Körperlich-sportliche Aktivität und affektives Befinden im Alltag

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Einflussfaktoren für das befindensregulative Potential von körperlich-sportlicher Aktivität

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- Albert Schweizer -

Inhaltsverzeichnis

Tabellen- und Abbildungsverzeichnis **III**

Abkürzungsverzeichnis **IV**

Verzeichnis der Manuskripte **V**

ZUSAMMENFASSUNG **1**

1 **EINLEITUNG** **4**

2 **THEORETISCHER HINTERGRUND** **8**

2.1 Körperlich-sportliche Aktivität und affektives Befinden 8

2.1.1 Differenzierung von körperlich-sportlicher Aktivität 8

2.1.2 Affektives Befinden 9

2.1.3 Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden 11

2.2 Mögliche Einflussfaktoren im Zusammenspiel von körperlich-sportlicher Aktivität und affektivem Befinden 12

2.2.1 Situative Faktoren 13

2.2.2 Fähigkeit zur bewegungsbezogenen Befindensregulation 15

2.3 Ambulantes Assessment 17

2.3.1 Vorteile 17

2.3.2 Herausforderungen 18

3 **FORSCHUNGSFRAGEN** **20**

4 **ZUSAMMENFASSUNG DER MANUSKRIPTE** **23**

4.1 Manuskript 1: Physical Activity and Affective Well-being in Everyday Life 23

4.2 Manuskript 2: Sport Activities in Daily Routine 24

4.3 Manuskript 3: Physical-Activity-Related Mood Regulation and the Activity-Affect-Association 25

5 **ABSCHLIESSENDE DISKUSSION** **26**

5.1 Zusammenfassung und Diskussion der Hauptergebnisse 26

5.2 Stärken und Limitationen 34

5.3 Praktische Implikationen 38

5.4 Schlussfolgerung und Perspektive 40

6 **LITERATURVERZEICHNIS** **42**

7 **ANHANG** **49**

Manuskript 1: Physical Activity and Affective Well-Being in Everyday Life 50

Manuskript 2: Sport Activities in Daily Routine 66

Manuskript 3: Physical-Activity-Related Mood Regulation and the Activity-Affect-Association 81

Tabellen- und Abbildungsverzeichnis

Tabelle 1 *Ergebnisübersicht für die Assoziationen zwischen den jeweiligen Prädiktoren aus den Manuskripten und den drei Dimensionen des affektiven Befindens* 27

Abbildung 1 *Dynamische Ausdifferenzierung des subjektiven Wohlbefindens* (*Lehnert, Sudeck & Conzelmann, 2012 ; nach Schlicht, 2003)* 10

Abbildung 2 *Transdisziplinäres Modell möglicher Einflussfaktoren für körperlich-sportliches Aktivitätsverhalten (überarbeitete und angepasste Darstellung nach Bryan et al., 2011)* 13

Abbildung 3 *Modell zur Gesundheitskompetenz (angepasste Darstellung nach Sudeck & Pfeifer, 2016)* 16

Abkürzungsverzeichnis

ACSM	American College of Sports Medicine
EKG	Elektrokardiogramm
ESM	Experienced Sampling Method
HF	Herzfrequenz
HF_{max}	Maximale Herzfrequenz
ICC	Intraclass Coefficient
KSA	Körperlich-sportliche Aktivität
MDBF	Mehrdimensionaler Befindlichkeitsfragebogen
MET	Metabolic equivalent of task
PA	Positive Aktivierung
QoL	Quality of life
RPE	Rating of perceived exertion
RU	Ruhe
SG	Situational Goal / Situatives Ziel
VA	Valenz
WHO	World Health Organisation

Verzeichnis der Manuskripte

Diese Dissertation basiert auf den folgenden drei Manuskripten:

I. Jeckel, S. & Sudeck, G. (2016). Physical activity and affective well-being in everyday life: Comparing sport activities and daily physical activities regarding acute and sustainable associations. *Zeitschrift für Gesundheitspsychologie – European Journal of Health Psychology, 24* (3), 130-144. DOI: 10.1026/0943-8149/a000163

II. Jeckel, S. & Sudeck, G. (2017). Sport activities in daily routine: situational associations between individual goals, activity characteristics and affective well-being. *German Journal of Exercise and Sport Research*. DOI: 10.1007/s12662-017-0469-9

III. Sudeck, G., Jeckel, S. & Schubert, T. (2017, submitted). *The Moderating Role of Individual Differences in Physical-Activity-Related Mood Regulation for the Activity-Affect-Association in Real-Life Situations.*

ZUSAMMENFASSUNG

Körperlich-sportliche Aktivität ist positiv mit affektivem Befinden assoziiert. Darüber hinaus kann körperlich-sportliche Aktivität auch zu einer Reduktion von negativem Affekt beitragen. Die vorliegende Dissertation zielt darauf ab, das befindensregulative Potenzial körperlich-sportlicher Aktivität zu untersuchen. Es werden dabei in zwei empirischen Studien drei Forschungsziele verfolgt. Erstens soll eine Differenzierung zwischen körperlichen Alltagsaktivitäten und Sportaktivitäten vorgenommen werden, wenn es um Assoziationen mit affektivem Befinden im Alltagssetting geht (Studie 1, *Manuskript 1*). Zweitens werden davon ausgehend die Assoziationen zwischen Sportaktivitäten und affektivem Befinden im Alltagssetting situativ analysiert, um mögliche Faktoren für intraindividuelle Variabilität der affektiven Reaktionen zu identifizieren (Studie 1, *Manuskript 2*). Im dritten Schritt wird analysiert, inwieweit die individuelle Kompetenz zur bewegungsbezogenen Befindensregulation eine moderierende Rolle für die Aktivitäts-Affekt-Assoziation einnimmt (Studie 2, *Manuskript 3*). Durch dieses aufeinander aufbauende, sukzessive Vorgehen erweitert und bereichert die vorliegende Dissertation theoretische und empirische Erkenntnisse auf zweierlei Arten. Zum einen wird der Transfer von Ergebnissen aus Laborstudien bzw. strukturierten Sportprogrammen in den alltäglichen Handlungsverlauf durch die Anwendung des Ambulanten Assessments vorgenommen. Zum anderen wird die Situationsspezifik berücksichtigt, die somit nicht nur Aussagen über Unterschiede zwischen Personen, sondern auch innerhalb einer Person zulässt.

Bei Studie 1 handelt es sich um eine Ambulante Assessment-Studie, an der 46 gesunde Erwachsene über sieben konsekutive Tage teilnahmen. Die Aktivitätsparameter wurden objektiv durch einen Akzelerometer mit EKG-Sensor, welche die Teilnehmer an einem Brustgurt trugen, erfasst. Zusätzlich wurde die Aktivität durch ein Aktivitätsprotokoll erhoben, das die Teilnehmer jeden Abend ausfüllten. Affektives Befinden wurde mehrfach täglich event- als auch time-basiert über ein Smartphone erfragt. Situative Ziele und wahrgenommene Anstrengung wurden ebenfalls smartphone-basiert direkt vor bzw. nach den Sportaktivitäten erfasst.

Manuskript 1 untersuchte sowohl akute als auch nachhaltige Assoziationen zwischen körperlichen Alltagsaktivitäten bzw. Sportaktivitäten und dem affektiven Befinden. Mehrebenenanalysen konnten akute positive Effekte von Sportaktivitäten auf das affektive Befinden auch im Alltagssetting replizieren. Körperliche Alltagsaktivität zeigte akute positive Effekte auf Valenz und positive Aktivierung, nicht jedoch auf das Ruhe-

Erleben. Am Ende des Tages zeigten sich für Sportaktivitäten und körperliche Alltagsaktivität für Valenz und Ruhe positive Assoziationen. Die Ergebnisse bieten weiteres Hintergrundwissen für Aktivitätsempfehlungen, die auf befindensregulativem Potenzial von körperlicher Aktivität basieren.

Manuskript 2 liegt die Annahme zugrunde, dass das befindensregulative Potenzial sportlicher Aktivitäten situativ variiert. Es werden deshalb affektive Reaktionen auf Sportaktivitäten im alltäglichen Handlungsverlauf analysiert, um mögliche Einflussfaktoren für situativ variable Befindensveränderungen zu identifizieren. Die Ergebnisse der mehrebenenanalytischen Regressionsmodelle bestätigen zunächst die situative Heterogenität des affektiven Befindens, der situativen Ziele sowie der Aktivitätsparameter. Weiter konnte beobachtet werden, dass z.B. stärker ausgeprägten Zielen zur Gewichtsregulation und Aktivierung eine höhere Aktivitätsdosis folgte. Eine höhere Aktivitätsdosis führte zudem zu einer Steigerung der positiven Aktivierung nach der Sportaktivität. Die Ergebnisse zeigen, dass affektives Befinden, spezifische Ziele vor der Sportaktivität sowie die Aktivitätsgestaltung intraindividuell variieren. Sie unterstreichen die Bedeutung situativer Merkmale, wenn es um befindensregulatives Potenzial sportlicher Aktivitäten geht.

