA25	4-7	(m)	107,7	100,0	80,8	83,1	93,7	100,0		
SA26	7-9	ind.	100,7	100,7	80,2		94,5	87,6		
SA27	2-3	(m)	130,0	109,1			92,3			
SA28	7-8	(m)	105,9	94,4	79,1		85,7	85,7		
SA29	2-3	ind.	90,9	90,9			90,9	91,7		
SA40	1-2	(f)	90,9	100,0	82,9	82,8	91,7	91,7		
SA43	0-3 m	(m)	85,7		88,0		110,4	102,9		
SA44	7-9 lm	(m)	102,2	106,9	88,8	89,1	92,3	100,0		
SA47	0-3 m	ind.					92,7	89,0		
SA49	0-3 m	(m)	83,3				86,1	90,7		
SA51	0-6 m	(f)	94,6	96,4	86,8	86,7	92,4	94,0		
SA53	0-1	ind.	88,6		94,7		94,2	83,9		

(tab. 97. continued)

ID	age	sex	Femur pilastricus ri	/ le	Femoro-tibial ri	/ le	Tibia cnemicus ri	/ le	Scaro-clavicular ri	/ le
302	10-12	ind.	118,7	112,5		84,2	80,9	80,9		
304	5-7	(m)	100,0		76,6		87,5			
308	0-6 m	(f)	90,0	91,5			107,5	116,4		
318	11-14	(m)		115,8						
326	7-10	(m)	94,4	100,0	79,4		95,2			
329	16-20	(m)	100,0	100,0			80,0			
330	10-15	ind.	113,6	113,6						
332	6-7	(m)	114,3	107,1	79,6		94,4	85,0		
341	0-6 m	(m)	91,5	90,1		84,3	80,0	80,0		
356	5-7	(f)		110,0						
367	4-6	(m)	92,8	92,8			92,8	93,3		
370	8-9	(f)	113,3	121,4			78,9	75,0		
502	9-11	ind.					80,9	80,9		
534	4-6	(m)	107,1	107,1						
562	5-8	(m)	106,7	93,3			88,1	83,3		
568	2-4	(f)		109,1						
576	1-2	(m)	100,0	100,0		80,1		83,3		
621	7-9	(m)	106,2	106,2			80,9	85,0		
628	1-3	(f)	90,9	91,7			85,7	85,7		
656	0-6 m	(f)	111,1	100,0		88,2		111,1		
657	6-12 m	(m)	80,0	80,0			90,0	90,0		

11. Social stratification and group formation on the cemetery

Within the framework of the investigation of the cemetery of Grevenmacher, one question that is posed by archaeologist, as well as, anthropologist is the reconstruction of social stratification. In medieval times it was a custom that members of higher social status were buried within or in close proximity to the church building (Ohler 1990, Illi 1992). This was certainly the case in Grevenmacher. One fact that supports this theory is that in Grevenmacher, individuals buried within the church were laid in wooden coffins, whereas in the cemetery wooden furnishing of graves was very rare (Bis-Worch 2005). Therefore, it can be assumed that the position of an individual on the cemetery mirrors its social status. This raises the question if such a social differentiation is also visible in the bone material. Studies dealing with activity patterns (Havelková et al. 2011) or body height (Czarnetzki et al. 1983), confirm that it is quite possible to assign differences in bone manifestations to different social classes. Therefore, an attempt was made to evaluate characteristics in the bone material that supports a social stratification within the population of Grevenmacher.

For this purpose a group of 56 individuals was formed. The individuals used in this study consisted of 18 individuals buried within the church building, as well as, 38 individuals buried in close proximity. However, one problem in the selection of the respective individuals from the outer area is the lack of a visible delimitation between grave groups. On this account an artificial separation was created to divide individuals in close proximity to the church from individuals from the main area of the cemetery (fig. 130). The aim was to obtain a statistical amount of individuals in the separated groups, and not to include too many individuals from the main area. For the separated group consisting of 28 males, as well as, 28 females, different features like body height, activity patterns, as well as, different pathological changes were evaluated and compared with data gained from individuals buried at the main area of the cemetery.

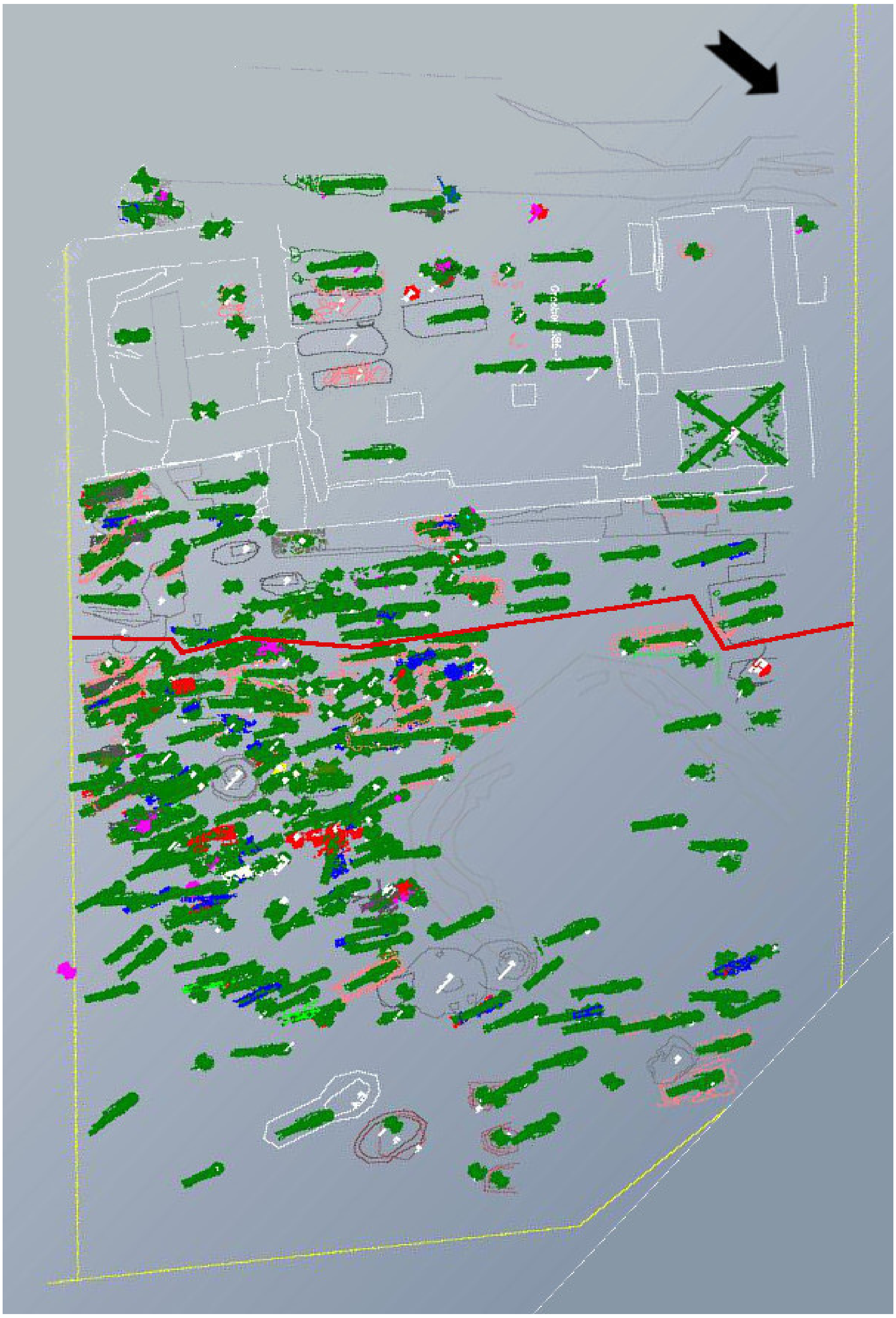


fig. 130. Site map of the cemetery, red line separates the two samples (Plan: CNRA Luxembourg)

11.1. Body height

Numerous studies examined the relation between body height and social status in past populations and emphasized the correlation of a taller stature of individuals from higher social classes often associated with a better nutritional status (Czarnetzki et al. 1983, Floud et al. 1990, Schweich and Knüsel 2003). This approach was assigned to the two Grevenmacher samples and tested if individuals buried around the church show higher values in body height compared to individuals from the rest of the cemetery.

tab. 98. Body height of males and females from the cemetery

	♂					♀				
formula	n	x	range	s	v	n	x	range	s	v
Breitinger 1938	71	169,1	159,9-178,9	4,06	19,0					
Bach 1965						71	161,1	154,3-169,6	3,42	15,3
Olivier 1978	80	168,3	154,5-186,4	6,08	31,9	71	159,1	148,4-171,1	5,23	22,7
Pearson 1899	76	166,1	154,8-179,1	4,82	24,3	72	156,3	147,9-168,3	4,26	20,4
TG-AW 1952	76	170,5	158,1-182,6	5,88	24,5	72	160,9	149,7-176,3	5,93	26,6
TG-AN 1952	76	165,8	153,5-179,4	5,31	25,9	72	157,4	147,2-171,3	5,10	24,1
Siegmund Kombi. 2010	76	167,4	156,1-178,7	5,18	22,6	72	158,0	148,5-168,9	4,95	20,4

tab. 99. Body height of males and females from within and around the church

	♂					♀				
formula	n	x	range	s	v	n	x	range	s	v
Breitinger 1938	23	170,0	162,4-179,1	3,74	16,7					
Bach 1965						20	161,0	152,1-169,5	3,74	17,4
Olivier 1978	26	168,5	156,9-180,9	5,42	24,0	20	160,6	153,6-174,5	5,11	21,1
Pearson 1899	24	166,8	158,0-176,7	4,04	18,7	20	156,6	150,5-163,8	3,36	13,3
TG-AW 1952	24	171,7	159,8-184,4	5,46	24,5	20	161,2	154,8-170,4	4,12	15,5
TG-AN 1952	24	166,9	156,4-178,0	4,94	21,6	20	157,7	151,5-165,9	3,70	14,4
Siegmund Kombi. 2010	24	168,5	158,1-179,7	4,75	21,6	20	158,5	152,3-166,7	3,68	14,4

The evaluation of the body height show slight differences between the two samples. Values from the church sample are higher in males and females compared to the cemetery sample (tab. 98,tab. 99). The differences in the respective formulas range between two and twelve millimeters in males and one and 15 millimeters in females, but they are not statistically significant. Even if the differences are very small, it is noticeable that all formulas resulted in higher values in the church sample.

11.2. Degenerative changes

The next step in the evaluation of possible differences due to different social status is the comparison of degenerative features on the bone. For this purpose degenerative changes of the joints and spine in both samples were examined and compared. The recording of the specific characteristics followed the classification of Schultz (1988) which was described in chapter 9: pathological changes.

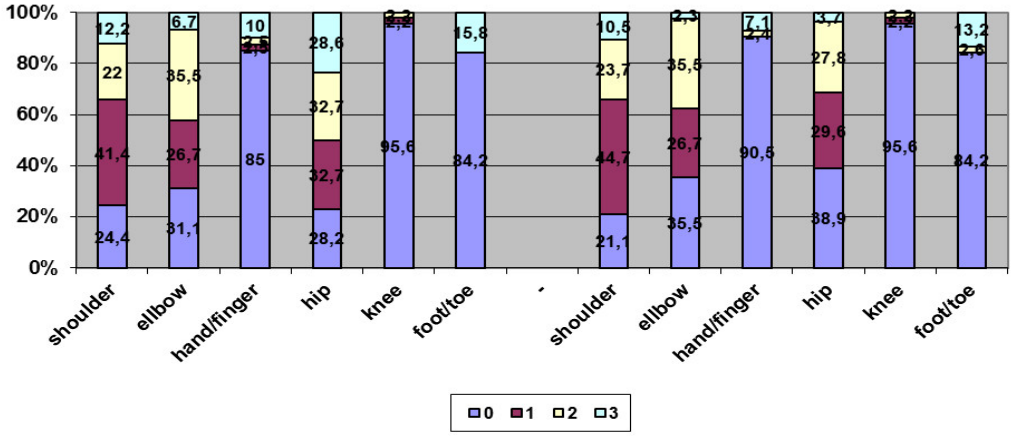


fig. 131. Severity code of degenerative changes of males from the cemetery, right and left body side

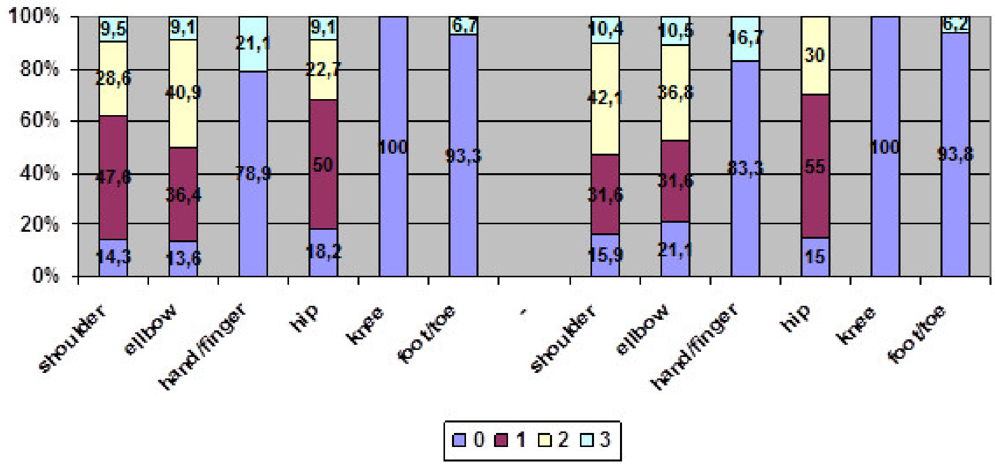


fig. 132. Severity code of degenerative changes of males from the church, right and left body side

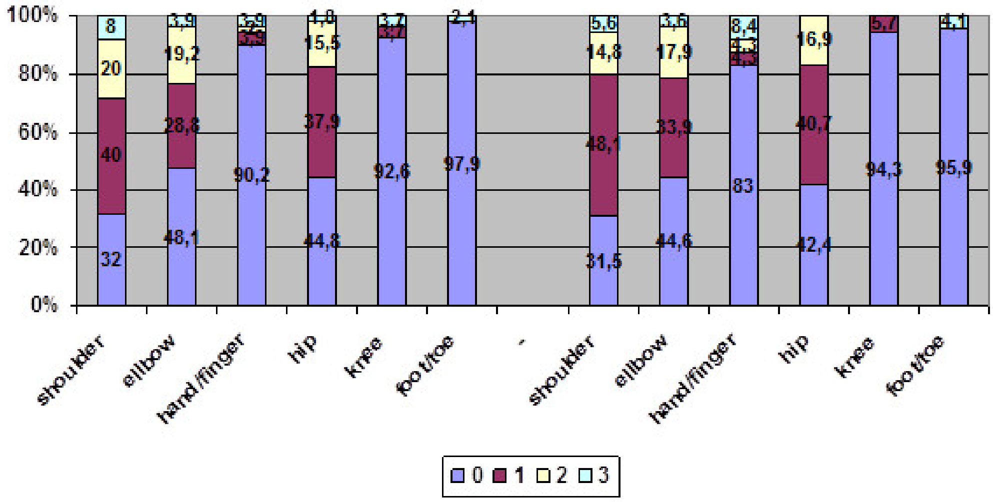


fig. 133. Severity code of degenerative changes of females from the cemetery, right and left body side

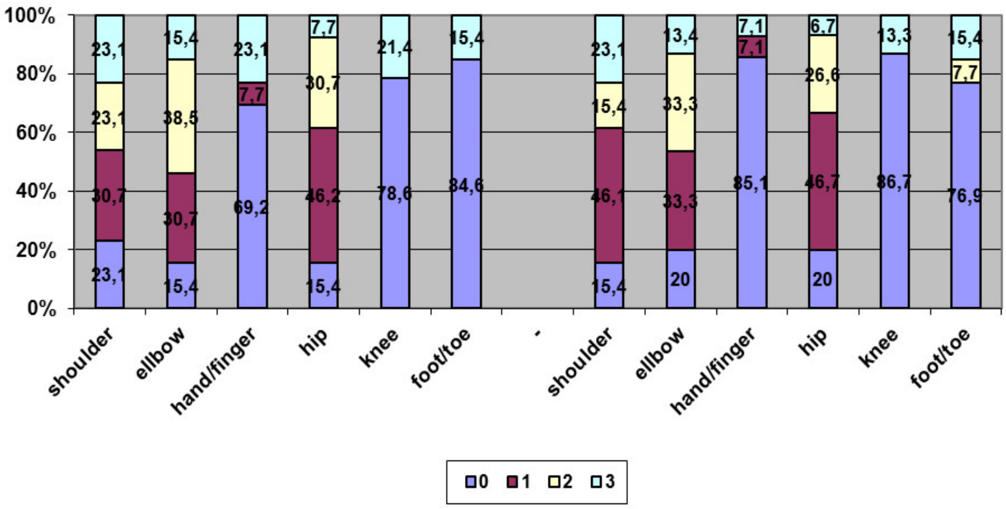


fig. 134. Severity code of degenerative changes of females from the church, right and left body side

Figures 131 to 134 show the distribution and characteristics of degenerative changes of the joints for the cemetery and church sample, separated for males and females. In males the distribution in the single joints is more or less the same with only slightly higher values in the church sample. In the females, also individuals of the church sample show overall more severe manifestations, whereas the differences are more pronounced than in males. In addition to the evaluation of changes of the joints, degenerative manifestations of the spine were also considered. For this purpose the occurrence of spondylosis, spondylarthrosis, as well as, Schmorl's nodes were compared in both samples. The occurrence and distribution of lesions in all three vertebral areas of the thoracic and lumbar spine follows the main distribution visible in the evaluation of the whole population, discussed in chapter 9: pathological changes. This is the case for both samples, as well as, both sexes. In direct comparison between the samples, individuals from the church show overall more severe manifestations, especially in the females, whereas these differences are not significant.

On the basis of degenerative changes, no separation of the two samples is possible that would support a differentiation due to different social status. If we suppose an increased physical activity in individuals from lower social rank, degenerative changes should be more severe in the cemetery sample. In our study we find the opposite case. It is quite possible that the increased values in the church sample especially in the females originate from an unbalanced age distribution within the group. In the cemetery sample only 36,3% of all females belong to the age categories early maturus (40-50 years) or late maturus and older (over 50 years). However in the church sample 66,6% of all female individuals can be assigned to these two age classes. In males this difference is not as pronounced as in the female samples. Here 57,9% individuals in the oldest age classes in the cemetery sample are compared with 62,5% in the church sample. Therefore, it is quite possible that the more or less balanced results in males and the more unbalanced outcomes in the females are rather an expression of age distribution than an activity related feature. To verify this theory, only individuals from the age classes maturus (40-50 years) and late maturus and older (over 50 years) were compared again. The results support the assumption of an age related influence because in this age categories, the differences between the cemetery and church sample are even more pronounced in both sexes. The fact that age has an influence on the manifestation of degenerative changes in the Grevenmacher material is already discussed in chapter 9: pathological changes. Furthermore studies of Knüsel et al. (1997) also confirm a superimposition of age effects over activity related features on joints of the vertebral column.

11.3. Entheseal changes

In their study Havelková et al. (2011) found significant differences in the manifestation of entheseal changes between population groups from different social status on early medieval Slavic cemeteries from Great Moravia. Individuals from an agricultural environment show a higher prevalence of entheseal changes than individuals associated with a castle. Based on the assumption that individuals from a higher social rank are engaged to a lesser extent in hard physical work and therefore develop lesser manifestations on specific enthesis, the specific areas on the bones of the two Grevenmacher samples were evaluated and compared.

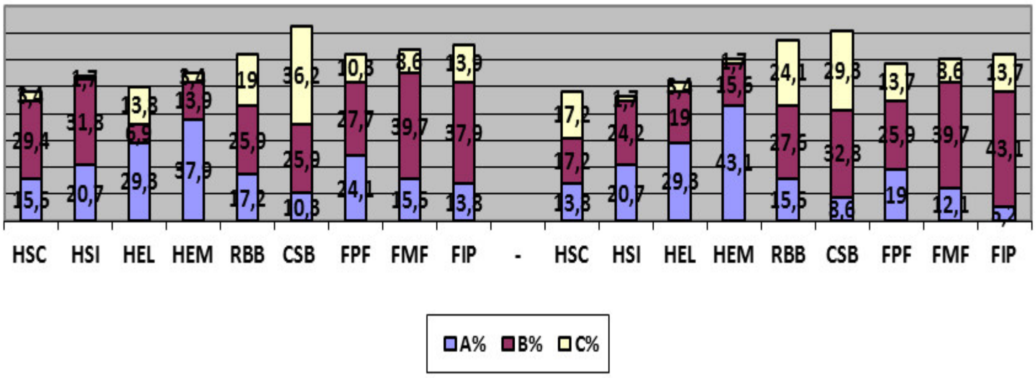


fig. 135. Severity code of entheseal changes of males from the cemetery, right and left body side

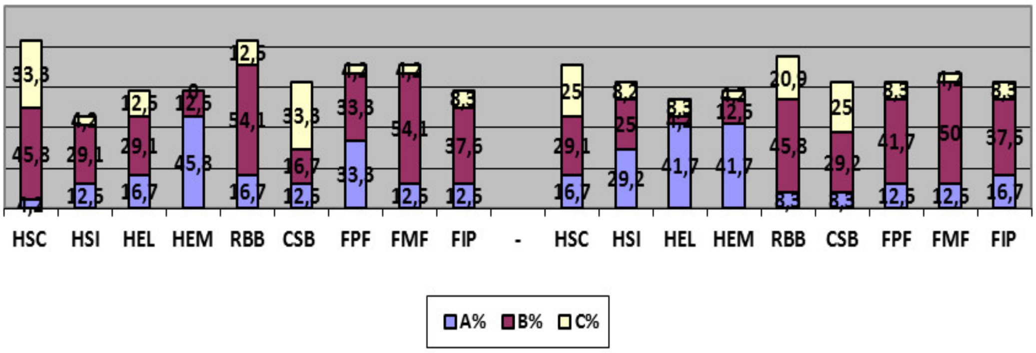


fig. 136. Severity code of entheseal changes of males from the church, right and left body side

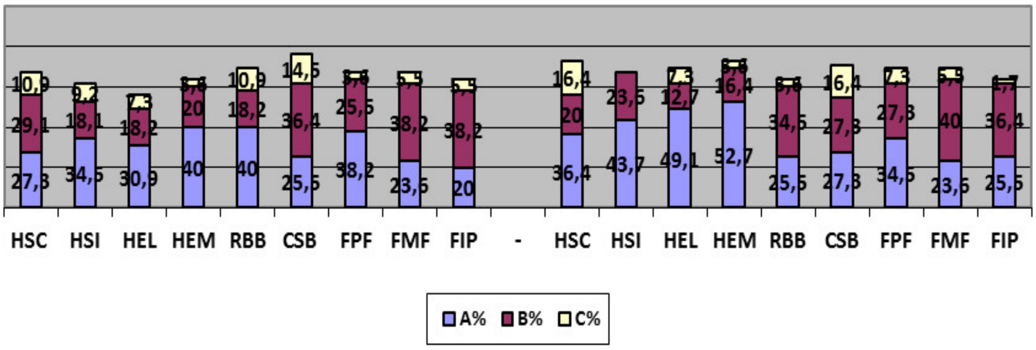


fig. 137. Severity code of entheseal changes of females from the cemetery, right and left body side

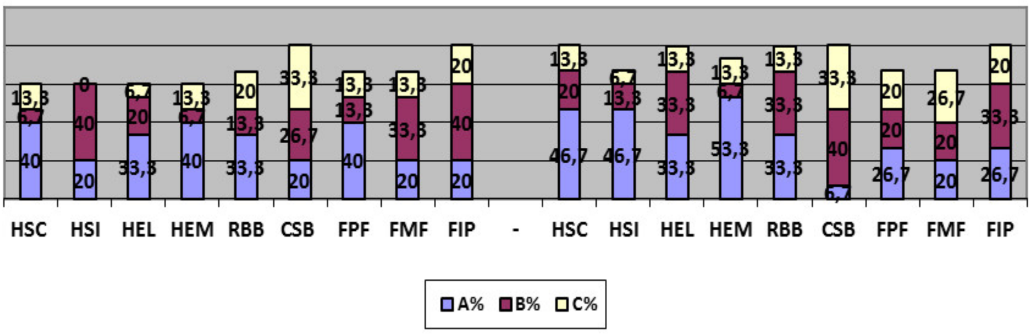


fig. 138. Severity code of entheseal changes of females from the church, right and left body side

Figures 135 to 138 show the distribution of entheseal changes of both samples separated for males and females. In males no significant difference in the manifestation of entheseal changes is visible. The cemetery sample shows overall slightly higher values in enthesis of the upper and lower limbs. Only occasionally values are slightly higher in the church sample. Females of the church sample however show an overall higher prevalence in entheseal changes. This concerns enthesis of the upper, as well as, the lower limbs. A similar distribution is already visible in the section about degenerative changes. Therefore, if the differences between the samples are based on different kinds of occupation, carried out by individuals from different social classes is again not confirmable. In the development of entheseal changes also age is an important factor (Cardoso and Henderson 2010, Havelková et al. 2011). This fact was already discussed in chapter 8: physical adaptations. So here again, it is quite possible that the distribution of entheseal changes in both samples is also an expression of age rather than different occupational activity.

11.4. *Bilateral asymmetry*

Another method to evaluate possible differences in occupational activity between the two samples is the study of limb bone asymmetry. This method was also already tested and discussed in chapter 8: physical adaptation. To evaluate the degree of bilateral asymmetry in both samples 32 measurement sections of the humerus, radius, ulna, as well as, femur and tibia were compared.

tab. 100. Male measures with significant differences

measure	cemetery n	x right	left	t-test	church n	x right	left	t-test
Ra4	30	17,1	15,9	3,214hs	18	17,0	16,5	1,148
Ra4a	31	16,1	15,0	3,082hs	19	16,3	15,3	2,508s
Ul12	31	14,5	13,8	2,351s	20	14,7	14,2	1,047

(s=significant; hs=highly significant)

tab. 101. Female measures with significant differences

mesure	cemetery n	x right	left	t-test	church n	x right	left	t-test
Ra4a	32	14,1	13,4	2,204hs	12	15,2	14,6	1,119
Ul1	22	245,6	243,2	2,676s	7	254,1	252,0	0,993
Ul12	37	12,4	11,7	2,951hs	13	12,9	11,8	2,435s
Fe7	46	25,8	26,6	-2,217s	16	25,6	26,5	0,078
Ti9	46	20,9	20,1	2,005hs	18	21,9	22,0	-0,088

(s=significant; hs=highly significant)

Tables 100 and 101 show the measurement sections with significant asymmetry between right and left body side, comparing the two samples, separated for males and females. In general only a small amount of measurements show a significant bilateral asymmetry, three measurements in males, five measurements in females. Individuals from the cemetery show a higher degree of asymmetry than individuals from the church. This is more visible in the females. Here measurements from the lower arm, as well as, femur and tibia are concerned, whereas four measurements of mid-shaft diameter (Ra4a, Ul12, Fe7; Ti9) and one linear measurement (Ul1) are affected. In males asymmetry is developed only in the transverse mid-shaft diameter of the radius (Ra4, Ra4a) and the ulna (Ul12). Individuals from the church share significant asymmetric manifestations only in the mid-shaft diameter of the radius (Ra4a in males) and the ulna (Ul12 in females). On the basis of these results, a separation of the two samples can be assumed, whereas in females these differences seem to be more pronounced than in males. However, the fact that males and females from the church sample show at least one measurment with a significant asymmetry, leads to the assumption that individuals from both samples were involved in more or less the same occupations, but to a different extent.

11.5. Teeth

In addition to the examinations on the bone, the teeth of individuals in both samples were also considered. For this purpose caries intensity and frequency, the level of attrition as well as the frequency of enamel hypoplasia was calculated and compared. Differences between the two samples can indicate a different nutritional status of the respective social classes. Recording of the respective features followed the classifications already described in chapter 9. In males from the cemetery the intensity of caries is 22,6%, the frequency of caries is up to 75,9%. In the church sample values differ considerably. The intensity of caries is significantly lower with 12,9%. Additionally more individuals are affected and the frequency of caries is increased up to 80,9%. Overall the females values are more balanced. The sample from the cemetery shows an intensity of 21,8% and a frequency of 75,0%. Values from the church sample are just slightly lower with an intensity of 19,2% and a frequency of 73,7%. Therefore, in the male part of the church sample a lesser amount of teeth are affected but on the other hand more individuals show carious lesions. In this case age is not the leading factor. As already discussed in chapter 9, no relation between caries development and age is detectable in the Grevenmacher population. Furthermore, the females do not show increased values in the church sample. However, if the different distribution of carious lesions in both male samples can be related to different nutritional habits cannot be explained for certain. If this was the case, why should it just be visible in the males and not also in the females?
Comparing the degree of attrition, the church sample shows more affected individuals, as well as, more severe manifestations in both, males and females. However, the fact that attrition is also very closely related to age in the Grevenmacher series, supports the option that the higher proportion of individuals from older age classes in the church sample is very likely responsible for the increased values of attrition. Finally, the frequency of the occurrence of enamel hypoplasia was checked for both samples. In the individuals from the cemetery 11,9% of the males and 16,3% of the females show disturbance of dental mineralization. In the church sample the proportion in males is 21,4% and thereby almost twice as high as in the cemetery sample. However, in the females the value is 10,7% and thus much lower compared to the cemetery sample. Therefore, males from the church show an overall higher frequency in enamel hypoplasia, as well as, in caries compared to the cemetery sample. In females the caries infestation is more or less balanced in both samples, the occurrence of enamel hypoplasia however is increased. The connection between the occurrence of enamel hypoplasia and increased caries infestations has already been stated in literature (Pascoe and Seow 1994, Oliveira et al. 2005). This fact could explain the overall high values in both categories in the males from the church sample. However, statements about enamel hypoplasia and social differences are more contradictory to some extent. On one hand people of lower social status are supposed to develop more stress markers due to less favorable life conditions and a greater exposure to various kinds of stress. On the other hand people from higher social status

and better life conditions will survive phases of increased stress and express stress markers in a higher frequency (Palubeckaité et al. 2002). Finally, some researchers deny the significance of enamel hypoplasia as indicators of dietary stress due to their various etiology (Neiburger 1990). Therefore, the occurrence of neither caries nor enamel hypoplasia reveals a clear statement about social differentiation.

11.6. Summary

Overall the evaluation and comparison of different features visible on bone and teeth did not support a separation of the two samples that can be related to different social status of the respective individuals buried around the church. The records of degenerative, as well as, entheseal changes are rather age related phenomena than can be ascribed to different occupational habits due to social differentiation. The differences in body height are not significant between the samples and cannot be related to a better nutritional status of the church sample. However, the evaluation of limb bone asymmetry yielded some significant differences in a few measurement sections in males and females, concerning in particular the forearm. At first sight this fact may be an indication of different occupational activities, with an increased impact on individuals from the cemetery. However, this circumstance is diluted by the fact that two of the measurements show significant values in the church sample. Now it can be assumed, that individuals from both groups where involved in more or less the same activities. Whereas individuals represented in the cemetery sample exercised this occupation more intensively. The comparison of carious lesions, as well as, dental attrition also did not show a clear difference between the samples. If differences in the intensity and frequency of caries in the male samples can be related to different nutritional habits due to different social status cannot be answered for certain.

If we assume a social separation in the burials on the cemetery of Grevenmacher, it is not visible in manifestations on bone and teeth. Reasons for this circumstance are various.

One option is, that differences in occupation or nutrition were not present or they were present to a low extent in the living population and therefore do not find their expression in manifestations on bones or teeth. A second possibility concerns the long occupation time of the cemetery and its corresponding re-use of graves over time. In the first phases of the occupation it can be assumed that separated burial areas for individuals of higher social status were established. However, in the course of time, more and more individuals were buried in the limited area of the cemetery and of course every citizen claims a place as close to the church building as possible. This led to a mixture of burials from individuals of different social classes concerning all areas within the church, near the church, as well as, on the rest of the cemetery. In this course a homogenization of the dead population occurred and therefore possible differences manifest in the bones cannot be assigned to a specific social class.

11.7. Group formation on the cemetery

Preferred areas for burials on a cemetery were not just assigned to individuals from higher social status. Throughout history divers groups of people were buried on special areas on or apart of the cemetery. There were special areas for non-adults, males and females, non-baptized or infidels, strangers that did not belong to the respective community, sick people or individuals that died an unnatural death for example by natural disasters or by the hand of the executioner (Ohler 1990, Illi 1992). If such separate areas were established on the cemetery of Grevenmacher it is hard to prove using the anthropological record. Some information might give the distribution of males and females, as well as, the non-adults on the cemetery. However, the mapping of the area revealed no specific space occupied preferred by males or females. Both sexes are more or less evenly distributed on the cemetery, as well as, within the church building. Graves of the non-adults were also distributed over the cemetery. However, there are some areas where preferred children of younger age classes were buried. In an area along the northern wall of the church building, bones of at least 12 infant individuals with age of death ranging between <1 and 7-8 years were recovered. Similar accumulations of infant bones were located in the choir area, and in a small pit in the center of the nave within the church building. Both complexes were already examined by Obertová et al. (2008, 2009). The complex along the outer wall of the church building was at first described as a burial for so called "Traufkinder". These are burials of unbaptized non-adults along the eaves of a church. The rainwater flowing from the roof of the holy building ensures a "post-mortem baptism" of these children. Due to high rates of infant mortality infants were baptized immediately after birth. As "Traufkinder" buried infants were mostly stillborn children or neonates that died during birth (Ohler 1990, Illi 1992, Ulrich-Bochsler 1997). However, the age of the children ranging from <1 and 7-8 years contradicts the designation as "Traufkinder" because in this age it can be considered that the infants were already baptized. However it is quite possible that unbaptized newborns were buried first and the older children followed subsequently. The accumulations of infant bones within the church show similar age distributions as the "Traufkinder" record. However, in this case more neonates, infants around one and two years of age and even two preterm births were present. The context of these burials is still unclear. Obertová et al. (2009) assume that these places within the church were intentionally reserved for children and this implies that these children were maybe part of a higher social class.

The cases of the burials of non-adults confirm that there were special places reserved for specific groups of individuals on the cemetery. The fact that these areas are not detectable any more is related to the repeated re-occupation of graves through time on the limited cemetery area, already mentioned above. Another reason is that possibly not all outer areas of the cemetery were recorded during the excavation. So it is quite possible that groups of individuals buried on these outer areas of the cemetery are lost for examination.

12. Comparison of the data from the inhumation graves and the burned bone complex

One of the special features at the site of Grevenmacher is the fact, that there were two different complexes of human bone material unearthed at the excavations in the years 2003 till 2005. The first complex is the inhumation graves of the cemetery to the east, as well as, within the church building. The second is a complex of human remains found in a separated area also within the church building. In the north-western part of the building, fundaments delimited a separate area of 2,30 x 2,90 m. Within this area a layer of burned human bone material was recovered, 30-40 cm thick, mixed with animal bones, sediments, stones and mortar remains (Bis-Worch 2005). The various discolorations of the burned bones show the influence of different temperatures during the combustion. The spectrum ranges from totally unburned in the undermost area of the layer to slightly burned with typical brown, black and greyish shades representing temperatures from 200° to 550°C. Temperatures over 650°C leaving typical shades of white on the bones were reached just to a lower extent. The burned, as well as, the unburned remains of the complex include bones from all anatomical regions (long bones, skull fragments, teeth, hand and foot bones) and from non-adult, as well as, from adult individuals. An estimated quantity of 1536 kg of material was recovered. A random sample of 37,1 kg was evaluated by the author in the course of a Magister thesis at the University of Tuebingen (Germany) (Trautmann 2007).

In this chapter the results achieved from this study should be compared to the data obtained from the study of the skeletal material from the cemetery. Information available from the burned bone remains includes the state of representation, age and sex distribution, different measurement sections, the reconstruction of body height and non-metric traits. The aim of this comparison is to figure out if the individuals represented in the burned bone complex originate from the same population buried on the cemetery. The accumulation of common aspects in both samples would support this thesis. If this is not the case, one might assume that two different populations or at least a special part of the population were treated differently in regard to their funerary practice.

12.1. *State of representation*

In chapter 2 about the general conditions of the bone material from the cemetery, the state of representation of different anatomical parts, as well as, the whole skeleton was presented. The same was carried out for the anatomical regions present in the burned bone complex. The amount of bones per anatomical region was evaluated on one hand by the amount of bone fragments present, on the other hand by the weight of the respective fragments. All values are given in percentages and presented in figure 139.

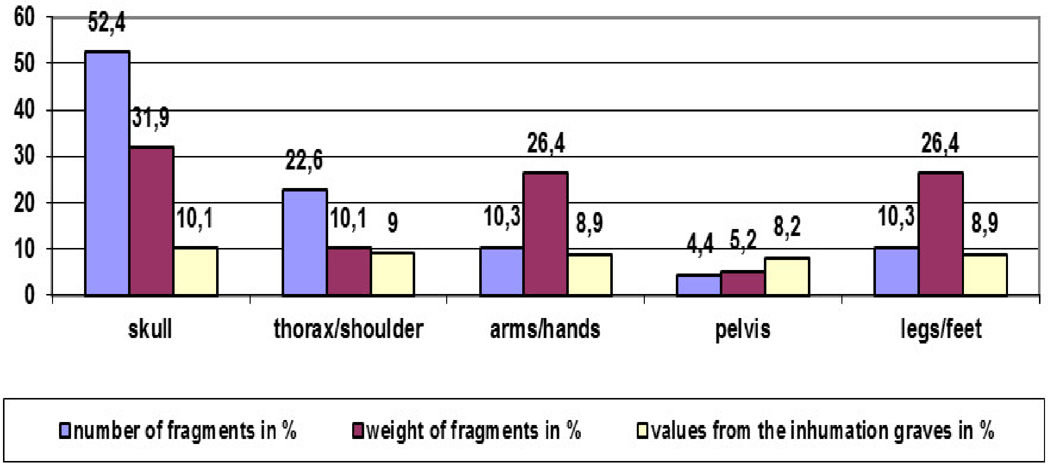


fig. 139. Comparison of representation of anatomical regions

The comparison of the representation of respective anatomical regions shows similar results in the burned bone complex, as well as, in the inhumation graves. In all three categories values of the skull are the highest followed by the thorax/shoulder region and the upper and lower limbs. Pelvic bones are represented to the lowest extent. One observation that can be made on the basis of these results is that the burned bone complex contains remains from all anatomical regions. Therefore, it can be assumed that whole skeletons were burned and that a selection of specific body parts did not happen. The exceptional high amount of skull fragments in the sample can be explained on one hand with the high fragility of the skull, on the other hand with the high viability of skull fragments. However, the similar results in both samples lead not automatically to a similar origin of the bones. It should be noted that in general bones of more compact composition (skull, long bones) have a greater chance to survive different taphonomic events than bones with a high amount of spongy tissue (vertebrae, pelvis). This applies to combustion, as well as, to decomposition in the ground. Therefore, the similar values in both samples are due to bone viability (Bello and Andrews 2006). A direct connection between both samples on the basis of the similar results in this specific case is therefore not feasible.

12.2. Age and sex distribution

As mentioned above, the burned bone complex includes remains from non-adult, as well as, adult individuals from both sexes. Unfortunately, a further separation of adult individuals in the single age categories adultus, maturus and senilis was not possible. However, a further separation of the non-adult individuals was possible. Table 102 and figure 140 show the age distribution of the burned bone complex and the inhumation graves in figures and in percentages.

tab. 102. Percentages of individuals in the respective age categories

	neonatus	infans I	infans II	juvenis	adults	age indet.	total
Burned bone complex	3 4,0%	9 12,0%	8 10,7%	10 13,3%	38 50,7%	7 9,3%	75 100%
Inhumation graves	21 5,7%	45 12,1%	38 10,2%	10 2,7%	238 64,2%	19 5,1	371 100%

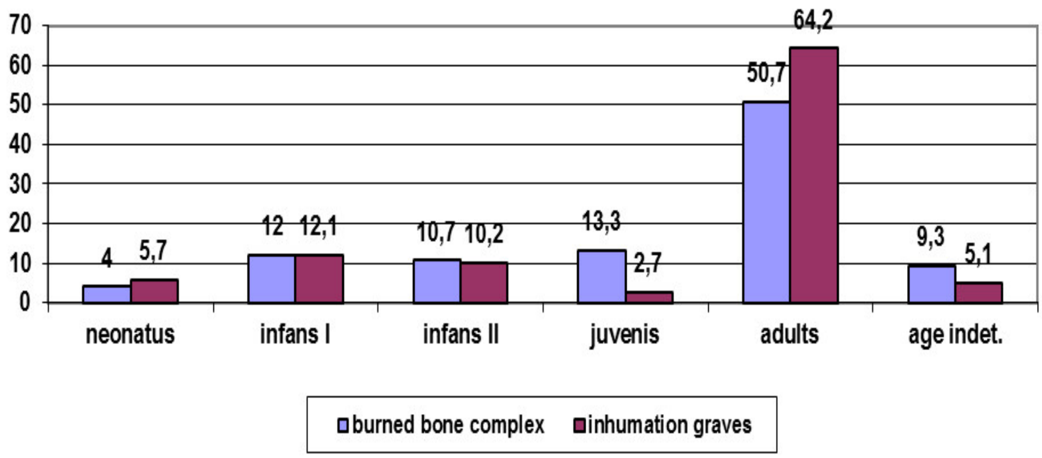


fig. 140. Percentages of individuals in the respective age categories

The age distribution of both complexes shows very similar results. The non-adults in particular from neonatus to infans II show more or less the same values. Differences therefore are visible in the categories juvenis and in the adults. If we add both categories we get a percentage of 64,0% in the burned bone complex and 66,9% in the inhumation graves. These values are again very similar. However, if we have a closer look on the distribution within the respective category some differences are observable. The burned bone complex shows a proportion of 13,3% in the juvenile category and a proportion of 50,7% in the adults. In the inhumation graves the part of the juveniles is just 2,7% but the adult value is 64,2%. One cause for this disproportion is to be seen in the fact, that a differentiation in burned bone fragments between juvenile and adult individuals due to bone size and thickness is not always clear. Also, adhesion of single epiphysis allows not always a secure classification because adhesion in many epiphyses occurs around the transition from juvenile to adult category. Therefore, it is quite possible that individuals categorized as juveniles are in fact adults and vice versa. If we suppose that eight of the ten individuals categorized as juveniles are really adults and add them to the 38 adult individuals the values for the juveniles would be 2,6% and for the adults 61,3%. This would perfectly correspond to the values of the inhumation graves. As mentioned in chapter 4: Paleodemography, juveniles have in general the lowest probability of death in a population. In the case of the burned bone complex the juveniles have the highest probability of death. This also supports the theory that an uncertain differentiation of bone fragments is most probably the reason for the disproportion of the values.

The next step is a comparison of the proportion of non-adults in the respective samples. The proportion of non-adults in the sample from the inhumation graves is 30,7%. In the burned bone complex a ratio of 40,0% is given, which is about 9% higher. If we assume again that eight juvenile individuals rather belong to the adult category the ratio of non-adults drops to 29,3%, which corresponds again to the value from the inhumation graves.

tab. 103. Comparison of sex distribution of both samples

	male	female	sex indet.	total
Burned bone complex	22 57,9%	16 42,1%	0 0,0%	38 100%
Inhumation graves	120 50,2%	129 46,7%	8 3,1%	257 100%

In the burned bone complex 22 out of 38 adult individuals could be identified as rather male, and 16 as rather female. This resulted in percentages of 57,9% and 42,1% respectively. Furthermore, the ten juvenile individuals could also be identified. Four individuals are rather male, and six individuals are rather female. Again assuming that eight of the juveniles are rather adults, the figures would change as follows. 46 adult individuals were separated as 25 males and 21 females, which resulted in percentages of 54,3% and 45,7%. Again a compliance with the results from the inhumation graves with proportions of 50,2% in males and 46,7% in females is given. However, it should be noted that the sex determination in the burned bone complex is based on metrical allocations and with the help of comparisons with values from other bone samples. Therefore, the determination of the individuals is not assured.

12.3. Metrical analysis

For better comparison of burned and unburned bones, measurement sections developed especially for burned bone material were also measured at bones from the inhumation graves. This approach was already successfully carried out by Wahl (1988) at the roman burial ground of Stettfeld. The burned bone complex contains fragments of burned, as well as, unburned bones and the measurements were taken on both. The higher the temperature during the combustion process, the higher is the rate of shrinkage of the bone. Measurements taken on bones burned in the stages IV and V a "shrinking factor" of 12% was added according to Herrmann (1977) and Rösing (1977) to create a comparable basis for burned, as well as, unburned bones. Because sex determination at the burned bone fragments was unsure, measurement results include measures of males, as well as, females. To compare both series the male and female measurements of the inhumation graves had therefore also to be pooled. A total of 40 measurement sections were taken from bones of the burned bone complex. Only measurements of adult individuals and with five or more single measures were used for comparison. Therefore, a total of 26 measurements were left, presented in table 104. The direct comparison of measurements from burned and unburned bones shows overall similar values. However, 10 measurements revealed significant or even highly significant differences, whereas these deviations are in millimetre or even tenth of a millimetre ranges. The compensation of the fire-induced shrinkage of the bones of about on average 12% seems to be a valid value. The differences are mainly the result of a varying shrinkage in the different bones and bone sections, according to the proportion of cancellous bone material. Another reason is a possibly unbalanced ratio of male and female bones in the burned bone complex. Whereas the results from the inhumation graves include data from more or less equal shares of males and females, no reliable sex determination was possible in bones from the burned bone complex. Therefore, it is possible that an imbalance in the sexes is present in the sample. Furthermore, bones of female individuals shrink to a greater extent than bones from male individuals, due to a lower mineral content (Herrmann 1977, Herrmann et al. 1990, Wahl 1988).

Table 104 shows the results from the inhumation graves (ig) as well as from the burned bone complex (bbc) with the number of measures (n), the mean value (x), the standard of deviation (s) and the respective ranges. Differences between the two samples were checked by students t-test. Measurement sections are given as abbreviations. For the respective definition see the list at the end of chapter 5 (Metrical and morphological studies).

tab. 104. Measurement sections from the inhumation graves and the burned bone complex

		ig				bbc				
meas. ig	meas. bbc	n	x	range	s	n	x	range	s	t-test
W1	M1	99	5,6	3,7-8,3	0,89	150	5,2	3,5-7,7	0,89	3,471hs
W9	M9	83	7,4	5,2-10,1	0,94	17	6,5	4,9-8,9	0,88	3,633hs
W10	M10	82	12,5	9,1-16,4	1,58	16	11,2	8,8-14,0	1,51	3,031hs
W11	M11	83	14,2	10,8-19,0	1,88	16	14,4	12,2-18,0	1,56	-0,399
W17	M17	117	19,7	12,0-25,0	2,04	12	19,1	15,5-22,4	1,60	0,987
W18	M18	93	8,2	5,7-10,6	0,92	13	8,7	5,8-11,3	1,53	-1,673
W19	M19	78	2,8	1,7-5,1	0,63	7	2,8	1,9-3,8	0,62	0,000
M69	M15	120	29,2	19,0-38,0	3,68	6	22,9	15,8-36,3	6,47	3,930hs
M69b	M16	103	14,3	10,2-20,1	1,71	6	14,4	11,1-16,8	1,61	-0,140
AxW20	M20	90	10,9	9,0-12,0	1,28	7	10,5	6,9-12,8	1,86	0,770
AxW21	M21	90	11,8	10,0-15,0	0,92	7	10,4	7,8-13,7	1,61	3,648hs
Sc13	M26	112	27,1	22,0-34,0	2,53	8	23,6	20,3-28,9	2,67	3,767hs
Hu9	M27	108	43,5	36,0-53,0	3,32	7	45,3	38,4-50,7	4,55	-1,359
HuW28	M28	24	3,8	2,2-5,3	0,76	36	5,3	2,1-6,8	1,30	-5,093hs
RaW32	M32	113	21,5	17,0-25,0	1,60	16	20,5	16,1-23,1	2,07	2,252s
RaW33	M33	28	2,7	1,3-3,8	0,59	26	2,5	1,6-6,6	0,67	1,166
Ra5(6)	M34	90	31,6	24,3-39,3	2,66	7	30,2	25,6-36,4	3,94	1,293
UlW35	M35	94	24,5	18,0-35,4	2,63	11	24,2	20,3-28,0	2,47	0,360
UlW36	M36	75	19,7	15,6-25,1	1,82	6	18,1	12,3-22,6	3,31	1,936
Fe19	M39	126	45,6	38,0-55,0	3,58	9	43,1	36,1-50,4	4,56	1,987s
Fe8	M42	144	86,6	70,0-99,0	6,31	16	85,1	76,2-100,8	7,84	0,880
FeW43	M43	143	6,7	4,0-11,0	1,19	56	7,0	3,7-11,8	1,41	-1,516
FeW44	M44	37	5,6	3,2-9,5	1,36	26	5,3	3,4-7,4	1,03	0,849
Fe7	M44a	144	27,1	22,0-33,0	2,33	18	25,8	19,5-34,2	3,32	2,119s
FiW53	M53	85	14,4	10,9-21,6	2,17	13	14,4	11,4-19,0	2,21	0,000
FiW54	M54	81	25,2	20,5-31,7	2,33	7	23,5	20,0-28,9	2,95	1,814

(s=significant; hs=highly significant)

12.4. Reconstruction of body height

Table 105 shows the body height for males and females calculated after different formulas according to different authors as carried out in chapter 6 (Reconstruction of body height). Body height of individuals from the burned bone complex was evaluated according to tables from Rösing (1977) and Malinowski and Porawski (1969).

tab. 105. Comparison of body heights from the inhumation graves and the burned bone sample

	♂			♀				
formula	n	x	range	n	x	range	f/m%	diff. m-f
Breitinger (1938)	92	169,3	161,9-179,9					
Bach (1965)				91	161,1	152,8-169,6	95,16	8,2
Olivier (1978)	106	168,4	154,5-186,4	91	159,4	146,4-174,5	94,50	9,0
Pearson (1899)	100	166,2	154,8-179,1	92	156,4	147,9-168,3	94,10	9,8
TG-AW (1952)	106	170,8	158,1-184,4	94	160,9	149,7-176,3	94,14	9,9
TG-AN (1952)	106	166,1	153,5-179,4	94	157,3	147,2-171,3	94,70	8,7
Siegmund Kombi. (2010)	100	167,7	156,1-179,7	92	158,3	148,5-172,0	94,39	9,4
Rösing (1977)	15	171,2	168,5-173,4	14	157,9	154,0-162,9	92,20	13,3
Malinowski u. Porawski (1969)	15	163,4	161,0-165,5	14	149,9	145,0-153,8	91,70	13,5

The results according to Rösing (1977) for the burned bone complex correspond very well with the data of the inhumation graves. The result for the males is slightly higher than the average, but still within the range. The value for the females fits perfectly in the range of the other results. Values after Malinowski and Porawski (1969) are much lower compared to the data from the cemetery sample. One reason for this fact is that Malinowski and Porawski (1969) used different shrinking factors than Rösing (1977). Another reason for discrepancies could be explained with the different method underlying the reconstruction of body height from cremated bones. The high fragmentation of burned bone material allows only measurements of specific sections of a bone. These measures are the basis for reconstructions of the total bone length of which the estimation of the respective body height follows. The uncertainty of the achieved results is therefore much higher (Wahl 1988). Furthermore, the sample used for reconstruction is quite small with 15 males and 14 females compared to over 90 and over 100 individuals respectively, available from the inhumation graves. Again it must be pointed out that the sex determination of the burned bones is not secure and is based only on derived metrical differences.

12.5. Non-metric traits

tab. 106. Comparison of non-metric traits of the burned bone complex and the inhumation graves

trait	variation	bone present	trait present	%	bone present	trait present	%
For. (Inc.) supraorbitalis	present	35	13	35,1	236	125	53,0
For. frontale	present	35	6	17,1	237	102	43,0
For. zygomaticofaciale	missing double	26 26	3 8	11,6 30,8	209 209	20 88	9,6 42,1
Torus palatinus	present	22	1	4,5	107	11	10,2
Canalis hypoglossi	double	19	3	15,8	204	20	9,8

The evaluation of non-metric traits in burned bone material is very difficult due to the high rate of destruction and fragmentation. A total of seven traits could be detected in the burned bone sample whereas only five can be compared with the inhumation graves. Three of the traits, the Foramen (Incisura) supraorbitalis and frontalis and the double Foramen zygomaticofaciale are among the traits with the highest rates of frequency in the Grevenmacher population. The Torus palatinus and Canalis hypoglossi occur at a rate of about 10% which is also very common. The fact that these traits are present in the burned bone sample also with relatively high frequencies suggests a strong relationship between these two samples.

12.6. Interpretation of the results

The comparison of the two samples of human remains unearthed at the excavation at Grevenmacher, produced a lot of common aspects in the sections under study. The first section evaluated, was the state of representation of bones from different anatomical regions. However, the approximately equal results gained from both samples in this case, can be explained rather with bone viability and not with the origin from the same population.

The age and sex distribution however shows very similar results in both samples. This similarity is seen in the percentages in the single age categories, as well as, for the relation of adults and non-adults in the sample. The comparison of the measurements from both samples also show a high rate of accordance. The same can be stated about the reconstruction of body height. In both cases a shrinking factor of 12% was considered according to Herrmann (1977) and Rösing (1977) to allow a direct comparison of burned and unburned bones. The very similar results confirm that these shrinking factor determined by both authors works very well in the Grevenmacher material. However, the results in body height, according to Malinowski and Porawski (1969) result in much lower values compared to the values from the inhumation graves. The comparison of non-metric traits is based on a very small number due to fragmentation and destruction during the combustion process. However, five traits were present for comparison and the traits with the highest frequencies in the inhumation graves were also present in the burned bone complex.

To summarize, the high rate of accordance between the burned bone complex and the inhumation graves lead to the conclusion that both samples are from the same population. The question that is raised from this fact is about the occurrence of the unusual complex of burned bones in an adjoining room of the church building.