In Studie 2, die ebenfalls als Ambulantes Assessment an vier aufeinander folgenden Tagen stattfand, wurde affektives Befinden jeweils situationsspezifisch über ein Smartphone erfragt, die Fähigkeit zur bewegungsbezogenen Befindensregulation wurde in einem Vorab-Fragebogen erhoben und körperliche Aktivität wurde objektiv durch einen Akzelerometer, der an der Hüfte platziert war, erfasst.

Manuskript 3 widmet sich der inkonsistenten Befundlage bezüglich der positiven Assoziation zwischen körperlicher Aktivität und affektivem Befinden in den unterschiedlichen Affekt-Dimensionen. Es wird der Frage nachgegangen, inwieweit die individuelle Fähigkeit zur bewegungsbezogenen Befindensregulation die Assoziationen zwischen körperlicher Aktivität und affektivem Befinden moderiert. Die Ergebnisse der Mehrebenenanalysen zeigen sowohl für Valenz als auch für das Ruheempfinden Cross-Level-Interaktionseffekte. Die Prädiktionskraft des Prädiktors der Ebene 1 (innerhalb von Personen variierende körperliche Aktivität) steht also mit der Ausprägung des Prädiktors der Ebene 2 (individuelle Kompetenz zur bewegungsbezogenen Befindensregulation) in Zusammenhang. Individuelle Unterschiede in der bewegungsbezogenen Befindensregulationskompetenz konnten demnach als ein Moderator für die Assoziationen zwischen körperlicher Aktivität und affektivem Befinden in Alltagssituationen identifiziert werden.

Insgesamt zeigt die vorliegende Dissertation, dass körperlich-sportliche Aktivität, integriert in den Alltag, als ein Mittel zur Regulation von affektivem Befinden eingesetzt werden kann. Diesbezüglich wird aufgezeigt, dass eine situationsspezifische Betrachtung der Assoziationen zwischen Sportaktivitäten und affektiven Reaktionen von Bedeutung ist. Darüber hinaus unterstreicht die vorliegende Dissertation den Wert von Ambulantem Assessment, wenn es darum geht, Daten über das aktuelle Erleben und Verhalten von Personen in reellen Situationen zu erfassen und somit Aussagen für den Alltag treffen zu können. Demzufolge kann die vorliegende Dissertation konzeptionelles Wissen zum Potenzial von körperlich-sportlicher Aktivität für die Befindensregulation beisteuern. Praktische Implikationen für Aktivitätsverhalten werden zusammen mit zukünftigen Forschungsmöglichkeiten diskutiert.

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1 EINLEITUNG

Positive Effekte von körperlich-sportlicher Aktivität auf die psychische Gesundheit sind gut dokumentiert (z.B. Netz, Wu, Becker & Tenenbaum., 2005). Meta-Analysen zeigen, dass hierbei moderate Verbesserungen des momentanen affektiven Befindens zusammengefasst werden können (Reed & Ones, 2006). Akute Effekte beziehen sich dabei auf die unmittelbaren Auswirkungen von körperlich-sportlicher Aktivität auf das aktuelle Befinden. Sowohl für geplante, strukturierte Sportprogramme als auch für körperlich aktive Phasen unter Alltagsbedingungen konnten akute Effekte nachgewiesen werden (vgl. Schlicht, Ebner-Priemer & Kanning, 2013). Zusätzlich wurde immer wieder auch der Frage nach der Nachhaltigkeit dieser akuten Effekte nachgegangen. Guérin, Fortier und Sweet (2013) konnten positive Assoziationen zwischen Aktivität und Valenz sowie positiver Aktivierung bis zu 3 Stunden nach der Aktivität feststellen. Wichers und Kollegen (2012) resümierten ebenso 3 Stunden anhaltender positiver Effekte nach aktiven Perioden. Da sowohl affektive Reaktionen auf körperlich-sportliche Aktivitäten als auch das Aktivitätsverhalten selbst unter Laborbedingungen im Vergleich zum Alltags-Setting stark abweichen, können diese Befunde nicht auf Alltagsbedingungen übertragen werden (Bussmann, Ebner-Priemer & Fahrenberg, 2009). So ist es wichtig, dass sowohl Sportaktivitäten als auch körperliche Alltagsaktivität und das folgende affektive Befinden im natürlichen Handlungsverlauf von Personen erfasst werden, da hier die Teilnehmer selbst die Aktivitäten, als auch den Zeitpunkt sowie die Art der Ausführung bestimmen können.

Liao, Shonkoff und Dunton (2015) fassten 12 Studien mit einer leitenden Fragestellung zu akuten Effekten von körperlich-sportlicher Aktivität auf affektives Befinden zusammen. Sechs dieser Studien verwendeten Akzelerometrie zur Erfassung der körperlich-sportlichen Aktivität, so dass das Ausmaß als auch die Intensität dieser über den gesamten Tag in die Analysen mit einbezogen werden können. Auch für die Erfragung des affektiven Befindens während des Tages werden vermehrt elektronische Tagebücher (z.B. per Smartphone) eingesetzt. Dies entspricht dem Positionspapier von Kanning, Ebner-Priemer und Schlicht (2013), in dem Strategien zum Ambulanten Assessment implementiert werden. Liao und Kollegen (2015) fassen die Befunde so zusammen, dass körperlich-sportliche Aktivität übereinstimmend mit einer Verbesserung positiven Affekts zusammenhängt, die Ergebnisse bezüglich einer Reduktion des negativen Affekts jedoch inkonsistent sind. Bei detaillierterer Betrachtung des Affekts sind die Befunde für eine

stärkere positive Aktivierung nach körperlich-sportlicher Aktivität relativ konsistent, wohingegen die Ergebnisse kein eindeutiges Bild bezüglich des Ruheempfindens nach körperlich-sportlicher Aktivität zulassen.

Neben diesen teils noch uneinheitlichen Befunden bezüglich der Dimensionen des affektiven Befindens, bestehen weitere offene Fragen, die für ein besseres Verständnis der Assoziationen zwischen körperlich-sportlicher Aktivität und affektivem Befinden im alltäglichen Handlungsverlauf relevant sind. So unterscheiden die meisten Studien nicht zwischen den unterschiedlichen Formen körperlicher Aktivität. Tatsächliche Sportaktivitäten und rein körperliche Alltagsaktivitäten können aber gänzlich verschieden mit affektivem Befinden in Beziehung stehen, so dass eine getrennte Analyse von großer Bedeutung ist. Studien, die körperlich-sportliche Aktivität ausschließlich durch Akzelerometrie erfassen, können diese Differenzierung der Aktivitätsform nicht auf Basis der objektiv erhobenen Daten vornehmen. So ist eine Kombination aus Akzelerometrie und Selbstangabe der Teilnehmer notwendig.

Dem lange als sehr positiv dargestellten Zusammenhang zwischen körperlich-sportlicher Aktivität und affektivem Befinden, wurde seit der Jahrtausendwende vermehrt durch individuums-bezogene Analysen begegnet. Dabei wurde festgestellt, dass es auch Personen gibt, die sich nach sportlichen Aktivitäten unwohl fühlen (z.B. Backhouse, Ekkekakis, Biddle, Fosket & Williams, 2007; Ekkekakis, Parfitt & Petruzzello, 2011; Sudeck & Conzelmann, 2014). Es besteht also eine substanzielle interindividuelle Variabilität akuter Effekte von sportlichen Aktivitäten. Um ein besseres Verständnis dieser Heterogenität der akuten Effekte schaffen zu können, müssen mögliche Einflussfaktoren identifiziert werden (Rose & Parfitt, 2007; 2010). Darüber hinaus wurden in Studien kaum mehrere Aktivitäten einer Person in die Analysen eingeschlossen (z.B. Kwan & Bryan, 2010; Williams, Dunsinger, Jennings & Marcus, 2012). Demzufolge wird die intraindividuelle Konsistenz über mehrere Aktivitäten hinweg nicht beachtet. Unick und Kollegen (2015) konnten in ihrer Studie jedoch intraindividuelle Heterogenität bei mehreren Vorher-Nachher-Messungen innerhalb einer Person feststellen. Allerdings ist nicht viel über die Einflussfaktoren bekannt, die situative Heterogenität der affektiven Reaktionen nach Sportaktivitäten innerhalb von Personen bestimmen.