One approach to this question is the reconstruction of the number of individuals represented in the human bone material from Grevenmacher. As a first step it is necessary to reconstruct a total number of individuals involved in both samples. For the inhumation graves this point is discussed in chapter 3 (Number of individuals, age and sex determination). Here a minimum number of 1316 and a maximum number of 1591 individuals are considered. For the burned bone complex the estimation of a number of individuals resulted in a minimum of 1699 and a maximum of 3108 (Trautmann 2007). For both samples summarized a minimum number of 3015 and a maximum number of 4699 individuals must be assumed.

Both numbers are at first sight very high for a little rural village like Grevenmacher. On the other hand, occupation of the cemetery is proven from the 8th to the early 15th century. That means that the cemetery was in use for a minimum of 700 years. It is quite possible that a settlement of a respective size can yield so many deaths within 700 years. In chapter 4 about palaeodemography, data was calculated for the 371 individuals under study. The following calculations refer to the numbers of individuals estimated in this section.

Population size according to Acsádi and Nemeskéri (1970)
Number of individuals: 3015 and 4699
Live expectancy: 30,449
Occupation time: 700 years

$$P_1 = 1{,}1\frac{D \times e_0^0}{t} = 1{,}1\,\frac{3015 \times 30{,}45}{700} = 144{,}3$$

$$P_2 = 1{,}1\frac{D \times e_0^0}{t} = 1{,}1\,\frac{4699 \times 30{,}45}{700} = 224{,}8$$

The mortality rate was calculated with 4,1%, that means 4,1 deaths per year in 100 individuals (Bocquet u. Masset 1977).

4,1 deaths/a in 100 ind. > 5,9 deaths/a in 144 ind. > 9,2 deaths/a in 225 ind.
2870 deaths in 700 a > 4130 deaths in 700 a > 6440 deaths in 700 a

The calculated results are of course average values. In the beginning of the settlement a rural agrarian village can be assumed to have a population of 80 to 90 individuals (Rösener 1987, Vogt-Lüerssen 2001). In the course of time the village expanded and with the award of the town charter in 1252 an increase in population size occurred with the influx of people with other professions than farmers, in particular craftsman and traders (Bis-Worch 2010). Therefore, an average population between 150 and 250 individuals living at Grevenmacher, as well as, the estimated amount of deaths at the cemetery is not impossible. Furthermore, it can be expected that the town and therefore the cemetery had a greater catchment area and that people from farmsteads in the hinterland were also buried at the Grevenmacher cemetery. This leads to the question why over half of the bone remains are present in the burned bone complex. As already discussed by the author in Trautmann (2007) the cremation of human remains in medieval times was very unusual and even prohibited by church law (Fehring and Scholkmann 1995). However, the complex of Grevenmacher is not the only one of its kind. Großkopf (2000) evaluated a similar complex from the city of Mertert also localized in Luxembourg. The occurrence of this complex is still uncertain. Fehring and Scholkmann (1995) describe a similar pit filled with burned human bones in the municipal church St. Dionysius in Esslingen/Neckar (Germany). They assume an accidental burning of an ossuary as main cause. In the case of Grevenmacher it can be assumed that just bones without soft tissue and not whole bodies were burned. This fact is shown by the absence of typical parabolic cracks on the bones. But where did these bones come from?
The comparison between the two samples in this chapter came to the result that the individuals present in the burned bone complex, are part of the population also present on the cemetery. One option is that at a certain time the limited space of the cemetery was overcrowded. Part of the bones, (or maybe the whole cemetery) was excavated. This process is at least proven from graves at the interior of the church (Bis-Worch 2005). Then the bones were burned for the purpose of volume reduction. Afterwards the remains were buried again in "holy earth" within the church building. A coin found within the burned bone remains, as well as, a coin found in connection with vacated graves within the church building, dates the occurrence of the burned bone complex in a time range from the beginning to the middle of the 14th century (Bis-Worch 2005). If the removal of bones from older graves and their incineration can be associated with the outbreak of the plaque that was investing Europe in the 14th century (Naphy and Spicer 2006) or other highly infectious diseases in this area, and therefore the accumulation of a lot of dead that needed space for inhumation must stay open to speculation. Another reason could be the recurring famines that occurred again and again throughout the whole medieval period, in particular in the years from 1315 to 1319 (Goetz 2002, Schubert 2006).

13. Comparison of data from Grevenmacher with contemporaneous as well as ancient series from Luxembourg

Luxembourg with its wealth in archaeological sites from palaeolithic until modern times provides also a great amount of ancient human skeletal remains. Very recently Weidig et al. (2011) published a compilation of all archaeological sites of Luxembourg where human remains were unearthed. Although, the amount of skeletal remains is overall high, only a small amount of series is suitable for comparisons. One problem we have to face is that a lot of archaeological sites only reveal a small number of individuals. This is the case especially for sites from the Mesolithic and Neolithic age. In later periods like the Iron Age or roman period, the dominant type of burial was the cremation. Therefore from these periods only a few remains from inhumations are represented. Larger series with statistical relevant amounts of individuals are available only for the early and high medieval period until modern times. Although the excavated bone material is always part of the archaeological literature, examinations with modern anthropological methods were carried out more intensely only in the last few years. All these facts complicate the comparison between series within a respective time period, as well as, between series of different periods.

In this chapter archaeological, as well as, anthropological literature from Luxembourg was evaluated, to find relevant data for these mentioned comparisons. So an attempt was made to correlate data from Grevenmacher on one hand with series from other medieval sites and with samples from earlier time periods, to work out possible common aspects in morphological development of the ancient populations of Luxembourg over time.

The following features were compared:

1) Age and sex distribution. The age and sex determination of the respective series mainly followed the criteria established inter alia by Ferembach et al. (1979), Brooks and Suchey (1990) and Ubelaker (1978).

2) Metrical data, in particular various indices of the skull and infra-cranial skeleton. The measurements and indices were recorded according to Martin (1957) and Bräuer (1988)

3) Pathological changes of the joints and spine, as well as, dental diseases.

13.1. Comparison of skeletal remains from medieval and modern times

Most of the human skeletal remains unearthed in Luxembourg come from sites dating from early and high-medieval until modern times. At this point of time anthropological data from eleven of these sites are available.

tab. 107. Anthropological series from medieval Luxembourg

site	type	date	n	authors
Bartringen	merovingian cemetery	5th-7th	12	Teegen et al. (2003)
Escher/Gleicht	merovingian cemetery	6th-7th	12	Trautmann & Trautmann (2011)
Altwies-Groufbierg	merovingian cemetery	6th-7th	26	Trautmann & Trautmann (2011)
Diekirch	early medieval cemetery	8th-10th	159	Data kindly provided by Zuzana Obertová
Givenich	manor house with cemetery	11th/12th-15th	68	Rehbach et al. (2009), Weidig et al. (2009)
Grevenmacher	cemetery	8th-early 15th majority 13th-15th	min. 3015 (371 studied)	Obertová et al. (2008), Obertová et al. (2009)
Fentingen	church	10th-15th	44	Rehbach et al. (2005), Nothwang u. Rehbach (2006)
Luxembourg-Neumünster	cemetery and monas-tery	13th-18th majority 14th-15th	850 (174 studied)	d'Hollosy u. De Meulemeester (1999)
Luxembourg-St. Esprit	convent	12th-17th majority 15th	ca. 300 (130 studied)	Rehbach u. Bis-Worch (2006), Nothwang et al. (2006), Rehbach et al. (2007), Rehbach u. Nothwang (2007), Reh-bach (2008), Rehbach u. Nothwang (2009)
Grund/Wenzelsmauer	members of a military detachment?	late 16th - early 18th	23	Trautmann u. Trautmann (2011)
Luxembourg-Hospice civil	former convent	16th - 1792	27	Nothwang et al. (2004), Rehbach et al. (2007)

The comparison between the listed series is not without difficulties. We have to consider that the social, as well as, the chronological background differ significantly between the sites. Therefore, the series were divided according to their date and type. The Merovingian cemeteries from Bartringen, Escher/Gleicht and Altwies-Groufbierg form one group. The series from Diekirch, Givenich and Grevenmacher fall on one hand in the same time period, on the other hand they originate from cemeteries from rural settlements. The remains from the church of Fentingen were also assigned to this group. The human remains from the sites Luxembourg St. Esprit, Neumünster and Hospice civil come from cemeteries that are associated with convents. All three sites are dated to the late medieval period and the beginning of modern times. Exceptions are the individuals from Grund/Wenzelsmauer. Trautmann and Trautmann (2011c) assume that they were possibly members of a military detachment.

13.2. Comparison of age and sex distribution

Tables 108 and 109 show the age and sex distribution of all eleven series. The early medieval series from Bartringen, Escher/Gleicht and Altwies-Groufbierg are overall very small (2x12, 1x26 individuals) and do not reflect representative parts of a living population. Non-adult individuals are under-represented, neonates from 0-1 year are completely missing. In Bartringen one individual, two to three years of age, and two juveniles are present. At Escher/Gleicht and Altwies-Groufbierg only the categories infans II (3 ind.) and juvenile (2 ind.) are filled. Rather unusual is also the age distribution of the adult individuals. At Bartringen most of the individuals are older than 50 years which results in an unusual high average age at death of 45 years. Only one individual fills the category early adultus with its 20-25 years of age. At Altwies-Groufbierg all age categories are filled, but here also a high amount of individuals reached more than 50 years of age. At Escher/Gleicht however the few adult individuals fill the lower age classes from adultus I to maturus I. Only one individual reached more than 60 years of age. The series from the rural cemeteries of Grevenmacher, Diekirch and Givenich, respectively the church of Fentingen, show a more balanced age distribution. At Grevenmacher all age categories are filled. In Diekirch neonates and infants younger than three years of age are absent. In Givenich individuals older than 60 years of age are missing, as well as, juveniles in Fentingen. In all four series a deficit of non-adults is visible. At Givenich the amount of non-adults is the highest with 39,7%. The average age at death ranges between 27,0 and 33,4 years. The three monastic sites differ also among each other. At St. Esprit and Neumünster all age categories are filled, however again a significant deficit in non-adults is visible. At Hospice civil even only one non-adult individual (3-6 years) is present. Therefore, the average age at death is unusually high with 46,4 years. Also, Neumünster shows an increased age at death with 37 years. At St. Esprit age at death is much lower with 33 years.

tab. 108. Age distribution, amount of non-individuals and average age at death

site	neo	inf I	inf II	juv	ad I	ad II	mat I	mat II	sen	indet	n	proportion of non-adults	Ø age at death
Bartringen	0	1 (8,3%)	0	2 (16,7%)	1 (8,3%)	0	0	3 (25,0%)	5 (41,7%)	0	12	3 (25,0%)	45,0
Escher/Gleicht	0	0	3 (25,0%)	2 (16,8%)	1 (8,3%)	1 (8,3%)	4 (33,3%)	0	1 (8,3%)	0	12	5 (41,6%)	33,0
Altwies-Groufbierg	0	0	3 (11,5%)	2 (7,7%)	4 (15,5%)	3 (11,5%)	5 (19,2%)	6 (23,1%)	3 (11,5%)	0	26	5 (19,2%)	35,0
Givenich	5 (7,4%)	10 (14,7%)	10 (14,7)	2 (2,9%)	10 (14,7)	5 (7,4%)	19 (27,9%)	6 (8,8%)	0	1 (1,5%)	68	27 (39,7%)	27,5
Diekirch	0-4=5 (3,2%)	5-9=11 (6,9%)	10-14=14 (8,8%)	13 (8,2%)	70 (44,0%)		37 (23,3%)		9 (5,6%)	0	159	43 (27,0%)	27,0
Grevenmacher	21 (18,4%)	45 (39,5%)	38 (33,3%)	10 (8,8%)	42 (16,3%)	76 (29,6%)	68 (26,5%)	38 (14,8%)	14 (5,4%)	19 (7,4%)	371	114 (30,7%)	30,4
Fentingen	2 (5,4%)	5 (13,5%)	2 (5,4%)	0	3 (8,2%)	4 (10,8%)	10 (27,0%)	5 (13,5%)	1 (2,7%)	5 (13,5%)	37	9 (24,3%)	33,4
Luxembourg Neumünster	0-4=11 (6,3%)	5-9=7 (4,0%)	10-14=4 (2,3%)	11 (6,3%)	43 (24,7%)		39 (22,5%)		24 (13,8%)	35 (20,1%)	174	33 (18,9%)	37,0
Luxembourg St. Esprit	12 (9,2%)	10 (7,6%)	8 (6,2%)	8 (6,2%)	8 (6,2%)	22 (16,9%)	35 (26,9%)	16 (12,4%)	5 (3,8%)	6 (4,6%)	130	38 (29,2%)	33,0
Grund/ Wenzelsmauer	0	0	0	4 (17,4%)	9 (39,2%)	7 (30,4%)	1 (4,3%)	2 (8,7%)	0	0	23	4 (17,4%)	30,2
Luxembourg Hospice civil	0	1 (3,7%)	0	0	5 (18,5%)		8 (29,6%)		6 (22,3%)	7 (25,9%)	27	1 (3,7%)	46,4

tab. 109. Sex distribution and index of masculinity

site	sex	neo	inf I	inf II	juv	non-adults (%)	ad I	ad II	mat I	mat II	sen	indet	adults (%)	n total	♂-index
Bartringen	♂	0	1	0	2	3 (100,0%)	0	0	0	1	2	0	3 (33,3%)	6 (50,0%)	60,0
	♀	0	0	0	0	0	1	0	0	2	2	0	5 (55,6%)	5 (41,7%)	
	?	0	0	0	0	0	0	0	0	0	1	0	1 (11,1%)	1 (8,3%)	
Escher/Gleicht	♂	0	0	1	0	1 (20,0%)	1	1	2	0	0	0	4 (47,1%)	5 (41,7%)	133,3
	♀	0	0	0	1	1 (20,0%)	0	0	2	0	1	0	3 (42,9%)	4 (33,3%)	
	?	0	0	2	1	3 (60,0%)	0	0	0	0	0	0	0 (0,0%)	3 (25,0%)	
Altwies-Groufbierg	♂	0	0	7										7 (26,9%)	63,6
	♀	0	0	11										11 (42,3%)	
	?	0	0	8										8 (30,8%)	
Givenich	♂	0	5			5 (18,5%)	2	2	11	4	0	0	19 (46,3%)	24 (35,3%)	86,4
	♀	0	10			10 (37,1%)	8	3	8	2	0	1	22 (53,7%)	32 (47,1%)	
	?	5	7			12 (44,4%)	0	0	0	0	0	0	0 (0,0%)	12 (17,6%)	
Diekirch	♂	0	15		3	18 (41,9%)	36		26		7	0	69 (59,5%)	87 (54,7%)	160,5
	♀	0	11		10	21 (48,8%)	32		9		2	0	43 (37,1%)	64 (40,3%)	
	?	0	4		0	4 (9,3%)	2		2		0	0	4 (3,4%)	8 (5,0%)	
Grevenmacher	♂	7	14	19	6	46 (42,1%)	10	36	38	25	10	10	129 (50,2%)	175 (47,2%)	107,5
	♀	3	15	4	3	25 (21,9%)	29	36	30	13	4	5	120 (46,7%)	145 (39,1%)	
	?	11	16	15	1	41 (36,0%)	3	1	0	0	0	4	8 (3,1%)	51 (13,7%)	
Fentingen	♂	0	1		0	1 (11,1%)	1	1	7	4	1	0	14 (50,0%)	15 (40,6%)	155,6
	♀	0	2		0	2 (22,2%)	2	3	3	1	0	0	9 (32,1%)	11 (29,7%)	
	?	2	4		0	6 (66,7%)	0	0	0	0	0	5	5 (17,8%)	11 (29,7%)	
Luxembourg Neumünster	♂	No sex determination in non-adults				0	81						81 (58,3%)	81 (47,1%)	172,3
	♀					0	47						47 (33,8%)	47 (27,3%)	
	?					33 (100,0%)	11 from 139 inhumations						11 (7,9%)	44 (25,6%)	
Luxembourg St. Esprit	♂	5	6	5	4	20 (52,6%)	2	7	12	11	1	4	37 (40,2%)	57 (43,8%)	68,5
	♀	5	2	2	3	12 (31,6%)	6	15	23	5	4	1	54 (58,7%)	66 (50,8%)	
	?	2	2	1	1	6 (15,8%)	0	0	0	0	0	1	1 (1,1%)	7 (5,4%)	
Grund/Wenzelsmauer	♂	0	0	0	3	3 (75,0%)	6	6	1	2	0	0	15 (78,9%)	18 (78,3%)	375,0
	♀	0	0	0	0	0 (0,0%)	3	1	0	0	0	0	4 (21,1%)	4 (17,4%)	
	?	0	0	0	1	1 (25,0%)	0	0	0	0	0	0	0 (0,0%)	1 (4,3%)	
Luxembourg Hospice civil	♂	0	0	0	0	0	0		0		0	0	0 (0,0%)	0 (0,0%)	
	♀	0	0	0	0	0	5		8		6	7	26 (100,0%)	26 (96,3%)	
	?	0	1	0	0	1 (100,0%)	0		0		0	0	0 (0,0%)	1 (3,7%)	

The differences between the single sites are also visible in the different sex distributions of the adult individuals. At Bartringen and Escher/Gleicht the distribution is very balanced with a slight increase in females and males, respectively. At Altwies-Groufbireg, the values include the non-adults of the age classes infans II and juvenis. In this case the females outnumber the males (11:7). The rural sites show also a differenced picture in the sex distribution. At Givenich more females are present, at Grevenmacher and Fentingen more adult individuals are determined as males. However, the monastic sites show the greatest discrepancies. At Hospice Civil all 26 adult individuals are females, at St. Esprit the females also outnumber the males. However at Neumünster far more males than females are present. On one hand strong differences in the cemeteries of convents have to be expected depending on what kind of monastery it is, such as a friary or a nunnery. However, the occupation of a cemetery purely by one sex, as it is the case at Hospice civil, is an exception. In most cases the cemetery was open to other members of the ecclesiastical or even of the municipal community. Already the first comparisons of age and sex distributions disclose great discrepancies between the sites. Additionally, one-sided sex distribution is visible at Grund/Wenzelsmauer. 18 out of the 23 individuals were assigned to as males, only four were females. Neonates and infants were completely missing, three individuals were juveniles of at least 16 years. Most of the individuals died between 20 and 30 years of age, only six individuals were older than 30 years.

Due to the small number of individuals in connection with the very unbalanced age and sex distribution of the three Merovingian cemeteries gives us justification to assume, that in all three cases either a pre-selection of the buried individuals was carried out or the cemeteries were not recorded completely during the excavations. The rural sites of Grevenmacher and Givenich show more balanced distributions, however here again it can be assumed that not all areas of the burial sites were excavated and that several individuals were lost for examination. Whereas the cemetery of Grevenmacher can be considered as more or less representative for an average rural village, the individuals from Fentingen were found at the interior of a church. In this case also some kind of pre-selection of the individuals can be assumed. Normally graves within or near by the church were reserved for persons from secular higher social status or of the clergy. At the monastic sites of St. Esprit, Neumünster and Hospice civil also a preferred occupation of members of the respective convent can be assumed. However, as mentioned before, people from other social classes had the possibility to be buried in this places. Age and sex distribution of the individuals from Grund/Wenzelsmauer however confirm the assignment to a military unit.

13.3. Metrical data

The comparison of metrical data between the sites, reveal common aspects, as well as, differences in skull shape or robustness of the infra-cranial skeleton that indicate similar or different developmental traits, as well as, differences in working load or other physical activities. Therefore, indices of the skull and infra-cranium are presented in tables 110 and 111.

Individuals from the different sites show overall a great variation in skull shape. At the early medieval site of Escher/Gleicht and Altwies-Groufbierg the differences are significant between the sites, as well as, within the sites itself. However we have to consider that the data from both sites is not representative because the raw data, as well as, the values of the indices are based on a very small number of individuals (Escher/Gleicht: 1-3; Altwies-Groufbierg <5). The rural sites of Grevenmacher, Diekirch, Givenich and Fentingen as well as the monastic site of St. Esprit with their larger numbers of individuals yield values with higher statistical significance. Figures 141-144 show the length-with index, length-height index, width-height index and facial index of four of the sites. The values are summed up for males and females.

Indices of the skull

tab. 110. Indices of the skull available from eight sites

Index	Escher/Gl.		Altwies/Gr.		Givenich		Diekirch		Grevenma-cher		Fentingen		St. Esprit		Grund/Wenz.	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
length-width	77,9	74,6	67,2	79,0	78,8	75,2	74,0	75,9	75,4	75,4	74,6	75,9	81,7	83,6	79,1	73,9
length-height					73,0	70,8	70,9	69,0	70,6	70,9	68,6	71,6	75,2	73,6		
width-height					91,8	94,2	95,8	93,2	93,4	93,6	91,2	79,9	89,9	89,4	80,2	79,7
face					88,1	86,4			91,8	95,5	87,0	95,6	87,3	89,1		
orbital	75,3	94,7	80,0				81,4	82,0	85,5	86,4					89,5	
nasal	49,2						48,3	50,6	47,3	48,6					49,1	

(L-W= length–width; L-H=length-height; W-H=width-height)

tab. 111. Morphognostic description by means of indices of the skull

Index	Escher/Gl.	Altwies-Gr.	Givenich	Diekirch	Grevenm.	Fentingen	St. Esprit	Grund/ Wenz.
length-width ♂ ♀	mesokran dolichokran	hyperlochokr. mesokran	mesokran mesokran	dolichokran mesokran	mesokran mesokran	dolichokran mesokran	brachykran brachykran	mesokran dolichokran
length-height ♂ ♀			orthokran orthokran	orthokran chamaekran	orthokran orthokran	chamaekran orthokran	orthokran hypsikran	
width-height ♂ ♀			tapeinokran metriokran	metriokran metriokran	metriokran metriokran	tapeinokran tapeinokran	tapeinokran tapeinokran	tapeinokran tapeinokran
face ♂ ♀			mesoprosop mesoprosop		leptoprosop hyperleptopr.	mesoprosop hyperleptopr.	mesoprosop mesoprosop	
orbital ♂ ♀	chamaekonch hypsikonch	mesokonch		mesokonch mesokonch	hypsikonch hypsikonch			hypsikonch
nasal ♂ ♀	mesorrhin			mesorrhin mesorrhin	mesorrhin mesorrhin			mesorrhin

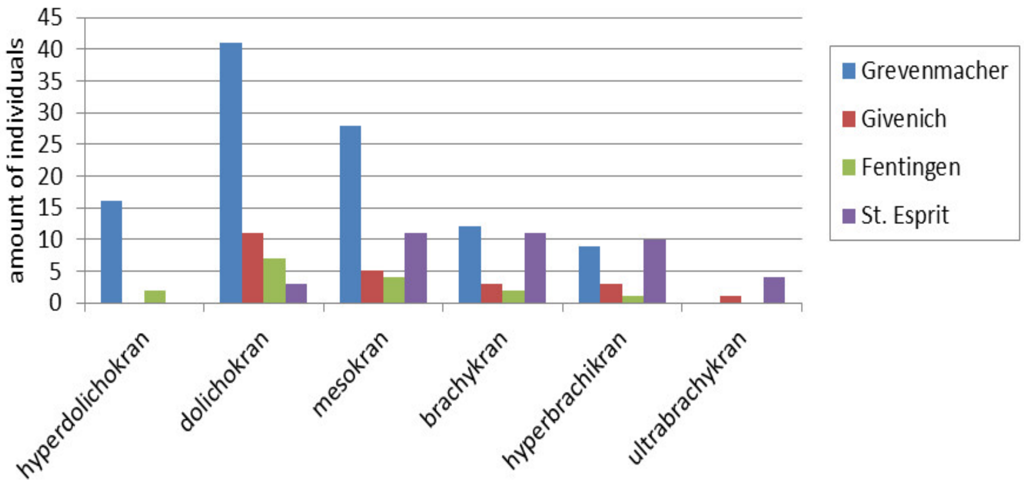


fig. 141. Comparison of the length-width index from four sites

The length-with index of the three rural sites show more or less the same curve shape (fig. 141). Most Individuals fall in the range of dolichokran and mesokran and show on average middle long skulls whereas the variation is very high and includes also extreme shapes from very long (hyperdolichokran) to very wide skulls (ultrabrachykran). Noticeable is the differing distribution visible in the individuals from St. Esprit. Here the curve is shifted in direction of wider skulls were most of the individuals show brachykran or even hyperbrachikran skull shapes.

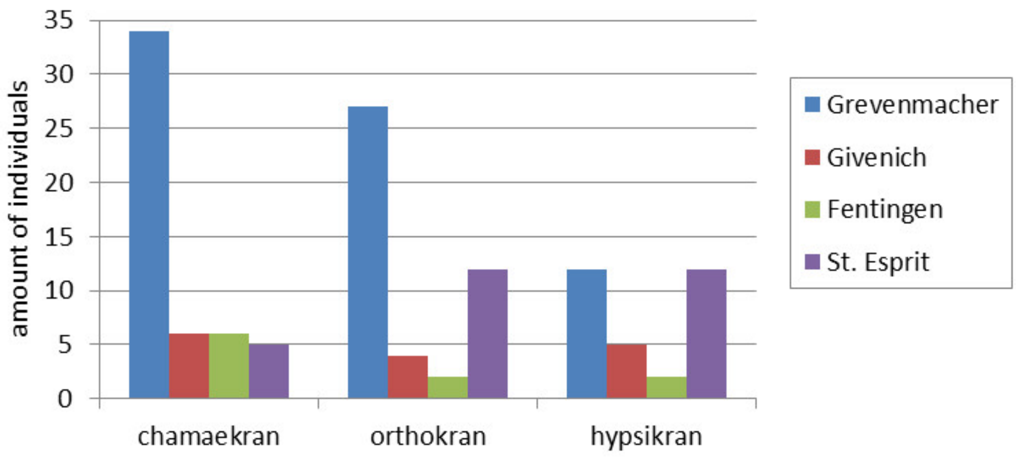


fig. 142. Comparison of the length-height index from four sites

The length-height index of the three rural sites shows again a very similar curve shape (fig. 142). Again all three types of shape are present whereas the flatter and lower (chamaekran) types dominate. Striking again is the opposite direction at St. Esprit. Here skull shapes from a more middle low to high (orthokran and hypsikran) type are dominant.

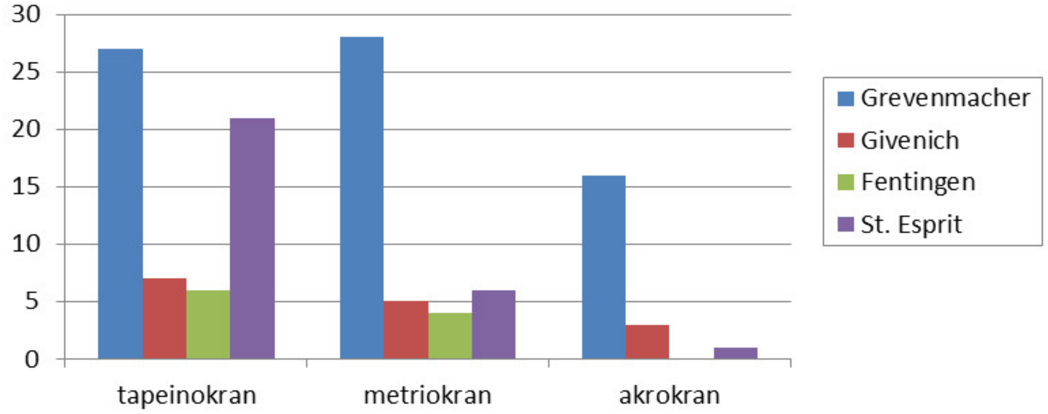


fig. 143. Comparison of the width-height index from four sites

The relation between height and width of the skull reveals similar results in all sites including the St. Esprit sample (fig. 143). Dominant are narrow and middle broad (tapeinokran and metriokran) shapes whereas the variation is overall very high again.

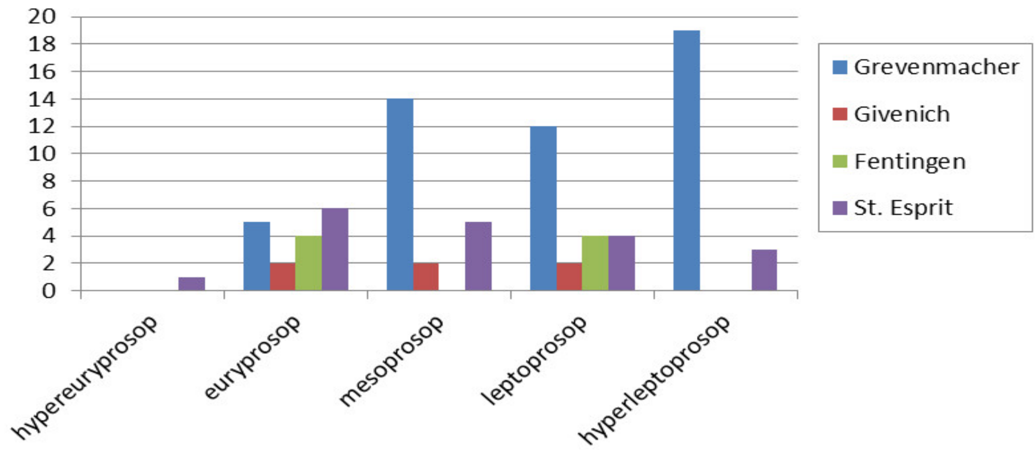


fig. 144. Comparison of the facial index from four sites

The facial index points in all series to on average middle high faces whereas the variation is highest at St. Esprit and Grevenmacher (fig. 144).

The examination of skull shapes revealed some interesting characteristics about the individuals from the different sites. The populations of the three rural sites show very similar types of skulls. The majority skulls are middle long to long, rather flat and narrow to middle broad with middle high faces. In contrast, individuals from the monastic St. Esprit sample show skull shapes that are broader than long and overall higher. They only share the narrower shape in relation to width and the middle high faces. The convent of St. Esprit was founded around 1230 (Rehbach and Bis-Worch 2006) as a nunnery and it can be assumed that the associated residents were predominantly not members of the local population. That could explain the differences in skull shape. Striking is also the overall great variation visible in all indices at all sites that indicate an overall high genetic mixing within the respective populations.

Indices of the infra-cranial skeleton

tab. 112. Indices of the infra-cranial skeleton available from eight sites

		humero-radial		**Fe length-thickness**		**Fe robustness**		**Fe pilastricus**		**femoro-tibial**	
site	sex	right/left		right/left		right/left		right/left		right/left	
Escher-Gleicht	♂ -	74,5		19,8						76,4	
Altwies-Groufbierg	♂ ♀			19,4 18,3						81,5 89,1	
Givenich	♂ ♀	74,7 72,7	67,3 72,5			13,2 13,2	12,0 12,6	106,8 104,2	107,6 98,0	82,0 80,9	80,8 78,9
Diekirch	♂ ♀	73,7 74,7	74,9 74,0	20,1 19,0	20,2 19,3	12,7 11,8	12,7 12,2	107,4 101,4	103,4 100,7	82,3 82,4	81,7 81,5
Grevenmacher	♂ ♀	75,4 75,6	74,8 74,6	20,2 20,2	19,6 19,7	12,7 12,9	12,5 12,5	100,5 100,2	102,0 100,0	82,4 82,1	83,0 82,6
Fentingen	♂ ♀	76,5 75,2	74,1 69,0			12,4 12,2	11,9 12,4	104,4 109,9	109,3 101,1	81,2 80,4	80,0 79,7
St. Esprit	♂ ♀					12,3 12,3					
Grund-Wenzelsmauer	♂ ♀	73,6 74,0		19,1 19,5						82,0 81,5	

(Escher/Gleicht, Altwies-Groufbierg, St. Esprit and Grund/Wenzelsmauer no differentiation between right and left body side)

The humero-radial, as well as, the femoro-tibial index, describe the relation of the respective bones to each other. The values are very balanced in all series. Information about physical activities cannot be derived in this case. However, the recorded indices of the femur can reveal some information concerning this aspect. The length-thickness index was available from five sites. The indices from the two early medieval sites are based on a low number of individual measurements and therefore are not very suitable for further comparisons. The index of robustness, as well as, the index pilastricus are available from the four rural sites of Givenich, Diekirch, Grevenmacher and Fentingen and in part from the monastic site of St. Esprit and allow at least a comparison between these sites. For the index of robustness the values are overall very similar in all four sites, the range of variation is only 0,7 in males and 1,0 in females. The values show overall moderate characteristics of physical activities in both sexes. The index pilastricus describes the shape of the cross-section of the femur mid-shaft and the connected characteristic of the Linea aspera. Individuals from Givenich and Fentingen reveal the highest values whereas individuals from Grevenmacher show the lowest. Therefore, it can be assumed that people at Givenich and Fentingen were exposed to increased physical activities concerning the lower extremities. However, to confirm this statement complete evaluations of the upper and lower extremities would be necessary. Unfortunately due to the sparse amount of data from Givenich and Fentingen it is not possible to carry out further examinations.

13.4. Comparison of body height

tab. 113. Comparison of body heights available from nine sites

site	Pearson (1899)			Olivier et al. (1978)			author unknown		
	n	x	range	n	x	range	n	x	range
Escher/Gleicht				♂ ?? ♀ -	170,0 -				
Altwies-Groufbierg				♂ ?? ♀ ??	170,0 159,0				
Givenich	♂ 14 ♀ 18	163,0 154,0	157,0-168,0 148,0-165,0	♂ 14 ♀ 16	166,8 159,1	156,9-173,4 146,9-169,5			
Diekirch				♂ ?? ♀ ??	170,0 160,0				
Grevenmacher	♂100 ♀ 94	166,2 156,4	154,8-179,1 147,9-168,3	♂ 106 ♀ 91	168,4 159,4	154,5-186,4 148,4-174,5			
Fentingen	♂ 15 ♀ 9	167,0 154,0		♂ 14 ♀ 10	170,8 160,2	162,2-186,5 151,5-160,9			
Luxembourg-St. Esprit	♂ 31 ♀ 51	163,4 152,5	160,0-167,0 150,0-156,0						
Luxembourg-Neumünster							♂ ?? ♀ ??	170,0 158,0	
Grund/Wenzelsmauer				♂ 15 ♀ 4	151,8 163,5	165,9-180,5 163,5-164,3			
Luxembourg-Hospice civil							♂ - ♀ 20	- 156,0	148,0-166,0

One problem in the comparability of body height of the different samples is that the authors used different formulas for calculation. Most authors used the formulas according to Pearson (1899) and Olivier et al. (1978). In the cases of Neumünster and Hospice civil no references for the used formulas are given. At Givenich and Fentingen originally only results after Pearson (1899) were available. To increase the comparability the results after Olivier et al. (1978) were calculated by the author using raw measurements from the respective publication. In the cases of St. Esprit, Neumünster and Hospice civil this step was not possible due to the absences of the respective data.
The calculations for the early medieval series from Escher/Gleicht and Altwies-Groufbierg resulted in body heights of 170,0 for males and 159,0 for females. Compared to the results from Grevenmacher, the males are around 2 cm taller, the females are the same height. However, it is to mention again that the calculations are based on a very small number of individuals. The results from Givenich, Diekirch, Grevenmacher and Fentingen are calculated according to Olivier et al. (1978) show overall balanced values for males and females. The males from Fentingen and Diekirch are the tallest with results around 170,0 cm, the Givenich males reached a stature of just 166,8 cm which is around three centimeters smaller. In the females the differences are less pronounced. The results range between 159,1 cm at Givenich and 160,2 cm at Fentingen. The values of St. Esprit are overall smaller compared to the rural sites with 163,4 cm for males and 152,5 cm for females. Values from Neumünster reveal again higher values with 170,0 cm for males and 158,0 cm for females. As already mentioned, the absence of raw measurements, as well as, information about the according formula in the publication complicates the traceability of these results. The females from Hospice civil show an average stature of 156,0 cm. In this case also no information about the used formula is given.

Changes in body height through time

According to Siegmund (2010), people from the early medieval period reached the highest statures in (pre-)history with on average 168 cm in males and 156 cm in females. In the course of the medieval period, body height decreased around 1,5 to 2 cm until modern times were people reached again values comparable to early medieval times. In order to ascertain possible chronological trends in the studied samples, body height of males and females were compared.

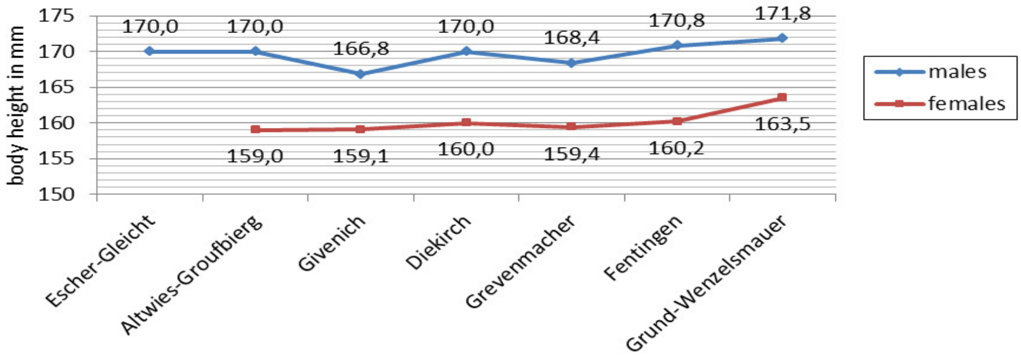


fig. 145. Comparison of body heights of males and females from different sites trough time

Figure 145 shows the results of body height from seven sites differenced for males and females lined up chronologically from early medieval till modern times. To avoid bias only samples were included where body height was calculated with the same method according to Olivier et al (1978) (see table 113). Overall the calculations show relatively balanced results in males and females. A decrease in body height as stated by Siegmund (2010) cannot be confirmed in the studied samples. Only the modern individuals from Grund/Wenzelsmauer are out of line with the highest statures of all samples. However, in this case this fact does not mirror the mentioned increase in body height in modern times, but rather support the designation as members of the military, were preferred able-bodied individuals were recruited.

Another question that can be posed in this context is if it is possible to difference samples from differing social backgrounds. Due to the specific location of the burials, it is assumed that the individuals from Givenich (burials at a manor house) and Fentingen (burials within a church) were members of a higher social class. As inter alia stated by Schweich and Knüsel (2003) the socio-economic status and the associated nutrition and health have influences on growth and development of individuals. Therefore, an increased body height in the two mentioned samples would support the assumed higher status. However, both samples do not show a significant increase in body height. Males from Givenich even show the lowest values of all studied samples. Therefore, the assumed higher status of the individuals, do not find its expression in higher statures.

13.5. *Comparison of pathological changes*

Joint diseases

A more comprehensive comparison of joint disease between series is only possible in the cases of Grevenmacher, Grund/Wenzelsmauer as well as Escher/Gleicht and Altwies-Groufbierg which all used the same scoring system. Joint diseases were also evaluated in the series of Diekirch, St. Esprit and Givenich however the values were based on a different scoring method. In the case of Fentingen degenerative changes of the joints were just described superficially.

tab. 114. Average degrees of osteoarthritis following a scoring system after Schultz (1988) of four main stages (0-3)

site	shoulder		elbow		hand/ finger		hip		knee		foot/toe	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Escher/Gleicht	0,2		0,0		0,3		0,2		0,3		0,0	
Altwies-Groufbierg	0,8		0,5		0,0		0,2		0,0		0,3	
Grevenmacher	1,3	1,3	1,2	1,1	0,5	0,4	1,1	1,2	0,4	0,4	0,4	0,2
Grund/ Wenzelsmauer	0,8	0,5	0,8	1,0	0,9	0,3	0,8	0,5	0,9	1,3	0,8	0,0

The comparison of the sites listed in table 113 reveal great differences between the respective populations. The early medieval individuals from Escher/Gleicht and Altwies-Groufbierg show overall lower degrees of osteoarthritis. Trautmann and Trautmann (2011a, 2011b) state that other early medieval groups show mean values of 1,2 and 1,8. However, an interpretation of these results is difficult because the values are based on a small number of individuals on the other hand the social background of the individuals is not clear. As already stated in chapter 9 about pathological changes, the individuals from Grevenmacher show overall increased rates of osteoarthritis especially in the shoulder and elbow joints. This is to be expected for a rather agricultural population. The individuals from Grund/Wenzelsmauer show overall lower degrees of osteoarthritis. Nevertheless, Trautmann and Trautmann (2011c) state a quite high physical activity especially in the male individuals, visible in the pronounced manifestations at muscle attachment sites.

Degenerative changes of the spine

tab. 115. Average degrees of degenerative changes of the spine

site	cervical		thoracic		lumbar	
	♂	♀	♂	♀	♂	♀
Escher/Gleicht	0,5		0,5		1,2	
Altwies-Groufbierg	0,8		0,0		0,6	
Grevenmacher	0,5	0,4	0,6	0,5	1,2	1,1
Grund/Wenzelsmauer	0,5	0,5	1,1	0,0	0,9	0,0

Degenerative changes of the spine show overall similar values in all samples. Differences due to physical activities cannot be derived. Individuals from the sites of Diekirch, St. Esprit and Givenich were also evaluated for joint and spine status. However, the authors used different scoring systems which complicates a direct comparison with the samples mentioned above. In all three cases the manifestations of osteoarthritis are characterized as overall low to moderately severe in the joints, as well as, in the spine. In all series the degree of osteoarthritis increases with age and males are overall more affected than females (Rehbach 2008, Rehbach et al. 2009). A direct comparison of sites like Grevenmacher and St. Esprit would be interesting due to their different social background. However, the fact that in both evaluations different scoring systems were used as well as the lack of useful numerical data in the case of St. Esprit inhibits further comparisons.

13.6. Teeth

tab. 116. Average degrees of caries frequency, intensity and frequency of enamel hypoplasia

	Caries frequency (%)			Caries intensity (%)			Enamel hypoplasia frequency (%)		
	♂	♀	total	♂	♀	total	♂	♀	total
Escher/Gleicht			100,0			14,2			
Altwies-Groufb.			36,8			8,7			
Givenich	87,5	72,7	81,5	25,9	11,7	21,2	50,0	27,3	40,7
Diekirch	78,7	85,0	81,6				55,6	61,5	58,3
Grevenmacher	77,2	74,7	75,9	19,9	21,4	20,6	13,9	15,0	14,0
St. Esprit	100,0	82,9	87,1	22,2	24,7	23,7	66,7	72,2	69,8
Grund/Wenzelsm.			83,3			15,3			

The examination of caries infestations in the series show very different results. Although the sites Escher/Gleicht and Altwies-Groufbierg are from the same archaeological background they show total different values in caries frequency, as well as, in intensity. This could be due to the low number of individuals, however the same fact applies for Givenich, Diekirch and Grevenmacher. The monastic site of St. Esprit however shows very high values in both categories. The occurrence of enamel hypoplasia was evaluated in four series. Here again the values differ significantly with the highest degrees in both sexes in the St. Esprit sample. The different values in the respective samples can be of various reasons. Caries infestation is also age related. Therefore, a different age distribution within the samples can lead to different infestation rates. Different social status of specific samples, as well as, differences between the sexes are further possible causes.

tab. 117. Average degrees of dental calculus, ante-mortem tooth loss and periapical lesions

	Dental calculus (%)			Ante-mortem tooth loss (%)			Periapical lesions (%)		
	♂	♀	total	♂	♀	total	♂	♀	total
Escher/Gleicht			42,8						
Altwies-Groufb.			22,2						
Givenich	93,8	100,0	96,3	81,3	81,8	81,4	56,3	54,5	55,6
Diekirch	93,5	72,5	83,7	75,5	68,2	72,2	41,5	22,7	33,0
Grevenmacher	96,2	97,5	96,8	78,5	72,1	77,2	36,4	22,5	28,8
St. Esprit	100,0	97,2	98,4	85,1	84,6	86,4	57,7	45,9	50,8
Grund/Wenzelsm.			78,3						26,1

(At Escher/Gleicht, Altwies-Groufbierg and Grund/Wenzelsmauer no differentiation of males and females)

The occurrence of dental calculus and ante-mortem tooth loss is overall high at Givenich, Grevenmacher and St. Esprit however periapical lesions are less frequent at Grevenmacher and Diekirch.

13.7. Summary

The comparison of anthropological data from contemporaneous sites from Luxembourg is not without difficulties. Attention should be paid in particular to the different social backgrounds of the samples. One question that could be asked in this context is if it is possible to differentiate the samples according to social status. Rehbach et al. (2009) assume in the case of Givenich that the individuals from the cemetery, that was associated with a manor house, could belong to a higher social class. The same could be expected in Fentingen where all individuals were buried within a church. This fact is often considered as privilege for individuals from higher social status. Additionally Teegen et al. (2003) describe rich grave goods found in the burials of the Merovingian cemetery of Bartringen which led them to assume the individuals belonged to a high social rank.
Rehbach et al. (2009) list some anthropological features that could indicate a higher social status. Therefore, an overall higher age at death, a better nutritional status and less physical load support a higher social status, that find its expression in an increased body height and less signs of malnutrition. An increased occurrence of dental calculus and carious lesions indicate a nutrition rich in carbohydrates and proteins. Also rather accessible for more affluent individuals. In the case of Bartringen no further information except the age and sex distribution is available. The comparison of body height did not reveal wider differences between the sites of Givenich, Fentingen and, for comparison, the rural sites of Diekirch and Grevenmacher. The evaluation of degenerative changes with regard to physical load is difficult due to different recording systems. Overall the samples of Givenich, Diekirch and Fentingen show low to middle high manifestations of osteoarthritis whereas individuals from Grevenmacher are affected to a higher degree. The evaluation of dental disease is more heterogeneous. Individuals from Givenich show on one hand more carious lesions on the other hand a higher frequency in enamel hypoplasia and periapical lesions compared to the Grevenmacher sample. The occurrence of dental calculus is the same in both sites. Now the question is if a lower degree of osteoarthritis, which is the only difference between the samples of Givenich and Fentingen on one side and Grevenmacher on the other side, is enough to state higher social status in these samples. Trautmann and Trautmann (2011c) state that the individuals of Grund/Wenzelsmauer, also have a lower degree in osteoarthritis, nevertheless, a high degree of physical activity is visible in the very pronounced muscle attachment sites.

13.8. The Luxembourg series and developmental trends in Europe

The comparison of different features on bones and teeth from the studied Luxembourg samples did not reveal clear evidence of social distinction or developmental changes through time. To figure out if this phenomenon only applies to the studied series from Luxembourg we have to look at studies from adjacent European countries. One topic examined in this context is the change in body height through time. As mentioned above, (fig. 145) the Luxembourg series show more or less balanced results, with less fluctuation and no clear increase or decrease of stature throughout the medieval period as cited by Siegmund (2010). De Beer (2003) as well as Maat (2005) published compilations of average statures of males including different samples from the Netherlands from 50 AD to 1997. They found a gradual, but distinct decrease in body height from the roman period during the middle ages till modern time, with its lowest level during the 17th and 18th century. Only from the second half of the 19th century on, a sharper increase in stature occurred continuing until present times. As main reasons for the decrease of stature during medieval times the authors cite an increase in inhabitants and thereby a related urbanization occurring from the 12th and 13th century on. These phenomena are visible in large areas of Northern and Western Europe. The rise of urban centers and the, in part, associated overcrowding due to increased migration from rural environments overwhelmed sanitary provision in many places. The results were often insufficient access to nutrition and safe drinking water that led to a massive increase in infectious diseases. A large number of people living in close proximity, aided the transmission of the infection from human to human. All these factors limited the standard of living in many towns especially for the lowest classes of the population that finds its expression in decreasing statures (Koepke and Baten 2005, Maat 2005). This development from early to late medieval times is also found in other parts of Europe, for example in England. Studies by Schweich and Knüsel (2003), Schweich (2005) as well as Roberts (2009) show a decrease of living conditions in connection with an increase in health problems during medieval times. Here again these facts are mirrored in decreasing statures that concern in particular urban environments. Koepke and Baten (2005) examined body heights compiled from different areas of Europe inter alia the Benelux, Northern France and Western Germany (pooled as "North Rhine" area) as well as Eastern, Western and Northern Europe. The examined time frame also included the last two millennia. Altogether they confirm the results from the previous mentioned studies. They offer several reasons for this development. Here again urbanization and its consequences discussed above play a major role. However, they also consider income, social inequality, public health and in particular climate as factors with regard on the different areas under study.

So all the studies mentioned above found a clear direction in stature development from antiquity to modern times and in particular during the Middle Ages. One reason why this fact cannot be found in the Luxembourg series is because of the low number of individuals available. Maat (2005), Schweich (2005) as well as Koepke and Baten (2005) examined a huge number of series with several thousands of individuals. The Luxembourg samples do not allow such an extensive study. Furthermore, the socio-cultural background of the Luxembourg series differs a lot. Most of the individuals are from rural settlements or convents. However, especially convents have very selective structures and do not represent an average population. The same applies for the military detachment from Grund/Wenzelsmauer. All of the mentioned series state that an increased urbanization in the respective countries and the associated decrease in quality of life leads to decreasing statures. This is not surprising because England, Belgium and the Netherlands were highly urbanized areas in the 11th even more in the 12th and 13th century with big cities that included already several thousand inhabitants. Although more people still lived in rural areas, a proportion shifted to urban environments (Goetz 2002). This was not the case in Luxembourg. In the county urbanization was rather underdeveloped. The city of Luxembourg was the only settlement with a clear urban character. Although a number of city foundations, as well as, the awarding of municipal rights to existing settlements occurred in the 12th and 13th century, no further urban centers developed. The settlements grew slowly and kept their rural characters to the greatest extent (Pauly 1993). On this account further studies concerning direct comparison of rural and urban populations are not possible with the Luxembourg material. Similar examinations by Lewis et al. (1995) as well as Lewis (2002) deal with the state of health of children and adults in respective populations in England. Jungklaus (2009) examined features such as life expectancy, child mortality and state of nutrition, as well as, pathological changes in several rural and urban medieval populations in north-eastern Germany (Brandenburg). In the case of Luxembourg however, the available data is again not sufficient enough. With the individuals from Grevenmacher a large series with rural background is now available. A convincing series from an urban background e.g. the city of Luxembourg however is still missing. The comparison of the Grevenmacher data with the outcomes of Jungklaus (2009) allows just a rough assessment. Although the dating of the examined series is very similar (13th-15th century), the different geographical locations with the connected climatic conditions limit the comparability of the sites. However, a good correlation of the data is visible in features like age distribution, life expectancy, as well as, child mortality. The data of Grevenmacher fits the results from the rural sites of Brandenburg. The same is visible in average body height. Other features like pathological changes or signs of physical activity revealed more varying results, mostly due to differing recording systems. Overall the data from Grevenmacher corresponds with the results for the rural populations examined by Jungklaus (2009), whereas results from the urban environments show larger discrepancies. This fact emphasizes again the overall rural character of Grevenmacher.

13.9. *Comparison of ancient sites*

After comparisons of medieval sites from Luxembourg with each other, an evaluation of data from ancient periods follows. This study includes the sites that had at least a part of the human remains examined and some data were available besides age and/or sex determination. A complete overview of the archaeological sites of all time periods from Luxembourg including human remains was published by Weidig et al. (2011).

The oldest human remains discovered in Luxembourg are two individuals found under a rock ledge from the Mesolithic site of Heffingen-Loschbour. One inhumation (Loschbour I) is dated from 6220 to 5990BC. From the second individual (Loschbour II), dated from 7050 to 6690BC, only some cremated skull fragments are preserved (Le Brun-Ricalens et al. 2005, Delsate et al. 2011, Toussaint et al. 2011). Heuertz (1969) published some data for the inhumation that was confirmed by studies by Delsate et al. (2009, 2011). Therefore, the skeleton is preserved almost completely, it is a male individual, 34-47 years of age and approximately 160,0 cm of height. As a specific feature he describes a sacralization of the fifth lumbar vertebra. Furthermore, he published some indices of the skull according to Martin (1957) (tab. 118) but unfortunately no raw measurements. According to the indices the individual has a long, but flat skull rather broad in relation to height with a high face and a broad nose.

tab. 118. Indices of the skull from individual Loschbour I according to Heuertz (1969)

Index		
length-width	65,0	hyperdolichokran
length-height	69,0	chamaekran
width-height	106,2	akrokran
length-earheight	61,0	orthokran
width-earheight	93,8	akrokran
jugofrontal?	90,9	
jugomandibular?	76,9	
facial	92,3	leptoprosop
upper facial	51,5	mesen
orbital	79,5	mesokonch
nasal	69,8	hyperchamaerrhin
cranial capacity (Manouvrier)	1584,0 cm^3	

The Neolithic site of Heffingen-Atsebach, a rock ledge dating around 5010±80BP, revealed the remains of two adult individuals, as well as, at least two non-adults. The skulls of the adult individuals were more or less complete and Heuertz (1969) published a morphological description based on some indices according to Martin (1957) (tab. 119). The first individual (Atsebach 1) was assigned as probably female, however the age is unknown. The second individual (Atsebach 2) out of a burial is probably male, 20-25 years of age with a reconstructed body height of around 169,0 cm. Both individuals differ significantly in their skull shape. In what way these individuals are connected to each other is not explained by Heuertz (1969).

tab. 119. Comparison of skull indices from the individuals Atsebach 1 and 2

Index	Atsebach 1		Atsebach 2	
length-width	75,3	mesokran	83,0	brachykran
length-height	68,7	chamaekran	82,4	hypsikran
width-height	91,2	tapeinokran	99,3	akrokran
length-earheight			67,1	hypsikran
width-earheight			80,9	metriokran
jugofrontal?	89,6		89,6	
jugomandibular?	81,2		81,9	
facial			88,4	mesoprosop
upper facial	52,6	mesen	56,5	lepten
orbital	79,5	mesokonch	90,0	hypsikonch
nasal	48,1	mesorrhin	41,4	leptorrhin

At the Neolithic site of Diekirch-Deiwelselter fragmented remains of one adult, as well as, one non-adult individual were discovered under a rock. Valloteau and Chenal (2007) conducted some anthropological studies on the bone material. The adult individual was around 20-25 years of age, the sex could not be determined for certain. Therefore, body height was calculated for both sexes according to Trotter and Gleser (1958) and resulted in 177,0 cm for a female and 162,0 cm if the individual would have been a male. The remains of the non-adult individual consist only of a fragment of the right mandible including seven teeth, as well as, the individual proximal epiphysis of the right tibia. The age was determined between six and thirteen years, a sex determination was not possible. Bones of both individuals underwent an AMS dating which resulted in an age of 5320±40BP (4250-4040 BC) for the non-adult and 4310±50BP (3020-2880 BC) for the adult individual.