Das sogenannte *Big Picture of Individual Differences in Physical Activity Behavior Change* (Bryan et al., 2011) berücksichtigt verschiedene Einflussfaktoren. So werden Aktivitätsparameter (z.B. Aktivitätsdosis), physiologische Reaktionen auf die Aktivität

(z.B. Herzfrequenz), subjektive Erfahrungen (z.B. situativ wahrgenommene Anstrengung) sowie die Motivation für die Sportaktivität (z.B. spezifische Ziele) in diesem komplexen Zusammenspiel vereint. Wenn Sportaktivitäten im alltäglichen Handlungsverlauf integriert sind, kann die Ausprägung dieser Faktoren demnach situativ variieren. Bezogen auf das Forschungsdefizit gilt es deshalb zu klären, inwieweit situative Assoziationen zwischen Zielen für Sportaktivitäten, den Aktivitätscharakteristika und dem affektiven Befinden nach den Sportaktivitäten bestehen, wenn Sportaktivitäten im Alltag von Personen integriert sind.

Neben den situativ variierenden Faktoren können auch personale Merkmale in diesem Komplex eine Rolle spielen. Hierbei ist zudem zu berücksichtigen, dass die Assoziation zwischen körperlicher Aktivität und affektivem Befinden über die Lebensspanne jedes Einzelnen hinweg veränderbar bleibt (Lee, Emerson & Williams, 2016). Persönliche Erfahrungen in formellen oder informellen Bildungs-Settings können hierfür grundlegend sein, weshalb dies ein wichtiges Thema für bereichsspezifische Förderung von Gesundheitskompetenz darstellt (Abel & Sommerhalder, 2015). Grundsätzlich verbergen sich hinter der Gesundheitskompetenz das Wissen, die Motivation sowie die Kompetenz, die Personen dazu befähigen, im Alltag sachkundige Entscheidungen bezüglich ihrer Gesundheit so treffen zu können, dass Gesundheit und Wohlbefinden positiv beeinflusst werden (z.B. Sørensen et al., 2012). Wenn dieses Konzept auf den Bereich der körperlich-sportlichen Aktivität übertragen wird, dann müssten Individuen in der Lage sein, körperlich-sportliche Aktivitäten in einer gesundheitsförderlichen Art und Weise in ihren Alltag zu integrieren – basierend auf ausreichend spezifischem Wissen, Motivation und Kompetenz. Sudeck und Pfeiffer (2016) entwickelten und validierten einen Fragebogen zur bewegungsbezogenen Gesundheitskompetenz, in dem die bewegungsbezogene Befindensregulation eine relevante Teilfacette darstellt. Sie kamen zu dem Schluss, dass es lohnenswert sei, mögliche Assoziationen zwischen bewegungsbezogener Befindensregulation und affektivem Wohlbefinden (als Indikator für psychische Gesundheit) zu analysieren.

Zusammengefasst besteht das übergeordnete Ziel dieser Dissertation darin, einen Transfer bestehender Befunde zur Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden auf natürliche Alltagsbedingungen von Personen vorzunehmen und darüber hinaus situative Analysen möglicher Einflussfaktoren für heterogene Ergebnisse innerhalb von Personen aufzudecken. Im Detail betrachtet die vorliegende Disser-

tation drei Kernbereiche, die in zwei empirischen Studien umgesetzt wurden. In *Manuskript 1* werden akute sowie nachhaltige Assoziationen zwischen körperlich-sportlicher Aktivität und affektivem Befinden im Alltag analysiert, wobei zwischen rein körperlicher Alltagsaktivität und sportlichen Aktivitäten differenziert wird. In *Manuskript 2* werden rein sportliche Aktivitäten im Alltag betrachtet und dabei situative Analysen der Assoziationen zwischen individuellen Beweggründen für Sport bzw. Aktivitätscharakteristika und dem affektiven Befinden beleuchtet. *Manuskript 3* betrachtet Assoziationen zwischen körperlicher Aktivität und affektivem Befinden unter Berücksichtigung der individuellen Fähigkeit zur bewegungsbezogenen Befindensregulation.

Die vorliegende Dissertation ist in vier Kapitel gegliedert, die auf diese Einleitung folgen. In Kapitel 2 werden der theoretische Hintergrund für die Untersuchung des befindensregulativen Potentials körperlich-sportlicher Aktivität vorgestellt und mögliche Einflussfaktoren auf diese Assoziationen sowie die viel versprechende Methode des Ambulanten Assessments. In Kapitel 3 werden die Zielsetzungen des Forschungsvorhabens zusammengefasst. Kapitel 4 gibt einen Überblick über die drei Manuskripte. Im abschließenden Kapitel 5 werden die Hauptergebnisse der drei Manuskripte sowie Stärken, Limitationen als auch mögliche Implikationen für zukünftige Forschungsvorhaben diskutiert.

2 THEORETISCHER HINTERGRUND

2.1 Körperlich-sportliche Aktivität und affektives Befinden

Im Folgenden wird der theoretische Hintergrund zum Thema körperlich-sportliche Aktivität und affektives Befinden präsentiert. Zunächst werden dabei die Hauptkonstrukte (körperlich-sportliche Aktivität, affektives Befinden) separat näher beleuchtet. Anschließend folgt eine Vorstellung bisher bekannter grundsätzlicher Mechanismen zum Zusammenhang von körperlich-sportlicher Aktivität und affektivem Befinden, die abschließend übergeht zum bisherigen Forschungsstand dieser Assoziation.

2.1.1 Differenzierung von körperlich-sportlicher Aktivität

Der Begriff *körperlich-sportliche Aktivität* ist als Oberbegriff für eine Vielzahl verschiedener Aktivitätstypen in verschiedenen Kontexten (Freizeit, Haushalt, Transport, Beruf) zu verstehen (Fuchs & Schlicht, 2012). Diese körperlichen Aktivitäten haben gemeinsam, dass sie unter willkürlichem Muskeleinsatz eine substantielle Erhöhung des Energieverbrauchs bewirken (Caspersen, Powell & Christenson, 1985). Spezifische Teilmengen sind *Sportaktivitäten* sowie *körperliche Alltagsaktivität.* Der Begriff *Sportaktivität* wird verwendet, wenn in der Freizeit strukturierte körperliche Aktivitäten mit erhöhtem Energieverbrauch durchgeführt werden. Der Begriff Sportaktivität ist dabei ‚motivneutral' (Fuchs, 2003) und umspannt mehr als klassische Sportarten, die häufig mit Wettkampf und Leistungsorientierung assoziiert werden. Es ist vielmehr ein breites Spektrum sportlicher Aktivitäten gemeint, die um ihrer selbst willen (Spaß und Genuss), aus personalen (Leistung), sozialen (Geselligkeit) oder gesundheitlichen Gründen (körperliche Fitness, Wohlbefinden) ausgeübt werden. Davon können *körperliche Alltagsaktivitäten* abgegrenzt werden, bei denen der erhöhte Energieverbrauch durch Aktivitäten im Haushalt (z. B. Wohnung reinigen), zu Transferzwecken (z.B. mit dem Rad zur Arbeit fahren), im Beruf (z.B. als Handwerker) oder auch in der Freizeit realisiert wird (z. B. Spazierengehen).

Grundsätzlich können bei der Betrachtung von körperlich-sportlicher Aktivität qualitative und quantitative Aspekte unterschieden werden (Strath et al., 2013). Zu den qualitativen Aspekten zählen z.B. der beschriebene Aktivitätstyp, die Struktur (Caspersen et al., 1985) und auch der Kontext (z.B. Kanning, 2013), in dem die Aktivität stattfindet.

Zu den quantitativen Aspekten zählen z.B. die Dauer, die Häufigkeit, die Intensität oder die Dosis (als Produkt aus Dauer und Intensität) von körperlich-sportlichen Aktivitäten. Die Dauer und die Häufigkeit werden üblicherweise erhoben, indem die zeitliche Länge sowie die Häufigkeit der Durchführung gemessen werden. Die Intensität körperlich-sportlicher Aktivitäten kann auf unterschiedliche Weise objektiv erfasst werden. So können zum Beispiel die Herzfrequenz (HF) oder die Beschleunigung von Personen gemessen werden. Diese erhobenen Daten könnten dann in Bezug zu validen Referenzwerten für Energieverbrauch (z.B. Metabolisches Äquivalent, MET) gesetzt werden, um die erhobenen körperlich-sportlichen Aktivitäten in bestimmte Aktivitätslevel einzuordnen. Darüber hinaus gibt es bezüglich der Intensität die Möglichkeit diese subjektiv über die wahrgenommene Anstrengung (rating of perceived exertion, RPE) zu erfragen. Eine genauere Betrachtung geeigneter Erhebungsverfahren wird in Kapitel 2.3 vorgenommen.

2.1.2 Affektives Befinden

Das zweite Hauptkonstrukt der Analysen der vorliegenden Dissertation ist das affektive Befinden. Nach Diener (1984) ist affektives Befinden (neben den kognitiven Bewertungen) Teil des subjektiven Wohlbefindens. So unterteilt er das subjektive Wohlbefinden in unterschiedliche Komponenten: Lebenszufriedenheit (kognitive Selbstevaluation), positiver Affekt und negativer Affekt. Hierbei wird der kognitive Anteil des subjektiven Wohlbefindens häufig als *quality of life* (QoL; Lehnert, Sudeck & Conzelmann, 2012) bezeichnet und unterstreicht damit eine bewusste kognitive Bewertung des eigenen Lebens, bei dem auch die Kriterien zur Bewertung von der Person selbst vorgegeben sind (Pavot & Diener, 1993). Der affektive Anteil des subjektiven Wohlbefindens, das affektive Befinden, kann wiederum unterteilt werden: in positiven/negativen Affekt und in Aktivierung/Deaktivierung (vgl. Lehnert, Sudeck & Conzelmann, 2012). *Affekt* ist definiert als „neurophysiological state that is consciously accessible as a simple, nonreflective feeling“ (Russel, 2003, p.147). Diese beiden Bereiche des affektiven Befindens können in drei Dimensionen ausgedrückt werden: Valenz (VA), Ruhe (RU) und positive Aktivierung (PA) (Schimmack & Grob, 2000; Wilhelm & Schoebi, 2007). Im Multidimensionalen Befindlichkeitsfragebogen (MDBF; Wilhelm & Schoebi, 2007), der ein valides Verfahren darstellt, um affektive Zustände im Alltag zu erfassen, werden diese Subdimensionen durch je zwei bipolare Adjektivpaare beschrieben: Valenz durch *wohl – unwohl* und

zufrieden – unzufrieden, Ruhe durch *angespannt – entspannt* und *ruhig – unruhig* und positive Aktivierung durch *müde – wach* und *energielos – energiegeladen*.

Die unterschiedlichen Anteile des subjektiven Wohlbefindens enthalten variierende dynamische Aspekte (siehe Abb. 1). So gibt es einen sogenannten *set-point*, der in etwa das individuelle Grundniveau einer Person beschreibt. Um dieses Grundniveau schwankt der *trait-aspect*, dessen Ausprägungen jedoch zeitstabiler und weniger stark variieren als die des *state-aspect*. Dieser kann sehr stark um den individuellen *set-point* variieren, wobei diese Schwankungen oft von kürzerer Dauer sind. Wie in Abbildung 1 zu sehen ist, kann dieser *state-aspect* durch verschiedene Stimuli beeinflusst werden.

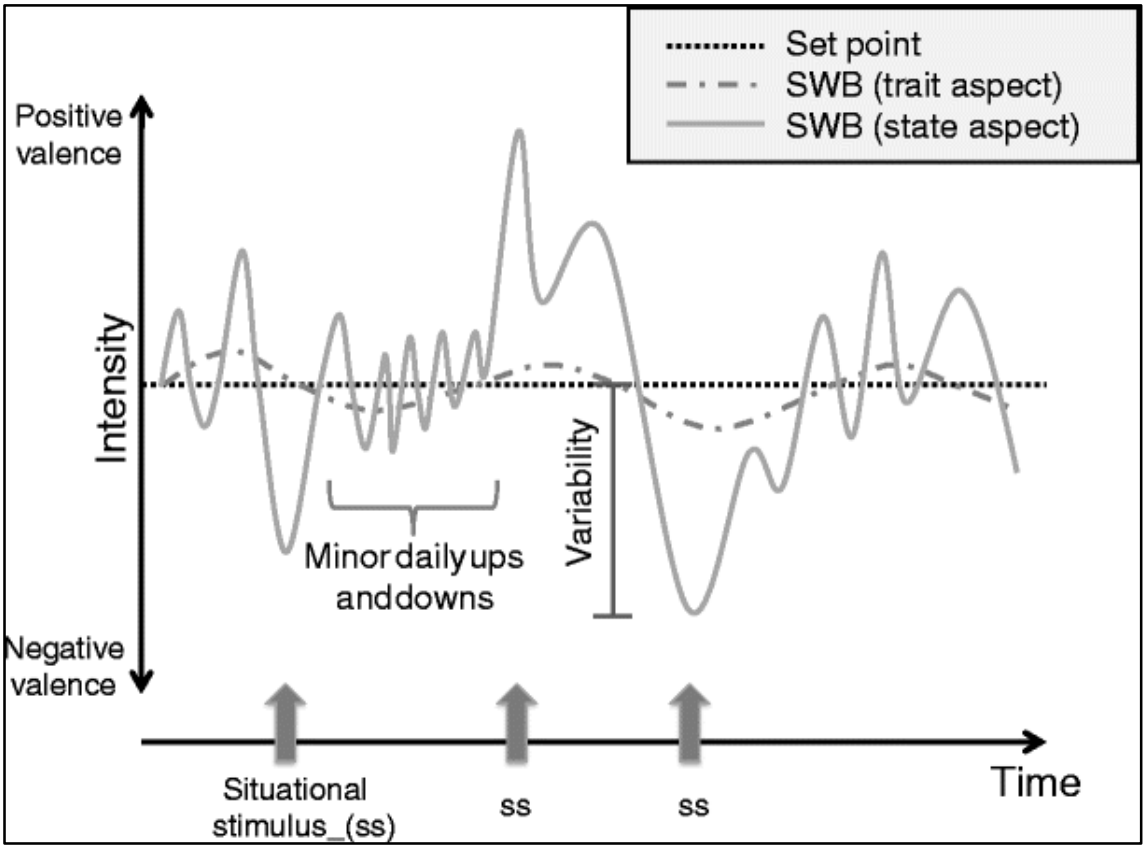

Abbildung 1. Dynamische Ausdifferenzierung des subjektiven Wohlbefindens (Lehnert, Sudeck & Conzelmann, 2012; nach Schlicht, 2003)

Als ein möglicher Stimulus wird zum Beispiel körperlich-sportliche Aktivität gesehen. Positive Assoziationen zwischen körperlich-sportlicher Aktivität und affektivem Befinden wurden in verschiedenen Reviews bestätigt (Arent, Landers & Etnier, 2000; Netz et al., 2005; Reed & Ones, 2006). Eine genauere Betrachtung des Forschungsstandes diesbezüglich soll im Folgenden vorgestellt werden.

2.1.3 Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden

Eine Vielzahl an Studien analysierte akute Effekte standardisierter körperlicher Belastungen unter Laborbedingungen. In einer Metaanalyse fassten Reed und Ones (2006) die Ergebnisse aus 158 Studien zusammen. Diese deuten darauf hin, dass die größten aktivitätsbedingten Effekte auf positiven Affekt bei niedrigen Intensitäten sowie für eine Dauer von bis zu 35 Minuten bestehen. Die Intensität sowie die Dauer der körperlichen Belastungen lassen sich unter Laborbedingungen sehr gut kontrollieren (z.B. auf einem Laufband oder Fahrradergometer). Affektive Reaktionen auf Verhalten im Alltag als auch das Verhalten selbst unterscheiden sich jedoch sehr stark von den vorgegebenen Bedingungen in einer Laborstudie, weshalb sich die externe Validität von Laborstudien nur schwer herstellen lässt (Bussmann et al., 2009). Weitere Studien zur Assoziation von körperlich-sportlicher Aktivität und affektivem Befinden wurden in organisierten Sportprogrammen durchgeführt. Hier konnten zahlreiche Studien eine relativ starke akute Verbesserung des affektiven Befindens für Teilnehmer dieser Sportprogramme belegen. Abele und Brehm (1993) berichten in ihrem Review von akuten Effekten nach der Teilnahme an diesen Sportprogrammen. Eine Verbesserung sowohl der positiven Aktivierung als auch des Ruheempfindens konnte festgehalten werden. In diesen Sportprogrammen sind jedoch die Bedingungen deutlich mehr vorgegeben als dies im Alltag der Fall ist, wo Personen selbst die Art der Aktivität wählen können (z.B. Ausdauer Training, Fitness-Kurs, alleine Joggen gehen, etc.). Darüber hinaus können Teilnehmer von Sportprogrammen nicht selbstständig entscheiden, wann die Sportaktivität in ihren Alltag integriert ist. Obwohl also viele positive Befunde bestehen, können die Ergebnisse nur schwer auf den natürlichen Alltag von Personen übertragen werden (Liao et al., 2015).