Under a rock accumulation referred to as "pseudo-dolmen" at the site of Berdorf-Schnellert, human remains of one adult, as well as, one non-adult individual were discovered. Valotteau et al. (2000) published some results of the anthropological studies of the remains. They assign the whole finding to a burial of the late Neolithic period, dating to 4120±40BP or 2890 to 2620 years BC. The adult individual was identified as male, 30-45 years of age with a reconstructed body height of 154±3,48 cm (Olivier et al. 1978). In the non-adult individual sex determination was not possible, age at death was determined between twelve and fifteen years. Valotteau et al. (2000) also published some measurement and indices from the infra-cranial skeleton (according to Martin 1957) listed in table 120.

tab. 120. Measures from the two individuals from Berdorf-Schnellert (all dimensions in mm)

measure	adult		infant		infant	
	left	right	left	right		left
Fe2	395,0				Ra3	26,5
Fe6	27,6		19,2	20,1	Ra4	11,0
Fe7	26,1		17,6	17,3	Ra5	8,5
Fe9	29,8		21,3	22,8	Ul11	9,5
Fe10	24,5		18,9	19,5	Ul12	10,8
Fe15	(23,0)		19,4	19,6	Ul13	13,8
Fe16	31,2			(22,0)	Ul14	15,3
Ti8a		31,1		25,6		
Ti9a		22,6		17,4		
Ti10b		68,0		55,0		
Ca1	73,6					
Ca2	46,5					
Ca3	27,2					
Ca4	35,0					
Fe robustness	21,5					
Fe pilastricus	105,7		109,1	116,2		
Fe platymericus	82,2		84,5	85,5		
Ti cnemicus		72,7		67,9		

The site Altwies-“Op dem Boesch“ revealed three individuals in two graves, assigned to the Neolithic bell-beaker culture. One grave (ALW-00-383) included a female individual, 25 to 40 years of age with a reconstructed stature of 161,6±3,56 according to Olivier et al. (1978). The woman was lying on the right body side, in her hands she held the skull of a neonate individual, four to twelve months of age, that was positioned in front of her. Two AMS dates from the complex resulted in 3870±50BP (2470-2200 BC) and 3680±40 (2150 to1940BC).
In a second pit the body of a male individual was buried (AWL-00-279). In this case only bones from the lower chest downwards were preserved. Due to the missing skull, an accurate age determination was not possible. However the individual is at least an adult with a reconstructed stature of 167,0 to 169,0 according to Cleuvenot and Houët (1993). Here again two AMS dates revealed time frames of 3880±40BP (2470-2210 BC) and 3820±40 (2430 to 2140BC). The simultaneous burial of the women and the child, as well as, the peculiar position of the two skeletons, suggest a close relationship between these two individuals. However, the question if there is also a relation to the male individual in the second pit cannot be answered for certain (Toussaint et al. 2000, 2002; Le Brun-Ricalens 2011 .

Iron Age and Roman period

A single grave under a rock shelter found at the site of Heffingen-Schléd revealed remains of a male individual, 30-35 years of age. The site dates 2490±40BP and is assigned to the Iron Age. Heuertz (1969) published some skull indices according to Martin (1957) listed in table 121, as well as, a reconstructed stature of 170,6 cm. He describes the skull morphology as middle long, but high and broad with a high face.

tab. 121. Indices of the skull from the individual of Heffingen-Schléd

Index		
length-width	76,1	mesokran
length-height	77,1	hypsikran
width-height	101,4	akrokran
length-earheight	64,9	hypsikran
width-earheight	85,3	metriokran
jugofrontal?	90,2	
jugomandibular?	79,5	
facial	93,6	leptoprosop
upper facial	55,3	lepten
orbital	84,6	mesokonch
nasal	43,1	leptorrhin

Another single burial from the Iron Age period, dating 2450±40BP (780-410BC) was unearthed at the site of Hersberg-Bourlach. The grave contained the remains of a male individual 20-40 years of age and a stature of 170,0 cm according to Trotter and Gleser (1958) (Valotteau et al. 2009, 2011).

The site of Pettange-Moersdorf dating around 650BC revealed the calvarium of a female individual. Heuertz (1969) published a series of measurements and indices of the skull according to (Martin 1957) (tab. 122). However, an age determination was not carried out although the skull is almost complete.

tab. 122. Measurement sections and indices of the skull from the calvarium of Pettange-Moersdorf

Mea		Mea		Mea		Index		
1	197	16	(28)	48	59	length-width	65,0	hypodolichokran
2a	182	17	(131)	51	42	length-height	66,5	chamaekran
3a	181	20	111	52	31	width-height	102,3	akrokran
5	(110)	22	110	54	(23)	length-earheight	56,4	chamaekran
5^1	146	29	114	55	47	width-earheight	86,7	akrokran
7	(36)	30	135	60	53	jugofrontal	84,3	
8	128	31	79	61	(58)	jugomandibular	79,7	eurymetop
9	102	40	(103)	33	130°	upper face	49,6	euryen
10	121	43	106	72	88°	orbital	73,8	chamaekonch
11	109	44	97	74	88°	nasal	48,9	mesorrhin
12	(104)	45	(124)					
13	88	46	(84)					

(all mesurements in mm)

Inhumations are overall rare from the Iron Age, as well as, the roman period. At these times the incineration was the dominant burial practice. In Luxembourg there are several burial grounds with numerous cremations some of them even anthropologically studied (tab. 123).

tab. 123. Sites with mainly cremated human remains

site	date	Number of graves	author
Titelberg-Lamadeleine	100BC-1st century AD	79 cremations 6 inhumations	Villemeur (1999)
Feulen	1st century BC	109 cremations (107 studied)	Kunter (2006)
Goeblange-Nospelt	50-10BC	11 cremations out of 14 graves	Le Goff (2009)
Bertrange-Tossenberg	1st-5th century AD	56 cremations 2 inhumations	Kunter (2003)

13.10. Summary

Overall the evaluation of literature concerning human remains from ancient sites in Luxembourg did not reveal much anthropological data that allows comprehensive comparisons over time. This is mainly because these remains were not studied by physical anthropologists, but archaeologists. An exception are the cremations from the Iron Age and roman period where special anthropological knowledge is necessary for evaluation but the resulting information is small due to the very fragmented material. The only common data that is present in several sites are indices of the skull and reconstructions of body height.

tab. 124. Comparison of skull indices of individuals from sites from the Mesolithic, Neolithic and Iron age, all published by Heuertz (1969)

site	Heffing-Loschbour 1	Heffingen-Atsebach 1	Heffingen-Atsebach 2	Heffingen-Schléd	Pettange-Moersdorf
period	Mesolithic	Neolithic	Neolithic	Iron Age	Iron Age
sex	male	female	male	male	female
length-width	65,0	75,3	83,0	76,1	65,0
length-height	69,0	68,7	82,4	77,1	66,5
width-height	106,2	91,2	99,3	101,4	102,3
length-earheight	61,0		67,1	64,9	56,4
width-earheight	93,8		80,9	85,3	86,7
jugofrontal	90,9	89,6	89,6	90,2	84,3
jugomandibular	76,9	81,2	81,9	79,5	79,7
facial	92,3		88,4	93,6	
upper facial	51,5	52,6	56,5	55,3	49,6
orbital	79,5	79,5	90,0	84,6	73,8
nasal	69,8	48,1	41,1	43,1	48,9

tab. 125. Comparison of body height of individuals from sites from the Mesolithic till the Roman period

site	date	sex	Trotter and Gleser (1958)	Olivier et al. (1978)	Cleuvenot & Houët (1993)	author unknown
Heffingen-Loschbour 1	6220-5990BC (Mesolithic)	♂				160,0
Heffingen-Atsebach 2	5010±80BP (Neolithic)	♂				169,0
Diekirch-Deiwelselter	3020-2880BC (Neolithic)	??	162,0 if ♂ 177,0 if ♀			
Berdorf-S chnellert	2890-2620BC (Neolithic)	♂		154,0±3,48		
Altwies-Op dem Boesch	2430- 2140BC 2150-1940BC (Neolithic)	♂ ♀		 161,6±3,56	167,0-169,0 160,4-163,7	
Heffingen-Schléd	2490±40BP (Iron Age)	♂				170,6
Hersberg-Bourlach	2450±40BP (780-410BC) (Iron Age)	♂	170,0			
Bertrange-Tossenberg	1^{st}-5^{th} century AD (Roman)	♂ ♂				169,0 171,0

The comparison of body height reveals some differences between the group of individuals from the Mesolithic and Neolithic and the summarized group from the Iron Age and Roman period. If we summarize the values in the respective group (only males) and calculate the mean value, we get 162,6 cm for the Stone Age sample and 170,2 cm for the Metal Age sample. In spite of the low number of individuals in both series an increase in body height is visible over time. If we pursue this development in Luxembourg including series from younger periods, we find values of 170,0 cm for males and 159,0 cm for females in the early medieval sites of Escher/Gleicht and Altwies-Groufbierg. For the medieval period we summarize the values from the seven sites Givenich, Diekirch, Grevenmacher, Fentingen, St.Esprit, Neumünster and Grund-Wenzelsmauer. This results in average body heights of 168,7 cm for males and 158,9 cm for females (fig. 146). It is therefore possible to find an increase in body height from the Neolithic to the early medieval period and a decrease from early to high medieval times.

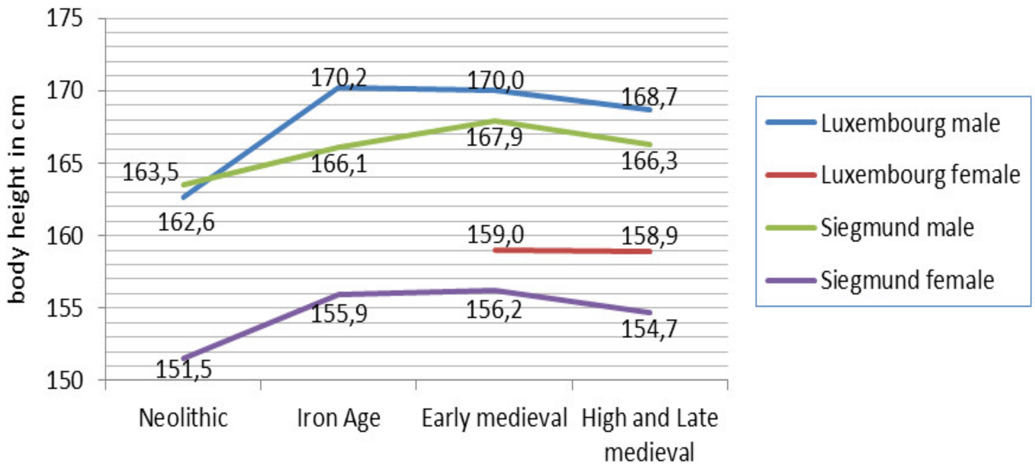


fig. 146. Average body heights through time from different sites from Luxembourg in comparison with results published by Siegmund (2010)

Siegmund (2010) confirms such a development in stature in a compilation of average body height from the younger Stone Age until modern times (fig. 146). This also applies to authors already mentioned above which studied different series from Europe (Koepke and Baten 2005, Maat 2005, Schweich 2005). However, the increase, as well as, the later decrease in stature is by far not as high as the values for Luxembourg. Although the outcomes from the Luxembourg sites are based on a low number of individuals, which result in rather high values especially for the Iron Age and early medieval period, the general tendency in the development of body height is clearly visible.

14. Conclusion

The study of the skeletal remains unearthed at the cemetery of Grevenmacher revealed a large amount of anthropological data characterizing the population of a central European medieval town. The occupation time of the cemetery spreads over approximately 700 years, probably from the 8th till the early 15th century. Unfortunately the majority of the graves can not be assigned to early or later time periods due to the dens and repeated re-occupation of early created graves in later times. However, it can be assumed that the burned bone complex found within the church, dated between 1346 and 1389, includes a large amount of individuals from the earlier occupation period. Most of the inhumation graves that entered this study date to the later period of the 13th and 14th century (Bis-Worch 2005). The data from 371 individuals were examined whereas 30,7% were neonates, infants and juveniles. The average life expectancy at birth was 30,4 years. Neonates and young infants show an overall high rate of death, another critical phase was the time of weaning around the age of two to three years. Here again infectious diseases due to a weakened immune system, as well as, other infections caused by the change in diet and the exposure to new pathogens are the main causes of death. Overall, infectious diseases can be considered as the main cause of death in childhood in (pre-) historic times. When the childhood years were left behind, males had a longer life expectancy of 23,7 years, whereas females lived on average only another 18,3 years. Hard physical work in particular in combination with the risks of pregnancy and childbirth were main causes of female mortality during the reproductive phase especially between 20 and 40 years of age.

The living conditions of a certain population always depends on a variety of environmental factors. The major factor is the settlement area with its respective climatic conditions that in turn influences the nutritional situation of the people (Koepke and Baten 2005). The ensurance of an adequate supply of food and water was the major purpose of a rural population, whose members were almost all agricultural workers. However, the farmers not only needed to ensure the nutrition of their own family. But they had to provide duties to the nobility or clergy that often owned the farmed land (Rösener 1987, Goetz 2002). In the early days of Grevenmacher the duties went to the convent of St. Maximien as well as to the archbishop of Trier, from the middle of the 12th century to the counts of Luxembourg (Bis-Worch 2010). Furthermore, food shortages or even famines occurred successively in the medieval period, in particular in the years 1314 to 1319 where great parts of Europe were affected (Goetz 2002, Schubert 2006). An increased susceptibility to infectious and other diseases are thereby the main consequences of malnutrition. Times of scarcity could also be assumed for the Grevenmacher population. However, the overall low rates of traces of malnutrition on the bones and teeth in the individuals indicate a generally good nutritional status of the population.

Noticable is also the good state of health in the Grevenmacher population in general. This concerns infectious and metabolic diseases, as well as, traumatic injuries. Here the rates of all the respective symptoms are much lower in comparison to other medieval series. The reasons for that fact are various. Different geographical locations and the connected climate and weather have direct influences on the nutrition. A different social composition of the population, as well as, different living conditions in general are also possible reasons.

Agricultural work in medieval times meant primarily hard physical labor with almost no technological support. The examination of different manifestations on the bones of the Grevenmacher individuals that could be connected to physical activity revealed some interesting results. Around 75% of all adult individuals show middle to high degrees of entheseal changes as well as osteoarthritis. These results indicate a high physical activity most likely due to everyday agricultural labor, which was the main purpose in life of the peasant population (Dinzelbacher 2010, Goetz 2002). However, it was not possible to assign specific manifestations on the bones to specific kinds of activity. Additionally, hand the various etiology, as well as, the strong correlation to age in both cases limits the significance of a clear assignment to physical activity.

In spite of the award of the municipal charter in 1252 the subsistence of the population seemed to be mainly agricultural based and Grevenmacher was a settlement of lesser importance. In the years 1357/58 Duke Wenzel authorized the implementation of a weekly market and Grevenmacher received the right to bear a seal. Therewith Grevenmacher was awarded the status of a central town in the area (Bis-Worch 2010). In the course of time a migration of people from the surrounding area as well as craftsmen and traders can be expected. How high the increase in population was over time cannot be answered for certain. Values referring to this matter are rare. Pauly (1993) mentions around 100 "fireplaces" in the last quarter of the 15th century at Grevenmacher. That means an estimated population size between 400 and 600 individuals. The reconstructed population size based on the skeletal material revealed values between 150 and 250 individuals in the 13th and the beginning of the 14th century. That would mean a doubling of the population in the 14th and 15th century. This theory could be considered a realistic scenario. However, the expansion made it necessary to produce a surplus in agricultural products to ensure an adequate diet for a growing population. The fertile grounds around the town, as well as, short trade routes to Trier and the city of Luxembourg in east-west direction as well as Echternach and Remich in north-south direction contributed to the food supply to ensure a variety of products.

One feature often regarded as a necessity for a town is the presence of a hospital (Vanja 2008). Such an institution is mentioned in the historical records of Grevenmacher, however it could not be supported by the bone material. Only a small amount of individuals show illness-related features on the bones, and only a small amount of old people are found among the dead. If there was a hospital in Grevenmacher, its residents were most

probably buried in the hospital graveyard and not at the public cemetery.
The development of a town is always accompanied by the establishment of different social classes. The appointment of public officials and servants by the overlord resulted in an upper class together with the local clergy. Craftsman and traders created the urban middle class (Goetz 2002). How distinct the social stratification was at Grevenmacher is difficult to answer. The rather small-town character of Grevenmacher with just a few central functions emphasized by Pauly (1993) would indicate only a certain number of officials would be considered of upper class. These persons were just a minority within the population. The attempt to divide social classes based on different manifestations on bones and teeth in combination with the position of the burial place on the cemetery did therefore not work out well.
The historical records confirm that Grevenmacher underwent major changes in the 13th and 14th century. The award of the municipal charter caused a gradually increase in population size, as well as, an enhancement of the town. However, socio-cultural changes did not occur immediately and the mentioned anthropological features support the still rural characteristic of the little town. This fact is emphasized by comparisons of different anthropological features with urban and rural populations from Brandenburg examined by Jungklaus (2009). Although this kind of comparison must be considered with caution due to the differing geographical locations of the respective series. However, the majority of the examined features also confirm the overall rural character of the Grevenmacher population. Further comparisons of anthropological data with values from other medieval sites from Luxembourg included facts about age and sex distribution, metrical and morphological data, as well as, pathological changes. The results revealed common features, as well as, differences most likely due to the different socio-cultural background of the respective sites. Thereby one focus was on the development of body height through medieval times already studied by other researchers (Schweich and Knüsel 2003, Koepke and Baten 2005, Maat 2005). The stated decrease of stature through the medieval period could not be confirmed by the Luxembourg material. The main reason is the overall low number of studied individuals available, as well as, the underdeveloped urbanization in the county of Luxembourg. However, an inclusion of anthropological data from Stone and Metal Age sites from Luxembourg revealed a trend of decreasing statures from the Mesolithic till Modern times in Luxembourg.
The detailed examination of the skeletal remains from the cemetery of Grevenmacher is a contribution to the understanding of the developmental history of a village on its way to becoming a town and its related population. However, the repeated re-occupation of the small cemetery area limits the detailed temporal allocation of defined areas, and it complicates the answer to certain questions in connection with the positioning of certain burials. Nevertheless, further comparisons with other series from different socio-cultural backgrounds help to complete the picture of medieval Luxembourg. It also forms the basis for further studies to deepen the achieved results, as well as, to open new doors

of scientific anthropological work. Due to the good preservation of the skeletal material, studies like the examination of stable isotopes are planned to aid in the understanding of the nutritional status of the population, and to investigate migration patterns and influx into the town. DNA analysis can help to reconstruct possible kinship relations of certain individuals. Finally new methods like the study of dental calculus to examine oral pathogens will offer new insights into the prevalence of disease in this population.

15. Summary/Zusammenfassung

15.1. Summary

The medieval cemetery of Grevenmacher, Luxembourg excavated in the years 2003 till 2005 by the Centre National de Recherche Archéologique Luxembourg, revealed a large amount of human skeletal remains. A minimum number of 1316 individuals could be reconstructed from inhumation graves located mainly in the cemetery to the east of the church. The earlier examination of a complex of burned human bones revealed an additional minimum number of 1699 Individuals. In the present study the main focus of examination was on the sekeletal remains from the inhumation graves, dating mainly from the 13th to the early 15th century. A total number of 371 individuals entered the study due to good preservation and representation and they formed the basis for the anthropological analysis. The rest of the individuals are mainly represented by isolated bones, found scattered in the graves or as accumulations in pits. Skeletons of adult individuals were represented to an average of 49,5%. In non-adults representation was lower with 39,6%. The condition of the bone material was overall good, and only a small amount of bones show erosion on the surface. 257 individuals filled the age categories adultus, maturus and senilis, 114 died before the age of 20. In the adults 129 individuals were determined as males, 120 were females and eight individuals are undetermined. In the non-adults sex determination revealed 46 males, 25 females and 43 undetermined individuals. The average life expectancy at the time of birth was 30,4 years. The calculation of population size revealed an average between 150 and 250 individuals living in the village of Grevenmacher in an assumed occupation time of 700 years.

The comprehensive measurement of the bones resulted in a great amount of anthropometric data. A pronounced sexual dimorphism between the sexes is visible on the raw measurements of the bones, as well as, the body height. Males from Grevenmacher reach an average body height of 166,2 cm. Females are with 156,4 cm on average 9,8 cm shorter.

The study of physical adaptations of specific parts of the skeleton revealed that the individuals of Grevenmacher were overall exposed to middle to high ranges of physical load. The distributions of entheseal changes reflect typical rural activities in flat terrain with increased load on the trunk area (shoulder, upper and lower arm). However, a direct assignment to specific activities was not possible.

The study of pathological changes helps to complete the picture of the living conditions of the population. Here the focus was on degenerative changes of the limbs and especially the spine, that support the exposure to high physical load throughout live of the Grevenmacher individuals. Overall a variety of diseases was diagnosed from non-specific

infections with inflammations of different kinds of bone tissue to neoplastic disease visible in the formation of different kinds of tumours. Metabolic disease is present in the form of anaemia and osteomalacia. Congenital changes find their expression in unfused bone parts mainly in the spine. Traumatic injuries are distributed all over the body from the skull to fractured clavicles, arm bones, parts of the pelvis and lower limbs.
A significant proportion of the population suffered from caries, dental calculus, as well as, periapical lesions like granuloma and apical cysts. Signs of nutritional deficiency were rarely found. This leads to the conclusion that the nutritional status of the individuals was generally good.
The large amount of non-adult individuals in combination with an excellent preservation of the bone material allowed a detailed examination of a part of a population, that was never possible before in Luxembourg. The anthropometric data allowed a detailed analysis of child growth and development in medieval times. Features like the time of weaning could be determined. The study of pathological features gave interesting insight in the burden of disease of the children and adolescents. Additional investigations concerning the reconstruction of possible kinship, as well as, the differentiation of social classes on the cemetery. The results gained from the evaluation were also used for additional studies concerning comparisons with a complex of burned human remains found within the church of Grevenmacher, and human remains from contemporaneous, as well as, ancient archaeological sites throughout Luxembourg.
The detailed examination of the skeletal remains from the cemetery of Grevenmacher is a contribution to the understanding of the developmental history of the village of Grevenmacher on its way of becoming a town and its related population. The overall good preservation of the human skeletal remains, as well as, the great number of individuals allowed a study of high statistical value. In contrast to other evaluated series from medieval Luxembourg, the individuals of Grevenmacher represent a cross-section of a rural population. The inclusion of a great amount of non-adult individuals enabled the study of a population sub-group that could not be carried out until now. Therefore, the combination of a detailed archaeological, as well as, anthropological examination of the historic remains of Grevenmacher, enriches the historical understanding of not only the village itself, but also the country of Luxembourg.

15.2. Zusammenfassung

Bei archäologischen Ausgrabungen auf dem mittelalterlichen Friedhof von Grevenmacher, Luxembourg, durchgeführt in den Jahren 2003 bis 2005 vom Nationalmuseum für Geschichte und Kunst, Luxembourg, wurde eine große Anzahl von menschlichen Überresten zutage gefördert. Aus Körpergräbern, die aus einem Friedhof östlich einer Kirche stamen, konnte eine Mindestanzahl von 1316 Individuen rekonstruiert werden. Die frühere Auswertung eines weiteren Befundes mit verbrannten menschlichen Knochen ergab eine weitere Mindestanzahl von 1699 Individuen. Der Fokus in der vorliegenden Studie liegt auf Knochenmaterial aus den Körpergräbern, die vom 13. bis ins 15. Jahrhundert datiert werden können. Die Reste von 371 Individuen wurden analysiert, ausschlaggebend dafür waren, in erster Linie eine gute Repräsentation der Skelette sowie eine gute Erhaltung der einzelnen Knochen. Die restlichen Individuen sind meist nur durch isolierte Knochen repräsentiert, die als Beifunde in Gräbern oder als Ansammlungen in Gruben aufgefunden wurden. Skelette adulter Individuen sind im Durchschnitt zu 49,5% repräsentiert. Bei den Kinderskeletten beträgt der Repräsentationsgrad nur 39,6%. Die Knochen sind überwiegend in einem guten Zustand, nur wenige zeigen stärkere Verwitterungsspuren hauptsächlich an der Oberfläche. 257 Individuen sind auf die Altersklassen adultus, maturus und senilis verteilt, 114 starben vor Erreichen des 20. Lebensjahres. Bei den Erwachsenen konnten 129 als männlich, 120 als weiblich klassifiziert werden, bei acht Individuen war keine Altersansprache möglich. Bei den Kindern und Jugendlichen ergab die Geschlechtsanalyse eine Anzahl von 46 männlichen und 25 weiblichen Individuen. 43 Individuen konnte keinem Geschlecht zugeordnet werden. Die durchschnittliche Lebenserwartung bei der Geburt betrug 30,4 Jahre. Eine Rekonstruktion der Populationsgröße ergab, das zwischen 150 und 250 Individuen bei einer Besiedelungszeit von ca. 700 Jahren in Grevenmacher gelebt haben.

Die umfangreiche Vermessung der Knochen erbrachte eine große Zahl anthropometrischer Daten. Daraus ließ sich unter anderem ein ausgeprägter Geschlechtsdimorphismus ableiten. Dieser zeigt sich einerseits bereits in den Rohdaten, andererseits in der rekonstruierten Körperhöhe. Die männlichen Individuen aus Grevenmacher erreichten eine durchschnittliche Größe von 166,2 cm während die Frauen mit 156,4 cm im Durchschnitt 9,8 cm kleiner waren. Die Untersuchung von physischen Anpassungen bestimmter Skelettabschnitte an umweltbedingte Belastungen ergab, dass die Grevenmacher Bevölkerung in mittlerem bis hohem Maße körperlichen Strapazen ausgesetzt war. Die Analyse der Ansatzstellen von Sehnen und Muskeln zeigt eine insgesamt hohe Belastung vor allem im Bereich des Oberkörpers (Schulter, Ober- und Unterarm) wie sie typisch für handwerkliche und agrarische Tätigkeiten in flachem Gelände sind. Eine genaue Zuordnung bestimmter Belastungsmerkmale zu bestimmten Tätigkeiten war jedoch nicht möglich.