Während der letzten Jahre wurde vermehrt diesem Defizit begegnet und die Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden im Alltag analysiert. In einem Review fassten Liao und ihre Kollegen (2015) 12 Studien zusammen, die diese Assoziation im Alltag untersuchten. Studien, die vor 2010 durchgeführt wurden, verwendeten häufig Selbstberichte der körperlich-sportlichen Aktivität, die teils per schriftlicher Befragung, teils mit elektronischen Tagebüchern erhoben wurden. Sechs von acht Studien, die seit 2010 durchgeführt wurden, verwendeten Akzelerometrie zur Erfassung der körperlich-sportlichen Aktivität. Dies ermöglicht, dass sowohl das Ausmaß als auch die Intensität der körperlich-sportlichen Aktivität über den gesamten Tagesverlauf in die Analysen einbezogen werden können (für eine ausführlichere Beschreibung der

Methode des Ambulanten Assessments siehe Kapitel 2.3). Zusammengefasst beschreiben die Ergebnisse nach Liao und Kollegen (2015) den Forschungsstand so, dass a) Körperlich-sportliche Aktivität übereinstimmend mit einer Verbesserung positiver Affekte verbunden ist, b) Befunde zur Reduktion negativer Affekte durch körperlich-sportliche Aktivität inkonsistent sind, c) Befunde für eine Steigerung der positiven Aktivierung nach körperlich-sportlicher Aktivität relativ konsistent sind und d) die Effekte von körperlich-sportlicher Aktivität auf das Ruheempfinden nicht eindeutig sind.

Neben diesen teils inkonsistenten Ergebnissen bezüglich der unterschiedlichen Befindensdimensionen bestehen weitere offene Fragen. So unterschieden die meisten Studien nicht zwischen den unterschiedlichen Formen der körperlichern Aktivität. Jedoch ist es sehr wahrscheinlich, dass Sportaktivitäten und körperliche Alltagsaktivität sehr unterschiedlich mit affektivem Befinden assoziiert sind, so dass eine Differenzierung sehr relevant scheint. Obwohl Akzelerometer basierte Studien die körperliche Aktivität über den gesamten Tag objektiv erfassen können, bleibt die Information über unterschiedliche Formen der Aktivität unklar (Gabrys et al., 2015). Eine Kombination aus Akzelerometerdaten und Selbstberichten, die nur sehr seltene Verwendung findet, sollte deshalb eingesetzt werden, so dass körperliche Alltagsaktivitäten (z.B. zu Fuß zum Einkaufen gehen) von sportlichen Aktivitäten, die in den Alltag integriert sind (z.B. Nordic Walking) unterschieden werden können.

2.2 Mögliche Einflussfaktoren im Zusammenspiel von körperlich-sportlicher Aktivität und affektivem Befinden

Das in Abbildung 2 dargestellte *Big Picture of Individual Differences in Physical Activity Behavior Change: A Transdisciplinary Approach* (Bryan et al., 2011; siehe Abb. 2) nähert sich dem Bewegungsverhalten transdisziplinär und umfasst verschiedene Einflussfaktoren: a) Aktivitätscharakteristika (z.B. Aktivitätsdosis), b) physiologische Reaktionen auf Aktivität (z.B. Herzfrequenz, HF), c) subjektive Erfahrungen (z.B. situatives Anstrengungsempfinden) sowie d) Motivation für körperlich-sportliche Aktivität (z.B. spezifische Ziele). Personale Faktoren (z.B. Fähigkeit zur Befindensregulation) wurden für die hier verwendete Darstellung ebenfalls integriert, da auch sie einen relevanten Einflussfaktor im komplexen Zusammenspiel zwischen körperlich-sportlicher Aktivität und affektivem Befinden darstellen können.

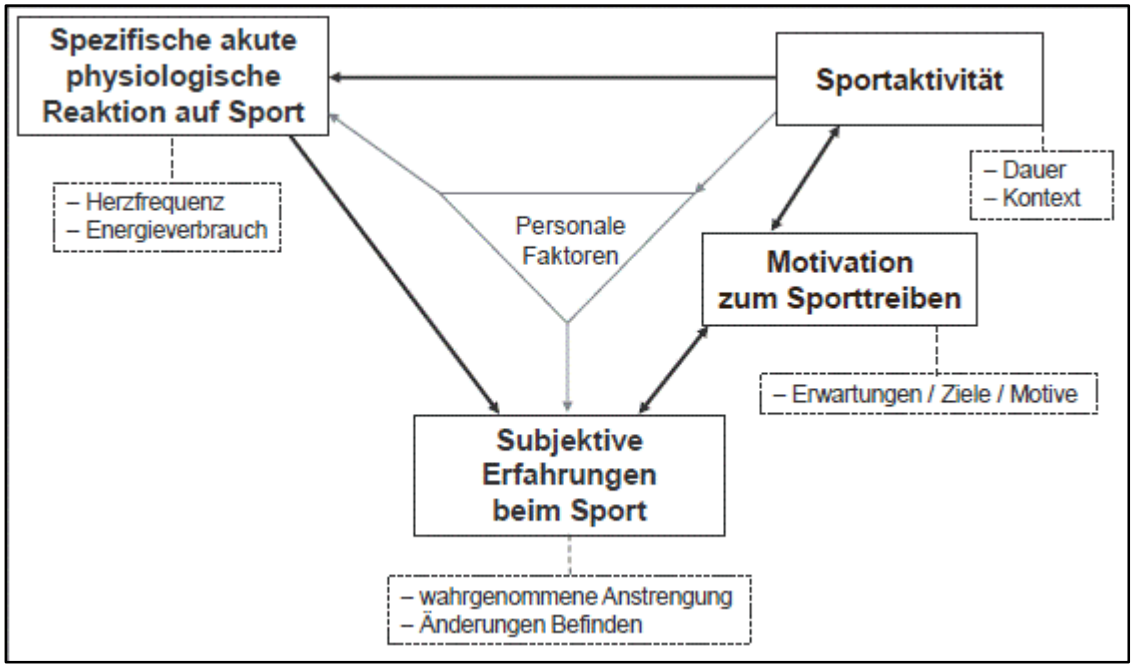

Abbildung 2. Transdisziplinäres Modell möglicher Einflussfaktoren für körperlich-sportliches Aktivitätsverhalten (überarbeitete und angepasste Darstellung nach Bryan et al., 2011)

Die vorliegende Dissertation erhebt keinen Anspruch einer vollständigen Darstellung des Forschungsstandes bezüglich der Einflussfaktoren für das Zusammenspiel von körperlich-sportlicher Aktivität und affektivem Befinden. Vielmehr stellen die folgenden beiden Kapitel eine Basis dafür dar, wie die eigenen Forschungsarbeiten eingeordnet werden können.

2.2.1 Situative Faktoren

Nach Nitsch (2004), der in seinem Rahmenkonzept für sportpsychologische Forschung und Intervention eine handlungstheoretische Perspektive aufzeigt, ist das Handeln als ein situativer Prozess zu verstehen. Eine Handlungssituation wird durch die jeweilige Konstellation von Person-, Umwelt- und Aufgabenfaktoren bestimmt. Demzufolge verändert sich die Situation einer Person insgesamt bereits mit der Veränderung einer dieser drei Komponenten (Person, Umwelt, Aufgabe). Überträgt man dieses Verständnis auf sportliche Aktivitäten, die in den Alltag integriert sind, so finden diese ganz natürlich in situativ variierenden Konstellationen statt. Demzufolge unterliegen die Assoziationen zwischen sportlicher Aktivität und affektivem Befinden den Einflüssen dieser variierenden

Situationen. Im Folgenden werden nun die bereits bei Bryan und Kollegen (2011) herausgearbeiteten Einflussfaktoren aufgegriffen und für das Zusammenspiel von körperlich-sportlicher Aktivität und affektivem Befinden näher betrachtet.

Die *Aktivitätsdosis* ist als wichtiger Einflussfaktor zu nennen. Dabei handelt es sich um die Funktion aus der Intensität und der Dauer einer Sportaktivität (McArdle, Katch & Katch, 2001). Reed und Ones (2006) fassen in ihrer Meta-Analyse zusammen, dass leichte bis moderate Aktivitätsdosen positiv mit positiver Aktivierung nach Sportaktivitäten zusammenhängen. Demgegenüber resultieren hohe und sehr hohe Aktivitätsdosen in einer zumindest zweitweisen Reduktion der positiven Aktivierung und weisen zudem größere interindividuelle Heterogenität auf. Allerdings wurde der Großteil dieser Studien unter Laborbedingungen durchgeführt.

Zahlreiche Studien zeigten unterschiedliche Effekte auf affektives Befinden nach Sportaktivitäten, abhängig von der gewählten *Intensität*. Studien, die die Dual-Mode Theorie (DMT; Ekkekakis, 2009) vertreten, zeigten gewissermaßen einheitlich, dass sich die meisten Personen wohl und aktiviert fühlen, wenn sie moderaten Intensitäten (55 < 70% der maximalen Herzfrequenz; HF_{max}; Norton, Norton & Sadgrove, 2010) nachgingen. Allerdings verändert sich dieser Effekt, sobald die Intensität eine bestimmte Schwelle übersteigt. So tritt individuell heterogenes affektives Befinden bei intensiven Intensitäten (70 < 90% HF_{max}) auf, das von angenehmen Zuständen bis zu starkem Unwohlsein reicht (z.B. Ekkekakis & Acevedo, 2006; Ekkekakis et al., 2011; Schlicht & Reicherz, 2012).

Befunde bezüglich des subjektiven Indikators der Intensität, der *wahrgenommenen Anstrengung* (Rating of perceived exertion; RPE) sind weniger eindeutig. Sudeck, Schmid und Conzelmann (2016) konnten keine within-person Assoziationen zwischen RPE und affektivem Befinden während sportlicher Aktivität feststellen. Demgegenüber konnten Guérin und Kollegen (2013) positive Assoziationen zwischen wahrgenommener Anstrengung und positivem Affekt für moderate bis intensive Aktivitäten feststellen.

Individuelle Ziele können ein weiterer Einflussfaktor für die situative Heterogenität von affektiven Reaktionen auf sportliche Aktivitäten sein. Eine Hauptthese der DMT (Ekkekakis, 2009) besteht darin, dass die Variabilität der affektiven Reaktionen bei intensiver sportlicher Aktivität auf kognitive Faktoren wie individuelle Ziele zurückzuführen ist. Es ist gut belegt, dass Personen aus unterschiedlichen Gründen sportlich aktiv sind (z.B. Lehnert, Sudeck & Conzelmann, 2011). Hinter diesen Zielen stehen bestimmte Erwartungen, was Personen durch die Sportaktivitäten erreichen wollen. Dies bezieht sich

auf die sog. goal contents (Austin & Vancouver, 1996) und beinhaltet einen hohen kognitiven Anteil (Heckhausen & Heckhausen, 2006). Guérin und Kollegen (2013) untersuchten in ihrer bereits erwähnten Studie unter Alltagsbedingungen den Einfluss situativer Motivation für moderate bis intensive Aktivität auf affektives Befinden nach der Aktivität. Sie fanden heraus, dass intrinsische Motivation (wie dies z.B. eine situative Erholungsintention ist) positiv mit positivem Affekt direkt nach sportlicher Aktivität assoziiert ist.

Wie die hier zusammengefassten Studien zu den einzelnen situativen Faktoren aufzeigen, lässt der momentane Forschungsstand zwar Tendenzen aber keine einheitlichen Aussagen für situationsspezifische Assoziationen zwischen sportlicher Aktivität und affektivem Befinden zu.

2.2.2 Fähigkeit zur bewegungsbezogenen Befindensregulation

Neben den oben genannten Einflussfaktoren, die als situativ variierend in das Person-Umwelt-Aufgabe Gefüge (Nitsch, 2004) einordbar sind, finden sich auch zeitstabilere, personale Faktoren, die im komplexen Zusammenspiel von körperlich-sportlicher Aktivität und affektivem Befinden von Bedeutung sind. Dies wurde in Abbildung 2 bereits angedeutet. In bisherigen Studien, die sich der Assoziation zwischen körperlich-sportlicher Aktivität und Affekt im alltäglichen Handlungsverlauf widmen, wurden bislang verschiedene personale Faktoren aus den Bereichen der Demografie (Alter, Geschlecht), des habituellen Bewegungsverhaltens (z.B. Hyde, Conroy, Pincus & Ram, 2011) sowie zur körperlichen Gesundheit (z.B. Body-Mass-Index; Kanning, Ebner-Priemer & Schlicht, 2015) und zur psychischen Gesundheit (satisfaction with life; Kanning et al., 2015; Depression; Wichers et al., 2012) untersucht. Eindeutige Folgerungen scheinen für personale Merkmale, die zeitlich (eher) stabil sind, derzeit noch nicht möglich. Einen weiteren dieser personalen Faktoren stellt z.B. die *Fähigkeit zur bewegungsbezogenen Befindensregulation* dar (Sudeck & Pfeifer, 2016). Ein kontextspezifisches Modell der bewegungsbezogenen Gesundheitskompetenz von Sudeck und Pfeifer (2016; Abb.3) beschreibt relevante Faktoren, die für eine gesundheitsförderliche Integration von körperlich-sportlicher Aktivität in den Alltag bedeutsam sind. Der individuellen Steuerungskompetenz für körperliche Belastungen wird dabei eine wichtige Funktion für die Förderung von Gesundheit und Wohlbefinden zugesprochen. Personen mit hoher Steuerungskompetenz für körperliches Training mit dem Ziel der Befindensregulation können nach diesem Ver-

ständnis ihre körperlichen Aktivitäten so gestalten und steuern, dass körperliche Gesundheitsgewinne optimiert und Gesundheitsrisiken minimiert werden, sowie das affektive Befinden und die psychische Gesundheit positiv beeinflusst werden (z.B. die Fähigkeit situativ aufgrund von Körpersignalen und wahrgenommener Anstrengung die physische Belastung so zu variieren, dass sich die Aktivität positiv auf das affektive Befinden auswirkt).

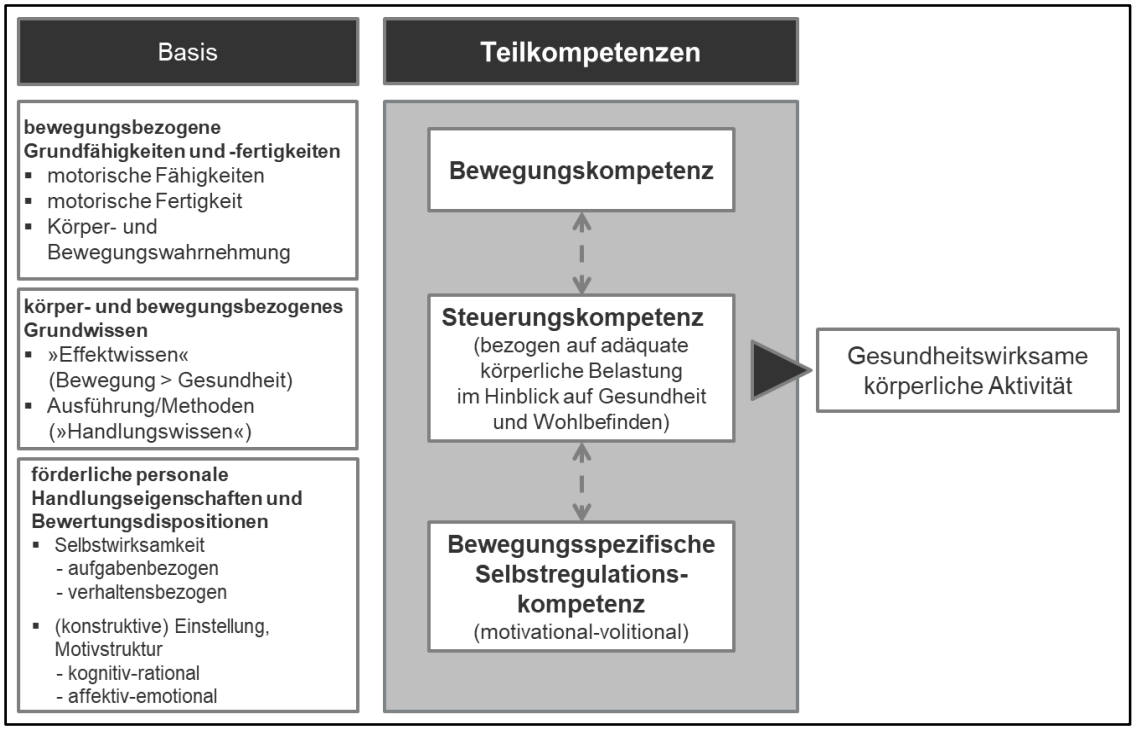

Abbildung 3. Modell zur bewegungsbezogenen Gesundheitskompetenz (angepasste Darstellung nach Sudeck & Pfeifer, 2016)

Modellkonform wäre die Steuerungskompetenz für bewegungsbezogene Befindensregulation als potenzieller Moderater für die Beziehung zwischen körperlich-sportlicher Aktivität und affektivem Befinden einzuordnen. Eine empirische Fundierung dieser Annahme steht jedoch aus. Bisherige empirische Studien zeigen lediglich, dass für die Steuerungskompetenz für bewegungsbezogene Befindensregulation große interindividuelle Unterschiede bei erwachsenen Personen und ein positiver Zusammenhang mit der Quantität des Bewegungsverhaltens zu beobachten sind (Sudeck & Pfeifer, 2016).