Die Untersuchung pathologischer Veränderungen ergänzt die Rekonstruktion der Lebensverhältnisse der Bevölkerung. Das Hauptaugenmerk lag hierbei auf degenerativen Veränderungen der Gliedmaßen und der Wirbelsäule, die eine hohe physische Belastung bei einer großen Zahl der Individuen zumindest teilweise bestätigen. Insgesamt konnte eine große Bandbreite an Krankheiten innerhalb der Bevölkerung diagnostiziert werden. Angefangen bei unspezifischen Infektionen mit Entzündungen unterschiedlicher Arten von Knochengewebe bis zu neoplastischen Erkrankungen in Form von verschiedenartigen Tumoren. Anämien und Osteomalazie zeigen Erkrankungen des Stoffwechsels an. Kongenitale Veränderungen finden sich in Form von nicht verwachsenen Knochenanschnitten vor allem im Bereich der Wirbelsäule. Traumatische Verletzungen sind an Knochen des gesamten Skeletts zu finden. Angefangen bei Schädelverletzungen über Frakturen des Schlüsselbeins, Armknochen, im Bereich des Beckens sowie der unteren Extremitäten. Eine große Anzahl der Individuen litt an Erkrankungen des Zahnapparates in Form von Karies, Zahnstein sowie periapikalen Läsionen wie Granulomen und apikalen Zysten. Anzeichen von Mangelernährung wurden nur vereinzelt gefunden, was darauf schließen lässt das der Ernährungszustand der Bevölkerung im Allgemeinen gut war.

Die große Anzahl an Kindern und Jugendlichen sowie die insgesamt gute Knochenerhaltung ermöglichte die ausführliche Untersuchung einer Personengruppe, die so in Luxembourg bisher nicht möglich war. Anthropometrische Daten erlauben eine detaillierte Studie von Wachstums- und Entwicklungsvorgängen. Ebenso konnten weitere Merkmale wie der Zeitpunkt des Abstillens bei den Kleinkindern bestimmt werden. Die Analyse pathologischer Veränderungen lässt einen genauen Blick auf die Krankheitsbelastung der Kinder und Jugendlichen zu. Weitere Untersuchung galten möglichen verwandtschaftlicher Beziehungen sowie die Unterscheidung sozialer Schichten innerhalb des Gräberfeldes. Des Weiteren wurden die gewonnen Daten aus dem Friedhof dazu verwendet Vergleiche, zum einen mit dem bereits teilweise ausgewerteten Brandknochenkomplex aus dem Kircheninneren, zum anderen mit Daten aus anderen archäologischen Fundstellen aus Luxembourg vorzunehmen, die ebenfalls menschliche Überreste enthielten.

Die detaillierte Auswertung der menschlichen Skelettreste aus dem Friedhof von Grevenmacher trägt so zum Verständnis der Entwicklungsgeschichte des Dorfes und seiner Bewohner auf seinem Weg zu Stadtwerdung bei. Die insgesamt gute Erhaltung des Skelettmaterials sowie die große Anzahl an Individuen ermöglichte eine Untersuchung auf hohem statistischem Level. Im Gegensatz zu anderen bereits untersuchten mittelalterlichen Serien aus Luxembourg stellen die Individuen aus Grevenmacher einen Querschnitt durch eine ländliche Bevölkerung dar. Die Einbeziehung einer großen Anzahl an Kindern und Jugendlichen ermöglichte die Analyse einer Teilpopulation die so bisher in Luxembourg nicht möglich war. Die Kombination einer detaillierten archäologischen als auch anthropologischen Auswertung vervollständigt so das historische Bild nicht nur der Stadt Grevenmacher sondern auch der Geschichte Luxembourgs.

16. References

Chapter 1: Introduction

Bis-Worch, C. (2005), Grevenmacher - die Ausgrabungen im Bereich des Baxerasgartens und neue Erkentnisse zur baulichen Entwicklung der Stadt. Unpublished scientific treatise.

Bis-Worch, C. (2010), Zur Stadtentwicklung Grevenmachers. In: Dewilde, M.; Ervynck, A.; Becuwe, F. (eds.) (2010), Cenulae recens factae. Een huldeboek voor John De Meulemeester. Jaarboek Abdijmuseum 'Ten Duinen 1138', Novi Monasterii Vol. 10, pp. 57-74.

d' Hollosy, M.; de Meulemeester, J. (1999), Le cimetière de Saint-Jean et l'étude des squelettes. In: Baray, Y. (ed.) (1999), Le Passé recomposé, Archéologie urbaine à Luxembourg. Catalogue d'exposition du Musée National d'Histoire et d'Art Luxembourg, pp. 149-153.

Nothwang, U.; Rehbach, N.-J.; Flohr, S. (2004), Die Gräberserie „Hospice cilvil" – eine Bestandsaufnahme aus dem Barock. Bulletin d'Information de Musée National d'Histoire et d'Art, Luxembourg 17, pp. 67-68.

Rehbach, N.J. (2008), Abschlussbericht zur anthropologischen Untersuchung der Gräberserie aus dem ehemaligen Kloster St. Esprit/Luxemburg. ADFG Nothwang u. Partner, Frankfurt/Main.

Rösener, M. (1987), Bauern im Mittelalter. C.H. Beck'sche Verlagsbuchhandlung, Nördlingen.

Trautmann, B. (2007), Anthropologische Auswertung einer Stichprobe aus dem Brandknochengemenge von Grevenmacher (Luxemburg). Magister thesis at the University of Tuebingen, Germany. http://tobias-lib.uni-tuebingen.de/volltexte/2008/3647

Vogt-Lüerssen, M. (2001), Der Alltag im Mittelalter. Verlag Ernst Probst, Mainz.

Wahl, J. (2007), Karies, Kampf und Schädelkult. 150 Jahre anthropologische Forschung in Südwestdeutschalnd. Materialhefte zur Archäologie in Baden-Württemberg Heft 79. Theiss Verlag, Stuttgart.

Weidig, I.; Bis-Worch, C.; Rehbach, N.-J.; Nothwang, U.; Sindermann, A.; Krier, J.; Le Brun-Ricalens, F.; Metzler, J. (2011), Luxembourg. In: Márquez-Grant, N.; Fibinger, L. (eds.) (2011), The Routledge Handbook of Archaeological Human Remains and Legislation. An international guide to laws and practice in the excavation and treatment of archaeological human remains. Routledge, Taylor and Francis Group, London.

Chapter 2: The bone material

Bello, S.; Andrews, P. (2006), The Intrinsic Pattern of Human Skeletons and its Influence on the Interpretation of Funerary Behaviours. In: Gowland, R.; Knüsel, C. (eds.) (2006), Social Archaeology of Funerary Remains. Oxbow, Oxford.

Carter, D.O.; Tibbett, M. (2008), Cadaver Decomposition and Soil: Processes. In: Tibbert, M.; Carter D.O. (2008), Soil Analysis in Forensic Taphonomy. CRC Press, Boca Raton.

Ohler, N. (1990), Sterben und Tod im Mittelalter. Artemis Verlag, München.

Trautmann, M. (2012), Die schnurkeramischen Bestattungen von Lauda-Königshofen. Steinzeitliche Hirtennomaden im Taubertal? Fundberichte aus Baden-Württemberg 32/1, pp. 265-476.

Chapter 3: Number of Individuals, age and sex distribution

AlQahtani, S.J.; Hector, M.P.; Liversidge, H.M. (2010), The London Atlas of Human Tooth Development and Eruption. American Journal of Physical Anthropology 142, pp. 481-490.

Baker, B.J.; Dupras, T.L.; Tocheri, M.W. (2005), The Osteology of Infants and Children. Texas A&M Universitiy anthropology series no. 12.

Bello, S.M.; Thomann, A.; Signoli, M.; Dutour, O.; Andrews, P. (2006), Age and Sex Bias in the Reconstruction of Past Population Structures. American Journal of Physical Anthropology 129, pp. 24-38.

Bello, S.M.; Andrews, P. (2006), The Intrinsic Pattern of Human Skeletons and its Influence on the Interpretation of Funerary Behaviours. In: Gowland, R.; Knüsel, C. (eds.) (2006), Social Archaeology of Funerary Remains. Oxbow, Oxford.

Black, T.K. (1978), Sexual dimorphism in the tooth crown diameters of the deciduous teeth. American Journal of Physeical Anthropology 48, pp. 77-82.

Brooks, S.; Suchey, J.M. (1990), Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. Human Evolution 5, No 3, pp. 277-238.

Cardoso, H.F.V.; Saunders, S.R. (2008), Two arch criteria of the ilium for sex determination of immature skeletal remains: A test of their accuracy and an assessment of intra- and inter-observer error. Forensic Science International 178, pp. 24-29.

Dollhopf, K.-D. (2002), Die verschwundenen Kinder. Bemerkungen zum Kinderdefizit bei Bestattungen auf frühmittelalterlichen Gräberfeldern. Archäologische Korrespondenzblatt 32, pp. 151-159.

Ferembach, D.; Schwidetzky, I.; Stloukal, M. (1979), Empfehlungen für die Alters- und Geschlechtsdiagnose am Skelett. Homo 30, 2, pp. 1-25.

Gerhardt, K. (1985), Anatomie für Ausgräber und Sammler. Materialhefte zur Vor- und Frühgeschichte in Baden-Württemberg 3. Theiss, Stuttgart.

Grupe, G.; Christiansen, K.; Schröder, I.; Wittwer-Backofen, U. (2005), Anthropologie. Ein einführendes Lehrbuch. Springer, Berlin.
Hermann, B.; Grupe, G.; Hummer, S.; Piepenbrink, H.; Schutkowski, H. (1990), Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden. Springer, Berlin.
Işcan, M.Y.; Loth, S.R. (1986), Estimation of Age and Determination of Sex from the Sternal Rib. In: Reichs, K.J. (ed.) (1986), Forensic Osteology. Advances in the Identification of Human Remains. Springfield.
Kölbl, S. (2004), Das Kinderdefizit im frühen Mittelalter – Realität oder Hypothese? Zur Deutung demographischer Strukturen in Gräberfeldern. Dissertation University of Tuebingen.
Kósa, F. (1978), Identifikation des Feten durch Skelettuntersuchungen. In: Hunger, H.; Leopold, D., (1978), Identifikation. Barth, Leipzig.
Lassen, C.; Hummel, S.; Herrmann, B. (2000), Molecular sex identification of stillborn and neonate individuals („Traufkinder") from the burial site Aegerten. Anthropologischer Anzeiger 58, 1, pp. 1-8.
Lewis, M.E. (2007), The Bioarchaeology of Children. Perspectives from Biological and Forensic Anthropology. Cambridge University Press, UK.
Loth, S.R.; Henneberg, M. (2001), Sexually dimorphic mandibular morphology in the first few years of life. American Journal of Physical Anthropology 115, pp. 179-186.
Martin, R. (1957), Lehrbuch der Anthropologie. Stuttgart.
Molleson, T.; Cruse, K. (1998), Some sexually dimorphic features of the human juvenile skull and their value in sex determination in immature skeletal remains. Journal of Archaeological Science 25, pp. 719-728.
Murail, P.; Bruzek, J.; Houët, F.; Cunha, E. (2005), DSP: A tool for probabilistic sex diagnosis using worldwide variability in hip-bone measures. Bulletins et Mémoires de la Société d'Anthropologie de Paris 17, 3-4, pp. 167-176.
Nemeskéri, J.; Harsányi, L.; Acsádi, G. (1960), Methoden zur Diagnose des Lebensalters von Skelettfunden. Anthropologischer Anzeiger 24, pp. 70-95.
Orme, N. (2001), Medieval Children. Yale University Press, London.
Rösing, F.W.; Graw, M.; Marré, B.; Ritz-Timme, S.; Rothschild, M.A.; Rötzscher, K.; Schmeling, A.; Schröder, I.; Geserick, G. (2005), Arbeitsgemeinschaft für Forensische Altersdiagnostik der Deutschen Gesellschaft für Rechtsmedizin. Empfehlungen für die forensische Geschlechts- und Altersdiagnose am Skelett. Rechtsmedizin 15, pp. 32-38.
Schaefer, M.; Black, S.; Scheuer, L. (2009), Juvenile Osteology. A Laboratory and Field Manual. Elsevier, London.
Scheuer, L.; Black S. (2000), Developmental Juvenile Osteology. Elsevier, London.
Schutkowski, H. (1987), Sex determination of fetal and neonate skeletons by means of discriminant analysis. International Journal of Anthropology 2, pp. 347-352.
Schutkowski, H. (1993), Sex determination of infant and juvenile skeletons: I. Morphognostic features. American Journal of Physical Anthropology 90, pp. 199-205.

Shahar, S. (1991), Kindheit im Mittelalter. Artemis & Winkler, München.
Stevenson, D.; Verter, J.; Fanaroff, A.; Ehrenkranz, W.O.R.; Shankaran, S.; Donovan, E.; Wright, L.; Lemons, J.; Tyson, J.; Korones, S.; Bauer, C.; Stoll, B.; Papile, L. (2000), Sex differences in outcomes of very low birthweight infants: the newborn male disadvantage. Archives of Diseases in Childhood Fetal and Neonatal Edition 83, pp. 182-185.
Schutkowski, H. (1991), Differentielle Sterblichkeit im Kindesalter. Zugänge und mögliche Ursachen am Beispiel einer mittelalterlichen Skelettserie. Archäologische Informationen 14/2, pp. 195-205.
Song, S. (2012), Does famine influence sex ratio at birth? Evidence from the 1959-1961 Great Leap Forward Famine in China. Proceedings of the Royal Society B, 279, pp. 2883-2890.
Stloukal, M.; Hanáková, H. (1978), Die Länge der Längsknochen altslawischer Bevölkerungen unter besonderer Berücksichtigung von Wachstumsfragen. Homo 29, pp. 53-69.
Ubelaker, D.H. (1979), Human Skeletal Remains: Excavation, Analysis and Interpretation. Smithsonian Institute Press, Washington D.C.
Ulizzi, L.; Zonta, L. (2002), Sex differential patterns in perinatal deaths in Italy. Human Biology 74, pp. 879-888.
Ulrich-Bochsler, Susi (1997), Anthropologischer Befunde zur Stellung von Frau und Kind im Mittelalter und Neuzeit. Berner Lehrmittel- und Medienverlag, Bern.
Wahl, J. (2007), Karies, Kampf und Schädelkult. 150 Jahre anthropologische Forschung in Südwestdeutschland. Materialhefte zur Archäologie in Baden-Württemberg Heft 79. Theiss Verlag, Stuttgart.
Wells, J.C.K. (2000), Natural Selection and Sex Differences in Morbidity and Mortality in Early Life. Journal of Theoretical Biology Vol. 202, Iss. 1, pp. 65-76.

Chapter 4: Paleodemography

Acsádi, G.; Nemeskéri, J. (1957), Paläodemographische Probleme am Beispiel des frühmittelalterlichen Gräberfeldes von Halimba-Cseres Kom. Veszprém/Ungarn. Homo 8, pp-133-148.

Acsádi, G.; Nemeskéri, J. (1970), History of human life span and mortality. Akadémiai Kiadó, Budapest.

Bello, S.; Andrews, P. (2006), The Intrinsic Pattern of Human Skeletons and its Influence on the Interpretation of Funerary Behaviours. In: Gowland, R.; Knüsel, C. (eds.) (2006), Social Archaeology of Funerary Remains. Oxbow, Oxford.

Bocquet, J.-P.; Masset, C. (1977), Estimateurs en paléodémographie. L'Homme 17, pp. 65-90.

Dollhopf, K.-D. (2002), Die verschwundenen Kinder. Bemerkungen zum Kinderdefizit bei Bestattungen auf frühmittelalterlichen Gräberfeldern. Archäologische Korrespondenzblatt 32, pp. 151-159.

Fuhrmann, B. (2006), Die Stadt im Mittelalter. Theiss, Stuttgart.

Gabler (2009), http://wirtschaftslexikon.gabler.de/Stichwort-Ergebnisseite.jsp. Last access 23.06.2011

Grupe, G.; Christiansen, K.; Schröder, I.; Wittwer-Backofen, U. (2005), Anthropologie. Ein einführendes Lehrbuch. Springer, Berlin.

Hermann, B.; Grupe, G.; Hummel, S.; Piepenbrink, H.; Schutkowski, H. (1990), Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden. Springer, Berlin.

Kölbl, S. (2004), Das Kinderdefizit im frühen Mittelalter – Realität oder Hypothese? Zur Deutung demographischer Strukturen in Gräberfeldern. Dissertation University of Tuebingen.

Langenscheidt, F. (1985), Methodenkritische Untersuchungen zur Paläodemographie am Beispiel zweier fränkischer Gräberfelder. Bundesinstitut für Bevölkerungsforschung, Wiesbaden, Materialien zur Bevölkerungswissenschaft, Sonderheft 2.

Lewis, M.E. (2007), The Bioarchaeology of Children. Perspectives from Biological and Forensic Anthropology. Cambridge University Press, UK.

Obertová, Z.; Menninger, M.; Wahl, J.; Bis-Worch, C. (2008), Die „Traufkinder" von der Nordseite der „Kirche 10" in Grevenmacher (Luxemburg) – anthropologische Auswertung der Skelettreste. Empreintes (Annuaire du MNHA) 1, pp. 92-99.

Obertová, Z.; Menninger, M.; Wahl, J.; Bis-Worch, C. (2009), Zu den Kinderbestattungen im mittelalterlichen Grevenmacher (Luxemburg) – Anthropologische Auswertung der Skelettreste. Bulletin der Schweizerischen Gesellschaft für Anthropologie 15, 1-2, pp. 19-31.

Strott, N. (2006), Paläodemographie frühmittelalterlicher Bevölkerungen Altbaierns – Diachrone und allopatrische Trends. Dissertation University of Munich.

Ulrich-Bochsler, Susi (1997), Anthropologischer Befunde zur Stellung von Frau und Kind im Mittelalter und Neuzeit. Berner Lehrmittel- und Medienverlag, Bern.

Vogt-Lüerssen, M. (2001), Der Alltag im Mittelalter. Verlag Ernst Probst, Mainz.

Weiss, K.M. (1973), Demographic models for Anthropology. Memoires of the Society for American Archaeology 27.

Chapter 5: Metrical and morphological studies

Alt, K.W.; Riemensperger, B.; Vach, W.; Krekerler, G. (1998), Zahnwurzellänge und Zahnhalsdurchmesser als Indikatoren zur Geschlechtsbestimmung an menschlichen Zähnen. Anthropologischer Anzeiger 56, pp. 131-144.

Bräuer, G. (1988), Osteometrie. In: Knussmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen, Band 1. Fischer, Stuttgart.

Gaillard, J. (1960), Détermination sexuelle d'un os coxal fragmentaire. Bulletins et Mémoires de la Société d'Anthropologie de Paris 10, 2, pp. 255-267.

Gejvall, N.G. (1963), Cremations. In: Brothwell, D.; Higgs, E. (eds.) (1963), Science in Archaeology. London.

Helmuth, H.; Rempe, U. (1968), Über den Geschlechtsdimorphismus des Epistropheus beim Menschen. Zeitschrift für Morphologie und Anthropologie 59, pp. 300-321.

Martin, R. (1957), Lehrbuch der Anthropologie. Stuttgart.

Mollison, T. (1938), Spezielle Methoden anthropologischer Messung. Handbuch der biologischen Arbeitsmethoden. T.7, pp. 595-671.

Müller, C. (1958), Schätzung der Körperhöhe bei Funden von Leichenbränden Ausgrabungen und Funde 3, pp. 52-58.

Murail, P.; Bruzek, J.; Houët, F.; Cunha, E. (2005), DSP: A tool for probabilistic sex diagnosis using worldwide variability in hip-bone measurement. Bulletins et Mémoires de la Société d'Anthropologie de Paris 17, 3-4, pp. 167-176.

Schulter-Ellis, F.P. ; Schmidt, D.J.; Hayek, L.C.; Craig, J. (1983), Determination of sex with a discriminant analysis of new pelvic bone measurements: Part I. Journal of Forensic Sciences 28, 1, pp. 169-180.

Starp, S.E. (1990), Untersuchungen zur Geschlechtsbestimmung der Individuen zweier frühneolithischer Skelettserien aus Baden-Württemberg anhand der Zahnmaße. Dissertation University of Tuebingen.

Teschler-Nicola, M.; Prossinger, H. (2001), Sex Determination using Tooth Dimensions. In: Alt, K.W.; Rösing, F.W.; Teschler-Nicola, M. (2001), Dental Anthropology. Fundamentals, Limits and Prospects. Springer, Wien.

Trautmann, M.; Trautmann, I. (2011c), Ausgrabung in Grund „Wenzelsmauer" 2008 – Die Bestattungen. Unpublished manuscript.

Trautmann, M. (2012), Die schnurkeramischen Bestattungen von Lauda-Königshofen. Steinzeitliche Hirtennomaden im Taubertal? Fundberichte in Baden-Württemberg 32/1, pp. 265-476.

van Vark, G.N. (1974), The investigation of human cremated skeletal material by multivariate statistical methods. I. Methodology. Ossa 1, pp. 63-95.

Wahl, J. (1988), Das römische Gräberfeld von Stettfeld I. Osteologische Untersuchungen der Knochenreste aus dem Gräberfeld. Landesdenkmalamt Baden-Württemberg, Forschungen und Bericht zur Vor- und Frühgeschichte in Baden-Württemberg Band 29. Theiss, Stuttgart.

Chapter 6: Reconstruction of body height

Bach, H. (1965), Zur Berechnung der Körperhöhe aus den langen Gliedmaßen weiblicher Skelette. Anthropologischer Anzeiger 29, pp. 12-21.

Breitinger, E. (1938), Zur Berechnung der Körperhöhe aus den langen Gliedmaßenknochen. Anthropologischer Anzeiger 14, pp. 249-274.

Cueni, A. (1995), Die menschlichen Gebeine. In: Descœudres, G. (1995), Sterben in Schwyz: Beharrung und Wandlung im Totenbrauchtum einer ländlichen Siedlung vom Spätmittelalter bis in die Neuzeit. Schweizer Beiträge zur Kulturgeschichte und Archäologie des Mittelalters 20/21, pp. 125-144.

Éry, K. (1998), Length of limb bones and stature in ancient populations in the Carpathian Basin. Humanbiologia Budapestinensis 26, Budapest.

Etter, H. (1982), Die Bevölkerung vom Münsterhof. In: Schneider, J. (1982), Der Münsterhof in Zürich. Bericht über die Stadtkernforschungen 1977/78, pp. 179-212. Olten, Freiburg.

Gejvall, N.-G. (1960), Westerhus: medieval population and church in the light of skeletal remains. Lund.

Godycki, M. (1956), Ossa Polonica: wczesnośredniowieczne cmentarzysko na Ostrowie lednickim. Materiały i prace antropologiczne 11, Wrocław.

Gregor, H.-J. (2003), Anthropologische Untersuchungen am Skelettmaterial von Sandau, St. Benedikt. In: Dannheimer, H. (2003), Sandau: Archäologie im Areal eines altbaierischen Klosters des frühen Mittelalters. Münchener Beiträge zur Vor- und Frühgeschichte 55, pp. 319-338.

Heinrich, W. (2001), Zwentendorf: Ein Gräberfeld aus dem 10.-11. Jahrhundert. Anthropologische Auswertung. Mitteilungen der Prähistorischen Kommission Wien 42.

Ivaniček, F. (1951), Staroslavenska nekropola u Ptuju: rezultati antropoloških istraživanja. Dela-Slovenska ahademija znanosti in umetnosti. Razred za zgodovinske in družebne vede 5, Ljubljana.

Lipták, P. (1957), Awaren und Mayaren im Donau-Theiss Zwischenstromgebiet: Zur Anthropologie des VII.-XIII. Jahrhunderts. Acta Archaeologica Hungaricae 8, pp. 199-268.

Lipták, P.; Farkas, G. (1967), Anthropologische Untersuchung an den aus der Urzeit und dem 10.-11. Jahrhundert stammenden Skelettmaterial des Gräberfeldes Békés-Povádzug. Anthropologiai Közlemények 11, pp. 127-163.

Nemeskéri, J.; Lipták, P.; Szöke, B. (1954), Le cimetiere du Xie siècle de Kérpuszta. Acta Archaeologica Hungaricae3, pp. 205-370.

Nemeskéri, J. (1963), Die spätmittelalterliche Bevölkerung von Fonyod. Anthropologia hungarica 6, 1/2.

Olivier, G.; Aaron, C.; Fully, G.; Tissier, G. (1978), New estimations of stature and cranial capacity in modern man. Journal of Human Evolution 7, pp. 513-518.

Papageorgopoulou, C. (2008), The medieval population of Tomils: an archaeo-anthropological approach. Dissertation University of Basel.

Pearson, K. (1899), On the reconstruction of the stature of prehistoric races. Mathematical contributions to the theory of evolution 5. Philosophical transactions of the Royal Society of London A 192, pp. 169-244.

Preuschoft, H.; Schneider, H. (1972), Die Skelettreste aus der Grabung St. Veit. In: Fehring, G.P. (1972), Unterregenbach: Kirchen, Herrensitz, Siedlungsbereiche. Forschungen und Berichte der Archäologie des Mittelalters in Baden-Württemberg 1, pp. 241-265.

Rösing, F.W. (1988), Körperhöhenrekonstruktion aus Skelettmaßen. In: Knussmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen, Band 1, pp. 587- 600. Fischer, Stuttgart.

Sarama, L. (1956), Crania et alia ossa Polonica: wczesnośredniowieczne cmentarzysko w Samborcu. Materiały iprace antropologiczne 7, Wrocław.

Siegmund; F. (2010), Die Körpergröße der Menschen in der Ur- und Frühgeschichte Mitteleuropas und ein Vergleich ihrer anthropologischen Schätzmethoden. Books on Demand GmbH, Norderstedt.

Trotter, M.; Gleser, G.C. (1952), Estimation of stature from long bones of American White and Negroes. American Journal of Physical Anthropology 10, pp. 463-514 and 355-356.

Ulrich-Bochsler, S. (1983), Die Skelettreste aus den Gräbern der Kirche Kirchlindach. In: Eggenberger, P.; Stöckli, W. (1983), Kirchlindach: Reformierte Stadtkirche, pp. 71-94.

Ulrich-Bochsler, S. (1988a), Die anthropologischen Forschungen. In: Eggenberger, P.; Kellenberger, H.; Ulrcih-Bochsler, S. (1988), Twann: Reformierte Pfarrkirche, pp. 69-80.

Ulrich-Bochsler, S. (1988b), Die anthropologischen Forschungen. In: Eggenberger, P.; Rast Cotting, M.; Ulrich-Bochsler, S. (1988), Rohrbach: Reformierte Pfarrkirche, pp. 103-111.

Ulrich-Bochsler, S.; Meyer, L. (1992), Die anthropologischen Forschungen. In: Eggenberger, P.; Bossert, M.; Ulrich-Bochsler, S. (1992), Walkringen: Reformierte Pfarrkirche.

Chapter 7: Non-metric traits

Alt, K. W. (1997), Odontologische Verwandtschaftsanalyse. Individuelle Charakteristika der Zähne in ihrer Bedeutung für Anthropologie, Archäologie und Rechtsmedizin. Fischer, Stuttgart.

Alt, K.W.; Vach, W. (1998), Kinship Studies in Skeletal Remains – Concepts and Examples. In: Alt, K.W.; Rösing, F.; Teschler-Nocola, M. (1998), Dental Anthropology. Fundamentals, Limits and Prospects. Springer, Wien.

Czarnetzki, A. (1971), Epigenetische Skelettmerkmale im Populationsvergleich. I. Rechts-Links-Unterschiede bilateral angelegter Merkmale. Zeitschrift für Morphologie und Anthropologie 63, 2, pp. 238-254.