2.3 Ambulantes Assessment

Wie in den Kapiteln 2.1.1. und 2.1.2 dargestellt, variieren sowohl körperlich-sportliche Aktivitäten als auch affektives Befinden in verschiedenen Situationen und zu unterschiedlichen Zeiten. Wenn Personen nach ihrem affektiven Befinden an unterschiedlichen Zeitpunkten in den vergangenen Tagen bis zum aktuellen Moment befragt werden, so ist es äußerst wahrscheinlich, dass die Antwort eine grobe Einschätzung ist. Ebenso verhält es sich für das Ausmaß an körperlich-sportlicher Aktivität, das von Tag zu Tag variieren kann, besonders, wenn man Tage am Wochenende sowie Werktage mitberücksichtigt. So ist es für eine Erhebung dieser Konstrukte im Alltag notwendig, dass Erhebungsstrategien bestehen, die dieser Variabilität begegnen. Das *Ambulante Assessment* ist ein solches Erhebungsverfahren, das sich dafür eignet. Kapitel 2.3.1 und 2.3.2 gehen auf die Vorteile und Herausforderungen ein, die bei der Anwendung dieser Erhebungsstrategie bestehen. Die Anwendung des Ambulanten Assessments in der vorliegenden Dissertation sowie der entstehende Nutzen für das Forschungsfeld des Bewegungsverhaltens ist innerhalb der Zusammenfassung der Forschungsfragen (Kapitel 3) integriert.

2.3.1 Vorteile

Ambulantes Assessment umfasst Erhebungsmethoden, die das Verhalten und Erleben unterschiedlicher Situationen im Alltag und in reellen Handlungsabläufen über eine bestimmte Zeitspanne erfassen möchten (Trull & Ebner-Priemer, 2014). Demzufolge schließt diese Definition retrospektive Erhebungen sowie Laborstudien aus. Darüber hinaus ist ein weiteres Charakteristikum des Ambulanten Assessments ein longitudinales Design, in dem wiederholte Messungen innerhalb einer Person in deren natürlichem Umfeld stattfinden, so dass auch die Variabilität der erfassten Merkmale (z.B. physiologische Parameter) abgebildet werden kann (Bolger & Laurenceau, 2013). Folgende drei Vorteile können festgehalten werden: a) ökologische Validität, b) die Möglichkeit, wiederholt Daten von einer Person mit hoher Messfrequenz zu erheben sowie c) die Messgenauigkeit.

Erstens bietet das Ambulante Assessment die Möglichkeit, die jeweils relevanten Daten so zu erheben, wie sie unter natürlichen Begebenheiten im Alltag auftreten (Reis, 2012). Dadurch können auch Situationen untersucht werden, die aufgrund von ethischen oder aus pragmatischen Gründen nicht unter Laborbedingungen hergestellt werden können. Darüber hinaus können Verhaltensänderungen beobachtet werden, die sich natürlich über eine Zeitspanne hinweg entwickeln. Außerdem kann der Kontext der Erhebung frei

gewählt werden, um dem natürlichen Umfeld der jeweiligen Personen zu entsprechen. Als Folgerung daraus können Ergebnisse aus Ambulanten Assessment Studien mehr ökologische Validität aufweisen als Ergebnisse aus Laborstudien, und somit Rückschlüsse auf reelle Lebenssituationen der Personen fördern.

Zweitens bietet das Ambulante Assessment die Möglichkeit Prozesse innerhalb von Personen zu betrachten, indem mehrere Messungen der gleichen Personen über eine bestimmte Zeitspanne analysiert werden. Dies führt dazu, dass das Verhalten von Personen oder ihr Erleben nicht nur als stabile *traits*, sondern auch als zeit- bzw. kontextabhängige *states* erfasst und beschrieben werden können. Diese Veränderungen in unterschiedlichen Situationen bzw. zu unterschiedlichen Zeitpunkten treten ganz natürlich im alltäglichen Leben auf und sind deshalb relevant für Zusammenhänge oder Folgerungen. Ambulantes Assessment ermöglicht somit die Einsicht in z.B. psychologische Prozesse innerhalb von Personen, die die empirische gesundheitspsychologische Forschung bereichern und nicht durch andere Methoden ersetzt werden können.

Drittens unterstützt eine Erhebung in Echtzeit die Genauigkeit der Messungen. So können Erhebungen von Erleben oder Verhalten genau in dem Moment vorgenommen werden, in dem sie tatsächlich auftreten. Auf diese Weise lassen sich Verzerrungen vermeiden, die üblicherweise in Selbstberichten durch die retrospektive Erhebungsweise oder die Einflüsse von Erinnerungskapazitäten auftreten (Schwarz, 2012). Retrospektive Berichte über affektives Befinden und Verhalten sind nicht identisch mit direkt in bestimmten Situationen abgefragten Daten, so dass angenommen werden muss, dass Personen diese retrospektiven Berichte nicht ausreichend valide beantworten können. Zusätzlich ermöglicht Ambulantes Assessment die Anwendung von direkten Erhebungen in Echtzeit, wie zum Beispiel über die Verwendung von Akzelerometern, um das Aktivitätsverhalten von Personen im Alltag zu erfassen. Eine Kombination verschiedener Erhebungsverfahren, wie beispielsweise Selbstberichte und physiologische Messungen, kann ein umfangreiches Bild z.B. über psychologische Prozesse im Alltag von Personen geben (Ebner-Priemer & Trull, 2009).

2.3.2 Herausforderungen

Neben den aufgeführten Vorteilen, die der Einsatz von Ambulantem Assessment bietet, bestehen auch einige Herausforderungen: a) die Compliance der Teilnehmer, b) methodisches Wissen, c) mögliche Reaktivität der Teilnehmer auf die Erhebungen sowie d)

ethische Belange. Erstens muss in Betracht gezogen werden, dass bei wiederholter Befragung über einen längeren Zeitraum, die Motivation der Teilnehmer im Verlauf der Studie nachlassen kann. Um dem zu begegnen, kann ein entsprechendes Belohnungssystem eingeführt werden bzw. muss bei der Datenanalyse mit fehlenden Werten umgegangen werden. Darüber hinaus kann es vorkommen, dass sich Teilnehmer nicht vollständig an die Instruktionen halten und beispielsweise Fragebögen nicht über den Tag verteilt, sondern jeweils en bloc für den gesamten Tag beantworten. Um diese nicht validen Daten zu identifizieren, können die elektronisch abgespeicherten Zeitpunkte der Befragung hilfreich sein. Elektronische Tagebücher sind zudem gegenüber den oftmals üblichen schriftlichen Befragungen vorzuziehen, da sie die Möglichkeit des Erinnerns bzw. der Aufforderung (durch ein akustisches Signal) bieten (Fahrenberg, Myrtek, Pawlik & Perrez, 2007).

Zweitens ist für den Einsatz von Ambulantem Assessment ein bestimmtes methodisches Wissen über psychometrische sowie statistische Analysen unverzichtbar (Shrout & Lane, 2012; Singer & Willett, 2003). So müssen beispielsweise die Messungen reliabel Veränderungen erheben können und Analysen müssen auf verschiedenen Ebenen durchgeführt werden (z.B. within- und between-person).

Drittens können wiederholte Messungen im Alltag von Personen eine gewisse Reaktivität hervorrufen (Barta, Tennen & Litt, 2012). Diese Reaktivität, die durch bestimmte zeitliche Tendenzen bei der Beantwortung der Fragen oder durch eine systematische Abfolge von fehlenden Werten deutlich werden kann, muss bei der Analyse der Daten berücksichtigt werden.

Viertens müssen ethische Belange beim Einsatz von Ambulantem Assessment berücksichtigt werden, die entstehende Belastungen für die Teilnehmer betreffen (z.B. Integrierbarkeit in den natürlichen Alltag) oder die Datenspeicherung (z.B. auf dem jeweiligen Gerät).

Unter Berücksichtigung der Vorteile, die das Ambulante Assessment bietet, scheint es ein äußerst nützliches Erhebungsverfahren zu sein, um Verhalten und Erleben von physiologischen und affektiven Prozessen, die im Alltag stattfinden, zu erheben.

3 FORSCHUNGSFRAGEN

Diese Dissertation verfolgt das übergeordnete Bestreben, das befindensregulative Potential körperlicher bzw. sportlicher Aktivitäten zu untersuchen. Darüber hinaus werden Einflussfaktoren in diesem komplexen Zusammenspiel beleuchtet und situativ analysiert. Die leitenden Forschungsfragen der drei Manuskripte beleuchten diese Zielsetzungen aus unterschiedlichen Perspektiven. In den beiden Studien, die den drei Manuskripten zu Grunde liegen, wurden die erläuterten Vorzüge der Methode des Ambulanten Assessment gewinnbringend genutzt. *Manuskript 1* und *Manuskript 2* basieren auf Daten, die in Studie 1 erhoben wurden. *Manuskript 3* liegen die Daten, die in Studie 2 erfasst wurden, zu Grunde.