Czarnetzki, A. (1972), Epigenetische Skelettmerkmale im Populationsvergleich. II. Frequenzunterschiede zwischen den Geschlechtern. Zeitschrift für Morphologie und Anthropologie 63, 3, pp. 341-350.

Grupe, G.; Christiansen, K.; Schröder, I.; Wittwer-Backofen, U. (2005), Anthropologie. Ein einführendes Lehrbuch. Springer, Berlin.

Hauser, G.; De Stefano, G.F. (1989), Epigenetic variants of the Human Skull. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Herrmann, B.; Gruppe, G.; Hummel, S.; Piepenbrink, H.; Schutkowski, H. (1990), Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden. Springer Berlin.

Tyrell, A. (2000), Skeletal non-metric traits and the assessment of inter- and intra- population diversity: Past problems and future potential. In: Cox, M.; Mays, S. (2000), Human Osteology in Archaeology and Forensic Science. Greenwich Medical Media Ltd., London.

Chapter 8: Physical adaptations

Auerbach, B.M.; Ruff, C.B. (2006), Limb bone bilateral asymmetry: variability and commonality among modern humans. Journal of Human Evolution 50, pp. 203-218.

Benjamin, M.; Kumai, T.; Milz, S.; Boszczyk, B.M.; Boszczyk, A.A.; Ralphs, J.R. (2002), The skeletal attachment of tendons – tendon entheses. Comparative Biochemistry and Physiology Part A 133, pp. 931-945.

Blackburn, A. (2011), Bilateral Asymmetry of the Humerus During Growth and Development. American Journal of Physical Anthropology 145, pp. 639-646.

Boulle, E.-L. (2001a), Evolution of two Human Skeletal Markers of the Squatting Position: A Diachronic Study from Antiquity to the Modern Age. American Journal of Physical Anthropology 115, pp. 50-56.

Boulle, E.-L. (2001b), Osteological Features Associated with Ankle Hyperdorsiflexion. International Journal of Osteoarchaeology 11, pp. 345-349.

Bräuer, G. (1988), Osteometrie. In: Knussmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen, Band 1. Fischer Stuttgart.

Cardoso, F.A.; Henderson, C.Y. (2010), Enthesopathy Formation in the Humerus: Data from Known Age-at-Death and Known Occupation Skeletal Collections. American Journal of Physical Anthropology 141, pp. 550-560.

Čuk, T.; Leben-Seljak, P.; Štefančič, M. (2001), Lateral Asymmetry of Human Long Bones. Variability and Evolution 9, 19-22.

Dinzelbacher, P. (2010), Lebenswelt des Mittelalters 1000-1500. Wissenschaftlicher Verlag Bachman, Badenweiler.

Goetz, H.-W. (2002), Leben im Mittelalter vom 7. bis zum 13, Jahrhundert. Verlag C.H. Beck, München.

Havelková, P.; Villotte, S.; Velemínský, P.; Poláček, L.; Dobisíková, M. (2011), Enthesopathies and Activity Patterns in the Early Medieval Great Moravian Population: Evidence of Division of Labour. International Journal of Osteoarchaeology 21, 4, pp. 487-504.

Hawkey, D.E.; Merbs, C.F. (1995), Activity-induced musculoskeletal stress markers (MSM) and subsistence strategy changes among ancient Hudson Bay Eskimos. International Journal of Osteoarchaeology 5, pp. 324-338.

Kujanová, M.; Bigoni, L.; Velemínská, J.; Velemínský, P. (2008), Limb Bone Asymmetry and Stress in medieval and Recent Populations of Central Europe. International Journal of Osteoarchaeology 18, pp. 476-491.

Mays, S. (1991), The medieval Burials from the Blackfriars friary, School Street, Ipswich, Suffolk (Excavated 1983-85). Ancient Monuments Laboratory Report 16/19 (Part One). English Heritage, London.

Niinimäki, S. (2011), What do Muscle Marker Ruggedness Scores actually tell us? International Journal of Osteoarchaeology 21, pp. 292-299.

Özener, B. (2010), Fluctuating and Directional Asymmetry in Young Human Males: Effect on Heavy Working Conditions and Socioeconomic Status. American Journal of Physical Anthropology 143, pp. 112-120.

Pauly, M. (2011), Geschichte Luxemburgs. Verlag C.H. Beck, München.

Robb, J.E. (1998), The Interpretation of Skeletal Muscle Sites: A Statistical Approach. International Journal of Osteoarchaeology 8, pp. 363-377.

Rösener, M. (1987), Bauern im Mittelalter. C.H. Beck'sche Verlagsbuchhandlung, Nördlingen.

Steele, J.; Mays, S. (1995), Handedness and Directional Asymmetry in the Long Bones of the Human Upper Limb. International Journal of Osteoarchaeology 5, pp. 39-49.

Trautmann, M. (2012), Die schnurkeramischen Bestattungen von Lauda-Königshofen. Steinzeitliche Hirtennomaden im Taubertal? Fundberichte in Baden-Württemberg 32/1, pp. 265-476.

Uomini, N.T. (2009), The prehistory of handedness: Archaeological data and comparative ethology. Journal of Human Evolution 57, pp. 411-419.

Villotte, S. (2006), Connaissances médicales actuelles, cotation des enthésopathies: Nouvelle méthode. Bulletins et Mémoires de la Société d'Anthropologie de Paris. 18, pp. 65-85.

Villotte, S. (2010), Actualité de la recherche: les altérations de l'entèse, pourquoi et comment les reconnaître. Cotation de l'aspect osseux de certaines enthèses fibrocartilagineuses. Document de travail, Workshop de la Société Suisse d'Anthropologie 25 et 26 Juin 2010.

Villotte, S.; Castex, D.; Couallier, V.; Dutour, O.; Knüsel, C.J.; Henry-Gambier, D. (2010a), Enthesopathies as Occupational Stress Markers: Evidence from the Upper Limb. American Journal of Physical Anthropology 142, 2, pp. 224-234.

Villotte, S.; Churchill, S.E.; Dutour, O.J.; Henry-Gambier, D. (2010b), Subsistence activities and the division of labor in the European Upper Paleolithic and Mesolithic: Evidence from upper limb enthesopathies. Journal of Human Evolution 59, pp. 35-43.

Weiss, E. (2004), Understanding Muscle Markers: Lower Limbs. American Journal of Physical Anthropology 125, pp. 232-238.

Weiss, E. (2007), Muscle Markers Revisited: Activity Pattern Reconstruction with Controls in a Central California Amerind Population. American Journal of Physical Anthropology 133, pp. 931-940.

Chapter 9: Paleopathology

Adler, C.-P. (1998), Knochenkrankheiten. Diagnostik makroskopischer, histologischer und radiologischer Strukturveränderungen des Skeletts. Springer, Berlin.

Alt, K.W.; Türp, J.C.; Wächter, R. (1998), Periapical Lesions – Clinical and Anthropological Aspects. In: Alt, K.W.; Rösing, F.W.; Teschler-Nocola, M. (eds.) (1998), Dental Anthropology. Springer, Wien, pp. 247-276.

Angel J.L.; Kelley, J.O.; Parrington, M.; Pinter, S.; (1987), Life stresses of the free Black community as represented by the First African Baptist Church, Philadelphia 1823-1841. American Journal of Physical Anthropology 74, pp. 213-229.

Arden, N.; Nevitt, M.C. (2006), Osteoarthritis: Epidemiology. Best Practice & Research Clinical Rheumatology 20, 1, pp. 3-25.

Aufderheide, A.C.; Rodriguez-Martin, C. (1998), The Cambridge Encyclopedia of Human Paleopathology. Cambridge University Press.

Baker, B.J.; Dupras, T.L.; Tocheri, M.W. (2005), The Osteology of Infants and Children. Texas A&M University Press.

Baud, C.A.; Kramar, C. (1990), Les calcifications biologiques en archéologie. Bulletins et Mémoires de la Société d'anthropologie de Paris, Nouvelle Série, t. 2, fasc. 3-4, pp. 163-169.

Bis-Worch, C. (2010), Zur Stadtentwicklung Grevenmachers. In: Dewilde, M.; Ervynck, A.; Becuwe, F. (eds.) (2010), Cenulae recens factae. Een huldeboek voor John De Meulemeester. Jaarboek Abdijmuseum 'Ten Duinen 1138', Novi Monasterii Vol. 10, pp. 57-74.

Boldsen, J.L. (2007), Early Childhood Stress and Adult Age Mortality – A Study of Dental Enamel Hypoplasia in the Medieval Danish Village of Tirup. American Journal of Physical Anthropology 132, pp. 59-66.

Bron, J.L.; van Royen, B.J.; Wuisman, P.I.J.M. (2007), The clinical significance of lumbosacral transitional anomalies. Acta Orthopaedica Belgica 73, pp. 687-695.

Brothwell, D. R. (1981), Digging up bones. Oxford University Press.

Busija, L.; Bridgett, L.; Williams, S.R.M.; Osborne, R.H.; Buchbinder, R.; March, L.; Fransen, M. (2010), Osteoarthritis. Best Practice & Research Clinical Rheumatology 24, pp. 757-768.

Capasso, L.; Kennedy, K.A.R.; Wilczak, C. (1999), Atlas of occupational markers on human remains. Edigrafital S.p.A., Teramo, Italy.

Capasso, L. (1996), Osteoma: Palaeopathology and Phylogeny. International Journal of Osteoarchaeology 7, pp. 615-620.

Case, T.D.; Burnett, S.; Nielsen, T. (2006), Os acromiale: Population differences and their etiological significance. Homo 57, 1, pp. 1-18.

Caselitz, P. (1998), Caries – Ancient Plague of Humankind. In: Alt, K.W.; Rösing, F.W.; Teschler-Nocola, M. (1998), Dental Anthropology. Springer, Wien, pp. 203-226.

Dar, G.; Masharawi, Y.; Paleg, S.; Steinberg, N.; May, H.; Medlej, B.; Paled, N.; Hershkovitz, I. (2010), Schmorl's nodes distribution in the human spine and its possible etiology. European Spine Journal 19, pp. 670-675.

De Coster, P.J.; Marks, L.A., Martens, L.C.; Huysseune, A. (2009), Dental agenesis: genetic and clinical perspectives. Journal of Oral Pathology and Medicine 38, pp. 1-17.

Dias, G.; Tayles, N. (1997), Abscess Cavity – a Misnomer. International Journal of Osteoarchaeology 7, pp. 548-554.

Dias, G.J.; Prasad, K.; Santos, A.L. (2007), Pathogenesis of Apical Periodontal Cysts: Guidelines for Diagnosis in Palaeopathology. International Journal of Osteoarchaeology 17, pp. 619-626.

Esclassan, R.; Grimoud, A.M.; Ruas, M.P.; Donat, R.; Sevin, A.; Astie, F.; Lucas, S.; Crubezy, E. (2009), Dental caries, tooth wear and diet in an adult medieval (12th-14th century) population from Mediterranean France. Archives of Oral Biology 54, pp. 287-297.

Eubanks, J.D.; Cheruvu, V.K. (2009), Prevalence of Sacral Spina Bifida Occulta and its Relationship to age, sex, race and the Sacral Table Angle. Spine 34, 15, pp. 1539-1543.

Faccia, K.J.; Williams, R.C. (2008), Schmorl's Nodes: Clinical Significance and Implications for the Bioarchaeological Record. International Journal of Osteoarchaeology 18, pp. 28-44.

Gevenois, P.A.; de Maertelaer, V.; Madani, A.; Winant, C.; Sergent, G.; De Vuyst, P. (1998), Asbestosis, pleural plaques and diffuse pleural thickening: three distinct benign responses to asbestos exposure. European Respiratory Journal 11, pp. 1021-1027.

Giunta, R.E.; Enders, A.; Lukas, B.; Marton, M.A.; Müller-Ferber, W. (2010), Geburtstraumatische Armplexusparese. Eine interdisziplinäre Herausforderung. Monatsschrift Kinderheilkunde 3, 158, pp. 262-272.

Goetz, H.-W. (2002), Leben im Mittelalter vom 7. bis zum 13. Jahrhundert. Verlag C.H. Beck, München.

Grupe, G.; Christiansen, K.; Schröder, I.; Wittwer-Backofen, U. (2005), Anthropologie. Ein einführendes Lehrbuch. Springer, Berlin.

Hillson, S. (2000), Dental Pathology. In: Katzenberg, M.A.; Saunders, S.R. (eds.), (2000), Biological Anthropology of the Human Skeleton. Wiley-Liss, Inc., New York, pp. 249-286.

Hillson, S. (2001), Recording Dental Caries in Archaeological Human Remains. International Journal of Osteoarchaeology 11, pp. 249-289.

Hillson, S. (2005), Teeth. Cambridge Manuals in Archaeology. Cambridge University Press.

Hunt, D.R.; Bullen, L. (2007), The Frequency of Os acromiale in the Robert J. Terry Collection. International Journal of Osteoarchaeology 17, pp. 309-317.

Illi, M. (1992), Wohin die Toten gingen – Begräbnis und Kirchhof in der vorindustriellen Stadt. Chronos Verlag, Zürich.

Jungklaus, B. (2009), Zur brandenburgischen Bevölkerung im Mittelalter und ihrer Lebensumstände aus anthropologischer Sicht. In. Müller, J.; Neitmann, F.; Schopper F. (eds.) (2009), Wie die Mark entstand. 850 Jahre Mark Brandenburg. Forschungen zur Archäologie im Land Brandenburg 11, pp. 249-281.
Jungklaus, B. (2010), Die Krankheitsbelastung der mittelalterlichen und frühneuzeitlichen Kinderpopulation von Tassdorf (Ldk. Märkisch-Oderland). Dissertation Freie Universität Berlin.
Jurmain, R.D. (1999), Stories from the skeleton: behavioural reconstruction in human osteology. Gordon and Breach Publishers, Amsterdam.
Kalichman, L.; Kim, D.H.; Li, L.; Guermazi A., Berkin, V.; Hunter, D.J. (2009), Spondylolysis and Spondylolisthesis: Prevalence and Association with Low Back Pain in the Adult Community-Based Population. Spine 34, 2, pp. 199-205.
Koester, F. (1940), Beobachtungen bei Pleuraverkalkungen. Lung 94(5), pp. 378-382.
Knüsel, C.J.; Göggel, S.; Lucy, D. (1997), Comparative degenerative joint disease of the vertebral column in the medieval monastic cemetery of the Gilbertine Priory of St. Andrew, Fishergate, York, England. American Journal of Physical Anthropology 103, pp. 481-495.
Komar, D.; Buikstra, J.E. (2003), Differential Diagnosis of a Prehistoric Biological Object from the Koster (Illinois) Site. International Journal of Osteoarchaeology 13, pp. 157-164.
Kumar, A.; Tubbs, R.S. (2011), Spina Bifida: A Diagnostic Dilemma in Paleopathology. Clinical Anatomy 24, pp. 19-33.
Lukacs, J.R. (2006), Explaining sex differences in dental caries prevalence: saliva, hormones and 'life history' etiologies. American Journal of Human Biology 18, pp. 450-555.
Lukacs, J.R. (2011), Sex differences in dental caries experience: clinical evidence, complex etiology. Clinical Oral Investigations 15, pp. 649-656.
Mayatepek, E. (2007), Pädiatrie. Elsevier, Urban und Fischer, Jena
Merbs, C.F. (2002), Spondylolysis in Inuit skeletons from Arctic Canada. International Journal of Osteoarchaeology 12, pp. 279-290.
Moynihan, P.J. (1998), Update on the nomenclature of carbohydrates and their dental effects. Journal of Dentistry 26, 3, pp. 209-218.
Niethard, F.U., Pfeil, J.; Biberthaler, P. (2009), Orthopädie und Unfallchirurgie. Thieme Verlag, Stuttgart.
Oda, I.; Abumi, K.; Lü, D.; Shono, Y.; Kaneda, K. (1996), Biomechanical Role of the Posterior Elements, Costovertebral Joints, and Rib Cage in the Stability of the Thoracic Spine. Spine 21, pp. 1423-1429.
Ohler, N. (1990), Sterben und Tod im Mittelalter. Artemis Verlg, München.
Ortner, D.J. (2003), Identification of Pathological Conditions in Human Skeletal Remains. Academic Press, London.

Palubeckaité, Ž.; Jankauskas, R.; Boldsen, J. (2002), Enamel Hypoplasia in Danish and Lithuanian Late Medieval/Early Modern Samples: a Possible Reflection of Child Morbidity and Mortality Patterns. International Journal of Osteoarchaeology 12, pp. 189-201.
Pitt, M.J. (1991), Rickets and Osteomalacia are still around. Radiologic Clinics of North America 29, 1, pp. 97-118.
Reitemeier, B.; Schwenzer, N.; Ehrenfeld, M. (2006), Einführung in die Zahnmedizin. Thieme, Stuttgart.
Roberts, C.; Manchester, K. (2007), The Archaeology of Disease. Cornell University Press, Ithaca, New York.
Rössler, H.; Rüther, W. (2007), Orthopädie und Unfallchirurgie. Elsevier GmbH, München.
Ruffié, J.; Sournia, J.-C. (2000), Die Seuchen in der Geschichte der Menschheit. Klett-Cotta, Stuttgart.
Schaefer, M.; Black, S.; Scheuer, L. (2009), Juvenile Osteology. A Laboratory and Field Manual. Elsevier Inc. New York.
Schubert, E. (2006), Essen und Trinken im Mittelalter. Wissenschaftliche Buchgesellschaft, Darmstadt.
Schultz, M. (1988), Paläopathologische Diagnostik. In: Knußmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen. Band I: Wesen und methoden der Anthropologie 1.Teil. Fischer , Stuttgart, pp. 480-496.
Schultz, M. (2003), Light Microscopic Analysis in Skeletal Paleopathology. In: Ortner D.J. (2003), Identification of Pathological Conditions in Human Skeletal Remains. Academic Press, London, pp. 73-107.
Schultz, M.; Cali-Thiele, P.; Schmidt-Schultz, T.H.; Kierdorf, U.; Kierdorf, H.; Teegen, W.-R.; Kreutz, K. (1998), Enamel Hypoplasias in Archaeological Skeletal Remains. In: Alt, K.W.; Rösing, F.W.; Teschler-Nocola, M. (eds.) (1998), Dental Anthropology. Springer, Wien, pp. 293-311.
Thelin, A.; Holmberg, S. (2007), Hip osteoarthritis in a rural male population: a prospective population-based register study. American Journal of Industrial Medicine 50, 8, pp. 604-607.
Trautmann, M. (2012), Die schnurkeramischen Bestattungen von Lauda-Königshofen. Steinzeitliche Hirtennomaden im Taubertal? Fundberichte in Baden-Württemberg 32/1, pp. 265-476.
Schutkowski, H.; Grupe, G. (1997), Zusammenhänge zwischen Cribra orbitalia, archäometrischen Befunden am Skelett und Habitatsbedingungen. Anthropologischer Anzeiger 55, pp. 155-166.
Stirland A.J. (2005), The Men of the Mary Rose. Raising the Dead. History Press Sutton Publishing.
Touger-Decker, R.; van Loveren, C. (2003), Sugars and dental caries. American Journal of Clinical Nutrition 78, 4, pp. 881-892.

Üstündag, H.; (2009), Schmorl's Nodes in a Post-Medieval Skeletal Sample from Klostermarienberg, Austria. International Journal of Osteoarchaeology 19, pp. 695-710.
Vanja, C. (2008), Offene Fragen und Perspektiven der Hospitalgeschichte. In: Scheutz, M.; Sommerlechner, A.; Weigl, H.; Weiß, S. (eds.) (2008), Europäisches Spitalwesen. Instutionelle Fürsorge in Mittelalter und Früher Neuzeit. Mitteilungen des Instituts für Österreichische Geschichtsforschung Ergänzungsband 51. Oldenburg Verlag, Wien.
Videman, T.; Sarna, S.; Battié, M.C.; Koskinen, S.; Gill, K.; Paananen, H.; Gibbons, L. (1995), The long-term effect of physical loading and exercise lifestyles on back-related symptoms, disabililty and spinal pathology among men. Spine 29, pp. 699-706.
Videman, T.; Battié, M.C. (1999), The influence of occupation on lumbar degeneration. Spine 24, pp. 1164-1168.
Wahl, J. (1988), Das römische Gräberfeld von Stettfeld I. Osteologische Untersuchungen der Knochenreste aus dem Gräberfeld. Landesdenkmalamt Baden-Württemberg, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg Band 29, Theiss, Stuttgart.
Walker-Bone, K.; Palmer, K.T. (2002), Muskuloskeletal disorders in farmers and farm workers. Occupational Medicine 52, 8, pp. 441-450.
Ward, C.V.; Mays, S.A.; Child, S.; Latimer, B. (2010), Lumbar Vertebral Morphology and Isthmic Spondylolysis in a British Medieval Population. American Journal of Physical Anthropology 141, pp. 273-280.
Weber, J.; Czarnetzki, A.; Spring, A. (2004), Paläopathologische Befunde der Wirbelsäule im frühen Mittelalter. Deutsches Ärtzteblatt 17, 101, pp. 1162-1167.
Weiss, E.; Jurmain, R. (2007), Osteoarthritis Revisited: A Contemporary Review of Etiology. International Journal of Osteoarchaeology 17, pp. 437-450.
White, D.J. (1997), Dental calculus: recent insights into occurrence, formation, prevention, removal and oral health effects of supragingival and subgingival deposits. European Journal of Oral Sciences 105, pp. 508-522.
Witkowski, R.; Prokop, O.; Ullrich, E. (1999), Lexikon der Syndrome und Fehlbildungen. Springer, Berlin.

Chapter 10: The children of Grevenmacher

Bach, H. (1965), Zur Berechnung der Körperhöhe aus den langen Gliedmaßen weiblicher Skelette. Anthropologischer Anzeiger 29, pp. 12-21.

Breitinger, E. (1938), Zur Berechnung der Körperhöhe aus den langen Gliedmaßenknochen. Anthropologischer Anzeiger 14, pp. 249-274.

Bello, S.; Andrews, P. (2006), The Intrinsic Pattern of Preservation of Human Skeletons and its Influence on the Interpretation of Funerary Behaviours. In: Gowland, R.; Knüsel, C. (eds.) (2006), Social Archaeology of Funerary Remains. Oxbow, Oxford, pp. 1-14

Bello, S.; Thomann, A.; Signoli, M.; Dutour, O.; Andrews, P. (2006), Age and Sex Bias in the Reconstruction of Past Populations Structures. American Journal of Physical Anthropology 129, pp. 24-38.

Black, T.K. (1978), Sexual dimorphism in the tooth crown diameters of the deciduous teeth. American Journal of Physical Anthropology 48, pp. 77-82.

Bogin, B. (2001), The Growth of Humanity. John Wiley & Sons Inc, New York.

Carli-Thiele, P. (1996), Spuren von Mangelerkrankungen an steinzeitlichen Kinderskeletten. Fortschrite in der Paläopathologie und Osteoarchäologie Band I. Verlag Goltze, Göttingen.

Grupe, G.; Christiansen, K.; Schröder, I.; Wittwer-Backofen, U. (2005), Anthropologie. Ein einführendes Lehrbuch. Springer, Berlin.

Hauser, G.; De Stefano, G.F. (1989), Epigenetic Variants of the Human Skull. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Hillson, S. (2005), Teeth. Cambridge Manuals in Archaeology. Cambridge University Press.

Jungklaus, B. (2010), Die Krankheitsbelastung der mittelalterlichen und frühneuzeitlichen Kinderpopulation von Tasdorf (Lkr. Märkisch-Oderland). Unpublished Dissertation Freie Universität Berlin.

Kósa, F. (1978), Feststellung der Körperlänge und des Alters menschlicher Feten auf Grund von Knochenmaßen. In: Hunger, H.; Leopold, D. (1978), Identifikation. Springer, Berlin. pp. 216-241.

Kreutz, K. (1997), Ätiologie und Epidemiologie von Erkrankungen des Kindealters bei der bajuwarischen Population von Straubing (Niederbayern). Beiträge zur Paläopathologie Band I. Cuviller Verlag, Göttingen.

Lewis, M.E. (2000), Non-adult Palaeopathology: Current Status and Future Potential. In: Cox, M.; Mays, S. (eds.) (2000), Human Osteology in Archaeology and Forensic Science. Greenwich Medical Media, UK, pp. 39-57.

Lewis, M.E. (2004), Endocranial lesions in non-adult skeletons: Understanding their aetiology. International Journal of Osteoarchaeology 14, pp. 82-97.

Lewis, M.E. (2007), The Bioarchaeology of children. Perspectives from Biological and Forensic Anthropology. Cambridge University Press, Cambridge, UK.

Neiburger, E.J. (1990), Enamel hypoplasias: poor indicators of dietary stress. American Journal of Physical Anthropology 82, 2, pp. 231-233.
Ogden, A.R.; Pinhasi, R.; White, W.J. (2007), Gross Enamel Hypoplasia in Molars From Subadults in a 16th-18th Century London Graveyard. American Journal of Physical Anthropology 133, 3, pp. 957-966.
Olivier, G.; Aaron, C.; Fully, G.; Tissier, G. (1978), New estimations of stature and cranial capacity in modern man. Journal of Human Evolution 7, pp. 513-518.
Ortner, D.J. (2003), Identification of pathological conditions in human skeletal remains. Elsevier, San Diego.
Palubeckaité, Ž.; Jankauskas, R.; Boldsen, J. (2002), Enamel Hypoplasia in Danish and Lithuanian Late Medieval/Early Modern Samples: a Possible Reflection of Child Morbidity and Mortality Patterns. International Journal of Osteoarchaeology 12, pp. 189-201.
Pearson, K. (1899), On the reconstruction of the stature of prehistoric races. Mathematical contributions to the theory of evolution 5. Philosophical transactions of the Royal Society of London A 192, pp. 169-244.
Roberts, C.; Manchester, K. (2007), The Archaeology of Disease. Cornell University Press, Ithaca, New York.
Schultz, M. (2003), Light Microscopic Analysis in Skeletal Paleopathology. In: Ortner D.J. (2003), Identification of Pathological Conditions in Human Skeletal Remains. Academic Press, London, pp. 73-107.
Schutkowski, H. (1987), Sex determination of foetal and neonate skeletons by means of discriminant analysis. International Journal of Anthropology 2, pp. 347-352.
Siegmund; F. (2010), Die Körpergröße der Menschen in der Ur- und Frühgeschichte Mitteleuropas und ein Vergleich ihrer anthropologischen Schätzmethoden. Books on Demand GmbH, Norderstedt.
Trotter, M.; Gleser, G.C. (1952), Estimation of stature from long bones of American White and Negroes. American Journal of Physical Anthropology 10, pp. 463-514 and 355-356.
Ubelaker, D.H. (1979), Human Skeletal Remains: Excavation, Analysis and Interpretation. Smithsonian Institute Press, Washington, DC.
Welte, B.; Wahl, J. (2010), Auxologische Studien an Skelettresten frühneolithischer Kinder und Jugendlicher aus Südwestdeutschland. Funderichte aus Baden-Württemberg 31, pp. 7-28.
Wessel, L.M.; Kaiser, M.M.; Wünsch, L.H.P.; Kahl, F.O. (2007), Kinderchirurgie. In: Mayatepek, E. (2007), Pädiatrie. Elsevier, München.
Witkowski, R.; Prokop, O.; Ullrich, E.; Thiel, G. (2003), Lexikon der Syndrome und Fehlbildungen. Springer, Berlin, Heidelberg.

Chapter 11: Social stratification and group formation on the cemetery

Bach, H. (1965), Zur Berechnung der Körperhöhe aus den langen Gliedmaßen weiblicher Skelette. Anthropologischer Anzeiger 29, pp. 12-21.

Breitinger, E. (1938), Zur Berechnung der Körperhöhe aus den langen Gliedmaßenknochen. Anthropologischer Anzeiger 14, pp. 249-274.

Bis-Worch, C. (2005), Grevenmacher - die Ausgrabungen im Bereich des Baxerasgartens und neue Erkentnisse zur baulichen Entwicklung der Stadt. Unpublished scientific treatise.

Cardoso, F.A.; Henderson, C.Y. (2010), Enthesopathy Formation in the Humerus: Data from Known Age-at Death and Known Occupation Skeletal Collections. American Journal of Physical Anthropology 141, pp. 550-560.

Czarnetzki, A.; Uhlig, C.; Wolf, R. (1983), Skelette erzählen... Menschen des frühen Mittelalters im Spiegel der Anthropologie und Medizin. Württembergisches Landesmuseum. Gulde-Druck GmbH, Tübingen.

Floud, R.; Wachter K.; Gregory, A. (1990), Height, health and history. Nutritional status in the United Kingdom, 1750-1980. Cambridge University Press, Cambridge, UK.

Havelková, P.; Villotte, S.; Velemínský, P.; Poláček, L.; Dobisíková, M. (2011), Enthesopathies and Activity Patterns in the Early Medieval Great Moravian Population: Evidence of Division of Labour. International Journal of Osteoarchaeology 21, 4, pp. 487-504.

Illi, M. (1992), Wohin die Toten gingen. Begräbnis und Kirchhof in der vorindustriellen Stadt. Chronos Verlag, Zürich

Knüsel, C.J.; Göggel, S.; Lucy, D. (1997), Comparative degenerative joint disease of the vertebral column in the medieval monastic cemetery of the Gilbertine Priory of St. Andrew, Fishergate, York, England. American Journal of Physical Anthropology 103, pp. 481-495.

Neiburger, E,J. (1990), Enamel Hypoplasias: Poor Indicators of Dietary Stress. American Journal of Physical Anthropology 82, 2, pp. 231-233.

Obertová, Z.; Menninger, M.; Wahl, J., Bis-Worch, C. (2008), Die „Traufkinder“ von der Nordseite der „Kirche 10“ in Grevenmacher (Luxemburg) – anthropologische Auswertung der Skelettreste. Empreintes Annuaire du Musée National d’histoire et d’art, 1, pp. 92-99.

Obertová, Z.; Menninger, M.; Wahl, J.; Bis-Worch, C. (2009), Zu den Kinderbestattungen im mittelalterlichen Grevenmacher (Luxemburg) – Anthropologische Auswertung der Skelettreste. Bulletin der Schweizerischen Gesellschaft für Anthropologie 15, 1-2, pp. 19-31.

Ohler, N. (1990), Sterben und Tod im Mittelalter, Artemis Verlag, München.

Oliveira, A.F.B.; Chaves, A.M.B.; Rosenblatt, A. (2005), The Influence of Enamel Defects on the Development of Early Childhood Caries in a Population with Low Socio-economic Status: A Longitudinal Study. Caries Research 40, pp. 296-302.
Olivier, G.; Aaron, C.; Fully, G.; Tissier, G. (1978), New estimations of stature and cranial capacity in modern man. Journal of Human Evolution 7, pp. 513-518.
Palubeckaité, Ž.; Jankauskas, R.; Boldsen, J. (2002), Enamel Hypoplasia in Danish and Lithuanian Late Medieval/Early Modern Samples: a Possible Reflection of Child Morbidity and Mortality Patterns. International Journal of Osteoarchaeology 12, pp. 189-201.
Pascoe, L.; Seow, W.K. (1994), Enamel hypoplasia and enamel caries in Australian Aboriginal children: prevalence and correlation between the two diseases. Pediatric Dentistry 16, 3, pp. 193-199.
Pearson, K. (1899), On the reconstruction of the stature of prehistoric races. Mathematical contributions to the theory of evolution 5. Philosophical transactions of the Royal Society of London A 192, pp. 169-244.
Ulrich-Bochsler, S. (1997), Anthropologische Befunde zur Stellung von Frau und Kind im mittelalter und Neuzeit. Soziobiologische und soziokulturelle Aspekte im Lichte von Archäologie, Geschichte, Volkskunde und Medizingeschichte. Berner Lehrmittel- und Medienverlag, Bern.
Schweich, M.; Knüsel, C. (2003), Bio-cultural effects in medieval populations. Economics and Human Biology 1, pp. 367-377.
Siegmund; F. (2010), Die Körpergröße der Menschen in der Ur- und Frühgeschichte Mitteleuropas und ein Vergleich ihrer anthropologischen Schätzmethoden. Books on Demand GmbH, Norderstedt.
Trotter, M.; Gleser, G.C. (1952), Estimation of stature from long bones of American White and Negroes. American Journal of Physical Anthropology 10, pp. 463-514 and 355-356.

Chapter 12: Comparison of the data from the inhumation graves and the burned bone complex

Bello, S.; Andrews, P. (2006), The Intrinsic Patterns of Preservation of Human Skeletons and its Influence on the Interpretation of Funerary Behaviours. In: Gowland, R.; Knüsel C. (eds.), Social Archaeology of Funerary Remains. Oxford, pp. 1-13.

Bis-Worch, C. (2005), Die Ausgrabungen im Bereich des Baxerasgartens und neue Erkentnisse zur baulichen Entwicklungsgeschichte Grevenmachers. Unpublished treatise.

Bis-Worch, C. (2010), Zur Stadtentwicklung Grevenmachers. In: Dewilde, M.; Ervynck, A.; Becuwe, F. (eds.) (2010), Cenulae recens factae. Een huldeboek voor John De Meulemeester. Jaarboek Abdijmuseum 'Ten Duinen 1138', Novi Monasterii Vol. 10, pp. 57-74.

Fehring, G.P.; Scholkmann, B. (1995), Die Stadtkirche St. Dionysius in Esslingen. Archäologie und Baugeschichte I. Forschungen und Berichte der Archäologie des Mittelalters in Baden-Württemberg Bd. 13/1.

Goetz, H.-W. (2002), Leben im Mittelalter vom 7. bis zum 13. Jahrhundert. Verlag C.H. Beck, München.

Großkopf, B. (2000), Anthropologische Analyse eines Fundkomplexes aus Luxemburg. University of Göttingen, unpublished treatise.

Herrmann (1977), Über die Abhängigkeit der Schrumpfung vom Mineralgehalt bei experimentell verbrannten Knochen. Anthropologischer Anzeiger 36, pp. 7-12.

Herrmann, B.; Grupe, G.; Hummel, S.; Piepenbrink, H.; Schutkowski, H. (1990), Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden. Springer, Berlin.

Malinowski A.; Porawski, R. (1969), Identifikationsmöglichkeiten menschlicher Brandknochen mit besonderer Berücksichtigung ihres Gewichts. Zacchia 44, pp. 1-19.

Naphy, W.; Spicer, A. (2006), Der Schwarze Tod. Die Pest in Europa. Magnus Verlag, Essen.

Rösener, M. (1987), Bauern im Mittelalter. C.H. Beck'sche Verlagsbuchhandlung, Nördlingen.

Rösing, F.W. (1977), Methoden und Aussagemöglichkeiten der anthropologischen Leichenbrandbearbeitung. Archäologie und Naturwissenschaften 1, pp. 53-80.

Schubert, E. (2006), Essen und Trinken im Mittelalter. Wissenschaftliche Buchgesellschaft, Darmstadt.

Trautmann, B. (2007), Anthropologische Auswertung einer Stichprobe aus dem Brandknochengemenge von Grevenmacher (Luxemburg). Magister thesis University of Tuebingen. tobias-lib.uni-tuebingen.de/volltexte/2008/3647/.

Wahl, J. (1988), Das römische Gräberfeld von Stettfeld I. Landesdenkmalamt Baden-Württemberg. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden Württemberg Band 29. Theiss Verlag, Stuttgart.

Vogt-Lüerssen, M. (2001), Der Alltag im Mittelalter. Verlag Ernst Probst, Mainz.

Chapter 13: Comparison of data from Grevenmacher with contemporaneous as well as ancient series from Luxembourg

Bogin, B. (2001), The Growth of Humanity. Wiley-Liss, Inc. New York.

Bräuer, G. (1988), Osteometrie. In: Knussmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen, Band 1. Fischer Stuttgart.

Brooks, S.; Suchey, J.M. (1990), Skeletal age determination based on the Os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. Human Evolution 5, No 3, pp. 277-238.

Cleuvenot, E.; Houët, F. (1993), Proposition des nouvelles equations d'estimation de stature applicables pour un sexe indéterminé, et basées sur les échantillons de Trotter et Gleser. Bulletin et Mémoires de la Société d'Anthropologie de Paris, nouvelle série 5, pp. 245-255.

De Beer, H. (2004), Observations on the history of Dutch physical stature from the late-Middle Ages to the present. Economics and Human Biology 2, pp. 45-55.

Delsate, D.; Guinet, J.M.; Saverwyns, S. (2009), De l'ocre sur le crâne mésolithique (haplogroupe U5a) de Reuland-Loschbour (Grand-Duché de Luxembourg). Bulletin de la Société Préhistorique Luxembourgeoise 31, pp. 7-30.

Delsate, D.; Brou, L; Spier, F. (2011), L'inhumation mésolithique de Loschbour (Loschbour 1) - Resultats des analyses récentes. Unter unseren Füssen, Archäologie in Luxemburg 1995-2010, MNHA-CNRA 2011.

D'Hollosy, M.; de Meulemeester, J. (1999), Le cimetière de Saint-Jean et l'étude des squelettes. In: Baray, L. (ed.) (1999), Le Passé recompose, Archéologie urbaine à Luxembourg, Catalogue d'exposition du Museé national d'histoire et d'art. Luxembourg, Museé national d'histoire et d'art, pp. 149-153.

Ferembach, D.; Schwidetzky, I.; Stloukal, M. (1979), Empfehlungen für die Alters- und Geschlechtsdiagnose am Skelett. Homo 30, 2, pp. 1-25.

Goetz, H.-W. (2002), Leben im Mittelalter vom 7. bis zum 13, Jahrhundert. Verlag C.H. Beck, München.

Heuertz, M. (1969), Documents préhistoriques du territoire luxembourgeois – le milieu naturel l'homme et son oeuvre, fascicule 1. Publication du Musée d'Histoire Naturelle et de la Société des naturalistes Luxembourgeois.

Jungklaus, B. (2009), Zur brandenburgischen Bevölkerung im Mittelalter und ihren Lebensumständen aus anthropologischer Sicht. In: Müller, J.; Neitmann, K.; Schopper, F. (2009), Wie die Mark entstand. 850 Jahre Mark Brandenburg. Forschungen zur Archäologie im Land Brandenburg 11, pp. 249-281.

Koepke, N.; Baten, J. (2005), The biological standard of living in Europe during the last two millennia. European Review of Economic History 9, pp. 61-95.

Kunter, M. (1991), Bestimmung der Leichenbrandreste von Clemency. In: Metzler, J.; Waringo, R.; Bis, R.; Metzler-Zens, N. (1991), Clemency et les tombes de l'aristocratie en Gaule Belgique. Dossiers d'Archéologie du Musée National d'histoire et d'art, I, Luxembourg: Musée National d'histoire et d'art.
Kunter, M. (2003), Anthropologische Untersuchung der beiden Skelette vom Tossenberg sowie der Leichenbrände an der Universität Giessen. Den Ausgriewer 13, pp. 34-35
Kunter, M (2006), Anthropologische Analyse der menschlichen Leichenbrände aus dem Brandgräberfeld von Feulen, Luxemburg. In: Schendzierlorz, S. (ed.) (2006), Feulen, ein spätlatènezeitliches-frührömisches Gräberfeld in Luxemburg. Dossiers d'Archéologie du Musée National d'histoire et d'art, IX, Luxembourg: Musée National d'histoire et d'art.
Le Brun-Ricalens (2011), L'Europe il y a 4200 ans... âge du Cuivre, premier âge d'Or... Unter unseren Füssen, Archäologie in Luxemburg 1995-2010, MNHA-CNRA 2011.
Le Brun-Ricalens, F.; Brou; L.; Valotteau, F. (2005), Le sepultures mésolithiques de «Loschbour». Extrait du catalogue du Musée National d'histoire et d'art, Préhistoire et Protohistoire au Luxembourg, pp. 80-83.
Lewis, M.E. (2002), Urbanisation and Child Health in Medieval and Post-Medieval England: An assessment of the morbidity and mortality of non-adult skeletons from the cemeteries of two urban and two rural sites in England (AD 850-1859). Bar British Series 339.
Lewis, M.E.; Roberts, C.A.; Manchester, K. (1995), Comparative Study of the Prevalence of Maxillary Sinusitis in Later Medieval Urban and Rural Populations in Northern England. American Journal of Physical Anthropology 98, pp. 497-506.
Maat, G.J.R. (2005), Two Millennia of Male Stature Development and Population Health and Wealth in the Low Countries. International Journal of Osteoarchaeology 15, pp. 276-290.
Martin, R. (1957), Lehrbuch der Anthropologie. Stuttgart.
Nothwang, U.; Rehbach, N.-J.; Flohr, S. (2004), Die Gräberserie „Hospice cilvil" – eine Bestandsaufnahme aus dem Barock. Bulletin d'Information de Musée National d'histoire et d'art, Luxembourg 17, pp. 67-68.
Nothwang, U.; Rehbach, N.-J. (2006), Abschlußbericht zur anthropologischen Untersuchung der Skelette aus der Kirchengrabung Fentingen. 2. Auflage. ADAG Nothwang u. Partner, Frankfurt/Main.
Nothwang, U.; Rehbach, N.-J.; Rauschmann, M.A. (2006), Eine Obduktion aus der Zeit um 1600 aus Luxemburg. Beiträge zur Archäozoologie und prähistorischen Anthropologie V, pp. 118-120.
Obertová, Z.; Menninger, M.; Wahl, J., Bis-Worch, C. (2008), Die „Traufkinder" von der Nordseite der „Kirche 10" in Grevenmacher (Luxemburg) – anthropologische Auswertung der Skelettreste. Empreintes Annuaire du Musée National d'histoire et d'art, 1, pp. 92-99.

Obertová, Z.; Menninger, M.; Wahl, J.; Bis-Worch, C. (2009), Zu den Kinderbestattungen im mittelalterlichen Grevenmacher (Luxemburg) – Anthropologische Auswertung der Skelettreste. Bulletin der Schweizerischen Gesellschaft für Anthropologie 15, 1-2, pp. 19-31.

Olivier, G.; Aaron, C.; Fully, G.; Tissier, G. (1978), New Estimations of Stature and Cranial Capacity in Modern Man. Journal of Human Evolution 7, pp. 513-518.

Pauly, M. (1993), Die Anfänge der kleineren Städte im früheren Herzogtum Luxemburg vor 1500. Siedlungsforschung. Archäologie-Geschichte-Geographie 11, pp. 123-165.

Rehbach, N.-J. (2008), Abschlußbericht zur anthropologischen Untersuchung der Gräberserie aus dem ehemaligen Kloster St. Esprit/Luxemburg. ADFG Nothwang u. Partner, Frankfurt/Main.

Rehbach, N.-J.; Bis-Worch, C. (2006), Das Kloster St.Esprit in Luxemburg und seine Toten. Beiträge zur Archäozoologie und prähistorischen Anthropologie V, pp. 110-117.

Rehbach, N.-J.; Nothwang, U. (2007), Ein Fall von Polydaktylie aus em Spätmittelalter. Beiträge zur Archäozoologie und prähistorischen Anthropologie VI, pp. 129-131.

Rehbach, N.-J.; Nothwang, U. (2009), Syphilis in einem frühneuzeitlichen Nonnenkloster in Luxemburg. Beiträge zur Archäozoologie und prähistorischen Anthropologie VII, pp. 195-198.

Rehbach, N.-J.; Nothwang, U.; Flohr, S. (2005), Die menschlichen Skelettfunde aus Fentingen – ein Vorbericht. Bulletin d'Information de Musée National d'histoire et d'art, Luxembourg, 18, pp. 70-72.

Rehbach, N.-J.; Nothwang, U.; Weidig, I. (2007), Veränderungen der Bestattungskultur aus anthropologischer Sicht am Beispiel eines Frauenordens aus Luxemburg. Mitteilungen der Deutschen Gesellschaft für Archäologie des Mittelalters und der Neuzeit 18, pp. 56-58.

Rehbach, N.-J.; Nothwang, U.; Weidig, I. Sindermann, A. (2009), Abschlussbericht zur anthropologischen Untersuchung einer Givenicher Skelettserie aus dem 8.-15. Jahrhundert. 3. korrigierte Auflage. ADFG Nothwang u. Partner, Frankfurt/Main.

Roberts, C.A. (2009), Health and Welfare in medieval England: the human skeletal remains contextualised. In: Gilchrist, R.; Reynolds A. (eds.) (2009), Reflections: 50 years of medieval Archaeology 1957-2007. Society for Medieval Archaeology Monograph 30, pp. 307-325.

Schultz, M. (1988), Paläopathologische Diagnostik. In: Knußmann, R. (ed.) (1988), Anthropologie. Handbuch der vergleichenden Biologie des Menschen. Band I: Wesen und Methoden der Anthropologie 1. Teil. Fischer, Stuttgart, pp. 480-496.

Schweich, M. (2005), Diachronic Effects of Bio-Cultural Factors on Stature and Body Proportions in British Archaeological Populations. Unpublished PhD thesis University of Bradford.

Schweich, M.; Knüsel, C. (2003), Bio-cultural effects in medieval populations. Economics and Human Biology 1, pp. 367-377.

Siegmund, F. (2010), Die Körpergröße der Menschen in der Ur- und Frühgeschichte Mitteleuropas und ein Vergleich ihrer anthropologischen Schätzmethoden. Books on Demand GmbH, Norderstedt.

Teegen, W.-R.; Kreutz, K.; Diegmann, J.; Kunter, M. (2003), Meningeale Veränderungen in der merowingerzeitlichen Adelsnekropoloe von Bartringen (Luxemburg) – I. Makroskopische Untersuchungen. Beiträge zur Archäozoologie und prähistorischen Anthropologie IV, pp. 182-185.

Toussaint, M.; Le Brun-Ricalens, F.; Hauzer, A.; Jost, C.; Schoelen, A.; Anslijn, J.-N.; Lambermont, S. (2000), Présentation préliminaire de deux tombes campaniformes découvertes à Altwies, „Op dem Boesch" (Grand-Duché de Luxembourg). Notae Praehistoricae 20, pp. 197-214.

Toussaint, M.; Le Brun-Ricalens, F; Hauzeur, A. (2002), Les deux sepultures campaniformes d'Altwies- "Op dem Boesch" (Grand-Duché de Luxembourg): métholologie, données anthropologiques préliminiaires et essai caractérisation des pratiques sépulcrales. Bulletin de la Société Préhistorique Luxembourgeoise 23-24, pp. 249-284.

Toussaint, M.; Brou, L.; Le Brun-Ricalens, F.; Spier, F. (2011), La crémation mésolithique de Loschbout (Loschbour 2). Unter unseren Füssen, Archäologie in Luxemburg 1995-2010, MNHA-CNRA 2011.

Trautmann, M.; Trautmann, I. (2011a), Ausgrabung Escher/Gleicht 2003-2006 – Anthropologische Untersuchungen. Unpublished manuscript.

Trautmann, M.; Trautmann, I. (2011b), Ausgarbung Altwies-Groufbierg 2001-2002 – Anthropologische Untersuchungen. Unpublished manuscript.

Trautmann, M.; Trautmann, I. (2011c), Ausgrabung in Grund „Wenzelsmauer" 2008 – Die Bestattungen. Unpublished manuscript.

Trotter, M.; Gleser, G.C. (1958), A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. American Journal of Physical Anthropology 16, pp. 79-123.

Ubelaker, D.H. (1979), Human Skeletal Remains: Excavation, Analysis and Interpretation. Smithsonian Institute Press, Washington D.C.

Valoteau, F., Toussaint, M.; Le Brun-Ricalens, F. (2000), Le pseudo-dolmen du Schnellert, commune de Berdorf (Grand-Duché de Luxembourg): état de la question à l'issue de la champagne de fouille 2000. Bulletin de la Société Préhistorique Luxembourgeoise 22, pp. 131-161.

Valotteau, F.; Chenal, F. (2005), Etude anthropologique et datation radiocarbone des squelettes néolithiques découverts en 1892 au Deiwelselter de Diekirch (Grand Duché de Luxembourg). Bulletin de la Société Préhistorique Luxembourgeoise 29, pp. 179-188.

Valotteau, F.; Toussaint, M.; Chenal, F.; Le Brun-Ricalens, F. (2009), Une sepulture du premier Âge du Fer sous abri-sous-roche à Hersberg (commune de Bech): une redécouverte 94 ans après… Empreintes, Annuaires du Musée National d'histoire et d'art, 2/2009, pp. 26-35.

Vallotteau, F.; Chenal, F.; Naton, H.-G. (2011), Une sepulture du premier Âge du Fer sous abri-sous-roche à Hersberg (commune de Bech): une redécouverte 94 ans après. Unter unseren Füssen, Archäologie in Luxemburg 1995-2010, MNHA-CNRA 2011.
Villemeur, I. (1999), L'Homme. In: Metzler-Zens, N.; Metzler, J.; Méniel, P.; Bis, R.; Gaeng, C.; Villemeur, I. (eds.), Lamadelaine – une nécropoloe de l'oppidum du Titelberg. Dossiers d'Archaeologie du Musée National d'histoire et d'art VI, Luxembourg: Musée National d'histoire et d'art.
Weidig, I.; Sindermann, A.; Rebach, N.-J.; Nohwang, U. (2009), A medieval skeletal series from Givenich (Luxembourg) and its pathologies. Beiträge zur Archäozoologie und prähistorischen Anthropologie VIII, pp. 165-169.
Weidig, I.; Bis-Worch, C.; Rehbach, N.-J.; Nothwang, U.; Sindermann, A.; Krier, J.; Le Brun-Ricalens, F.; Metzler, J. (2011), Luxembourg. In: Márquez-Grant, N.; Fibinger, L. (2011), The Routledge Handbook of Archaeological Human Remains and Legislation. An international guide to laws and practice in the excavation and treatment of archaeological human remains. Routledge, Taylor and Francis Group, London.

Chapter 14: Conclusion

Bis-Worch, C. (2010), Zur Stadtentwicklung Grevenmachers. In: Dewilde, M.; Ervynck, A.; Becuwe, F. (eds.) (2010), Cenulae recens factae. Een huldeboek voor John De Meulemeester. Jaarboek Abdijmuseum 'Ten Duinen 1138', Novi Monasterii Vol. 10, pp. 57-74.
Dinzelbacher, P. (2010), Lebenswelt des Mittelalters 1000-1500. Wissenschaftlicher Verlag Bachman, Badenweiler.
Goetz, H.-W. (2002), Leben im Mittelalter vom 7. bis zum 13, Jahrhundert. Verlag C.H. Beck, München.
Jungklaus, B. (2009), Zur brandenburgischen Bevölkerung im Mittelalter und ihren Lebensumständen aus anthropologischer Sicht. In: Müller, J.; Neitmann, K.; Schopper, F. (2009), Wie die Mark entstand. 850 Jahre Mark Brandenburg. Forschungen zur Archäologie im Land Brandenburg 11, pp. 249-281.
Koepke, N.; Baten, J. (2005), The biological standard of living in Europe during the last two millennia. European Review of Economic History 9, pp. 61-95.
Maat, G.J.R. (2005), Two Millennia of Male Stature Development and Population Health and Wealth in the Low Countries. International Journal of Osteoarchaeology 15, pp. 276-290.
Pauly, M. (1993), Die Anfänge der kleineren Städte im früheren Herzogtum Luxemburg vor 1500. Siedlungsforschung. Archäologie-Geschichte-Geographie 11, pp. 123-165.
Pauly, M. (2011), Geschichte Luxemburgs. Verlag, C.H. Beck, München.
Rösener, M. (1987), Bauern im Mittelalter. C.H. Beck'sche Verlagsbuchhandlung, Nördlingen.
Schweich, M.; Knüsel, C. (2003), Bio-cultural effects in medieval populations. Economics and Human Biology 1, pp. 367-377.
Vanja, C. (2008), Offene Fragen und Perspektiven der Hospitalgeschichte. In: Scheutz, M.; Sommerlechner, A.; Weigl, H.; Weiß, S. (eds.) (2008), Europäisches Spitalwesen. Instutionelle Fürsorge in Mittelalter und Früher Neuzeit. Mitteilungen des Instituts für Österreichische Geschichtsforschung Ergänzungsband 51. Oldenburg Verlag, Wien.
Vogt-Lüerssen, M. (2001), Der Alltag im Mittelalter. Verlag Ernst Probst, Mainz.

17. List of figures

18. List of tables

19. Curriculum Vitae

Name: Bernd Trautmann
Date of birth: 04.12.1976
Place of birth: Ravensburg

Education: Eberhard Karls University Tuebingen, Dissertation 2012
Eberhard Karls University Tuebingen, Magister Artium 2007
Magister thesis: *Anthropologische Auswertung einer Stichprobe aus dem Brandknochengemenge von Grevenmacher*

20. Acknowledgements

First of all I want to thank Prof. Dr. Joachim Wahl for the supervision and proficient support during the work process. He is an outstanding teacher and mentor and without his comprehensive training during my years of study as well as his permanent motivating support this work would not have been possible.
Thanks also to Prof. Nicholas Conard Ph.D. for his supervision and support.
Many thanks to Ms. Christiane Bis-Worch, conservator of the section of medieval studies at the Centre National de Recherche Archéologique Luxembourg for the provision of the human bone material as well as footage, literature and information concerning the excavation and the historical background of the town of Grevenmacher.

In addition thanks to the Fonds National de la Recherche Luxembourg, as well as, the Universitätsbund e.V. Tübingen for the financial support of this thesis.

Thanks to all colleagues of the work group of palaeoanthropology at the Institute for Archaeological Sciences in Tuebingen, Michael Francken, Catherine Bauer, Bea Welte, Monika Doll, Steve Zäuner, Heike Scherf, Marlijn Nobak and Vangelis Tourloukis. Special thanks to Martin and Iris Trautmann for their help and support with the bone material as well as data processing.

Very special thanks to Hannes Napierala for great comprehensive support, in as well as, outside the institute, also to Sebastien Villotte for introducing me to the world of entheseal changes. Thanks also to Denise Moser, Christoph Wissing, Markus Schumacher, Andreas Taller, Viola Schmid, Yamandu Hilbert, Oliver and Daniel Jöchle, Joe Hardy and Bernd Vögtle.

Great thanks to my family, in particular to Amelie, Nele and Svea, for their help and support not just during the work process but already the whole time of my life.