Manuskript 1 differenziert zwischen körperlicher Alltagsaktivität und Sportaktivitäten im Alltagssetting, wenn es um Assoziationen mit dem affektiven Befinden geht. Viele bis dato vorliegende Studien, die akute positive Effekte von körperlich-sportlicher Aktivität auf affektives Befinden bestätigen, fanden jedoch unter Laborbedingungen bzw. in strukturierten Sportprogrammen statt. Durch die Kombination aus Selbstbericht über die sportliche Aktivität und die objektive Erhebung der gesamten körperlich-sportlichen Aktivität durch Akzelerometrie kann eine genaue Differenzierung zwischen rein körperlichen Alltagsaktivitäten und Sportaktivitäten, die im Alltag integriert sind gemacht werden. Zudem wird durch die objektive Erfassung der körperlich-sportlichen Aktivität möglichen Verzerrungen durch ungenaue Angaben begegnet, die durch retrospektives oder sozial erwünschtes Ausfüllen von Aktivitätsfragebögen entstehen können. Die vorliegende Studie baut somit auf bestehende Ambulante Assessment-Studien auf, die auf positive Beziehungen zwischen körperlich-sportlicher Aktivität und affektivem Befinden im Alltagskontext hindeuten. Zusätzlich ermöglicht die Erhebungsmethode die Analyse nachgelagerter Effekte am Ende eines Tages. Somit kann dem bis dato bestehenden Defizit der nachgelagerten Effekte von körperlicher Alltagsaktivität bzw. Sportaktivität im alltäglichen Handlungsverlauf begegnet werden. Die Ergebnisse geben wichtiges Hintergrundwissen für Aktivitätsempfehlungen, die auf befindensregulativem Potenzial von körperlicher Aktivität basieren. Zusammengefasst lauten die Fragestellungen des *Manuskript 1* wie folgt:

(1) Inwieweit können bestehende Befunde bezügliche akuter Effekte von sportlicher Aktivität auf affektives Befinden auf Sportaktivitäten übertragen werden, die im Alltag von Personen unter reellen Bedingungen durchgeführt werden?

(2) Können bestehende positive Befunde bezüglich körperlich-sportlicher Aktivität und affektivem Befinden auch dann nachgewiesen werden, wenn es sich um rein körperliche Alltagsaktivität handelt?
(3) In welchem Ausmaß bestehen Assoziationen zwischen sportlicher Aktivität bzw. körperlicher Alltagsaktivität und affektivem Befinden auch noch am Ende eines Tages?

Manuskript 2 geht spezifiziert auf Assoziationen zwischen Sportaktivitäten im Alltagssetting und affektivem Befinden ein. In den letzten Jahren zeigte sich ein verstärktes Forschungsinteresse bezüglich interindividueller Unterschiede in den akuten affektiven Reaktionen auf Sportaktivitäten. Neben interindividuellen Variationen weisen aktuelle Studien zudem substanzielle intraindividuelle Variationen auf. Durch die Möglichkeit des ambulanten Assessments mehrere Messungen innerhalb einer Person durchzuführen und unterschiedliche Merkmale (z.B. EKG, situative Ziele) in Echtzeit zu erheben, können affektive Reaktionen im alltäglichen Handlungsverlauf analysiert werden. Mögliche Einflussfaktoren auf situativ variable Befindensveränderungen lassen sich so identifizieren. Die Ergebnisse geben Auskunft über die Bedeutung der Analyse von situativen Merkmalen bezüglich des befindensregulativen Potenzials sportlicher Aktivitäten. Folgende konkrete Fragestellungen behandelt *Manuskript 2*:

(1) Inwieweit besteht intraindividuelle Variabilität bezüglich situativer Beweggründe für Sportaktivitäten, Charakteristika der Sportaktivität (Intensität, Aktivitätsdosis, wahrgenommene Anstrengung) sowie affektivem Befinden über mehrere Aktivitäten hinweg?
(2) Welche Assoziationen bestehen zwischen situativen Beweggründen für sportliche Aktivitäten sowie affektivem Befinden vor der Sportaktivität und der Ausprägung der Aktivitätscharakteristika (Intensität, Aktivitätsdosis, wahrgenommene Anstrengung)?
(3) Welche Assoziationen bestehen zwischen Charakteristika der Sportaktivität sowie situativen Beweggründen für Sportaktivitäten und affektivem Befinden nach der Aktivität?

Manuskript 3 geht in Studie 2, die ebenfalls unter Alltagsbedingungen stattfand und sich mit Assoziationen zwischen körperlicher Aktivität und affektivem Befinden be-

schäftigt, insbesondere der Frage nach, ob die individuelle Fähigkeit zur Befindensregulation durch Bewegung eine moderierende Rolle zwischen Aktivität und affektivem Befinden einnimmt. Die Ergebnisse ermöglichen die Replikation von Teilergebnissen aus Studie 1 bezüglich eines positiven Zusammenhangs zwischen körperlicher Alltagsaktivität und affektivem Befinden. Jedoch liegt nun der Fokus auf der individuellen Fähigkeit zur Befindensregulation durch Bewegung, die als moderierende personale Variable hinzugezogen wird. Dies ermöglich differenziertere Aussagen für die drei Befindensdimensionen. Die konkrete Fragestellung von *Manuskript 3* lautet:

(1) Inwieweit nimmt die individuelle Fähigkeit zur Befindensregulation durch Bewegung eine moderierende Rolle für die Beziehung zwischen Aktivität und affektivem Befinden ein?

4 ZUSAMMENFASSUNG DER MANUSKRIPTE

4.1 Manuskript 1: Physical Activity and Affective Well-being in Everyday Life

Jeckel, S. & Sudeck, G. (2016). Physical activity and affective well-being in everyday life: Comparing sport activities and daily physical activities regarding acute and sustainable associations. *Zeitschrift für Gesundheitspsychologie – European Journal of Health Psychology, 24* (3), 130-144. DOI: 10.1026/0943-8149/a000163

Ziel: Viele Studien belegen akute positive Effekte von körperlicher Aktivität auf affektives Befinden, allerdings geschah dies häufig in Laborstudien oder strukturierten Sportprogrammen. Die vorliegende Studie baut auf bestehende Ambulante Assessment-Studien auf, die auf positive Beziehungen zwischen körperlicher Aktivität und affektivem Befinden (Valenz, positive Aktivierung) im Alltagskontext hindeuten und explizit zwischen Sportaktivitäten und körperlichen Alltagsaktivitäten differenzieren. Zudem wird die Nachhaltigkeit von Assoziationen analysiert.

Methoden: Über 7 Tage nahmen 21 Männer und 25 Frauen (M_{Alter} = 32) teil. Körperliche Aktivität wurde objektiv durch Akzelerometrie sowie zusätzlich durch ein Aktivitätsprotokoll erfasst. Affektives Befinden wurde mehrfach täglich über ein Smartphone erfragt.

Ergebnisse: Mehrebenenanalysen konnten akute positive Effekte von Sportaktivitäten auf das affektive Befinden (Valenz, Ruhe, positive Aktivierung) auch im Alltagssetting replizieren. Körperliche Alltagsaktivität zeigte akute positive Effekte auf Valenz und positive Aktivierung, nicht auf das Ruhe-Erleben. Am Ende des Tages zeigten sich für Sportaktivitäten und körperliche Alltagsaktivität für Valenz und Ruhe positive Assoziationen.

Schlussfolgerung: Dies bietet weiteres Hintergrundwissen für Aktivitätsempfehlungen, die auf befindungsregulativem Potenzial von körperlicher Aktivität basieren.

4.2 Manuskript 2: Sport Activities in Daily Routine

Jeckel, S. & Sudeck, G. (2017). Sport activities in daily routine: situational associations between individual goals, activity characteristics and affective well-being. *German Journal of Exercise and Sport Research*. DOI: 10.1007/s12662-017-0469-9

Ziel: Aktuelle Studien zeigen neben interindividuellen Unterschieden auch substanzielle intraindividuelle Variationen bezüglich akuter affektiver Reaktionen auf Sportaktivitäten. Eine Annahme ist daher, dass befindensregulatives Potenzial sportlicher Aktivitäten situativ variiert. Die vorliegende Studie analysiert affektive Reaktionen auf Sportaktivitäten im alltäglichen Handlungsverlauf, um mögliche Einflussfaktoren für situativ variable Befindensveränderungen zu identifizieren. Erstens wird gefragt, welche situativen Unterschiede im affektiven Befinden (Valenz, Ruhe, positive Aktivierung), in individuellen Zielen (z.B. Gewichtsregulation, Aktivierung) sowie bei Aktivitätsparametern (z.B. Aktivitätsdosis, wahrgenommene Anstrengung) bestehen. Zweitens wird geprüft, welche Assoziationen diese Merkmale mit der Gestaltung der Aktivitätsparameter aufweisen. Weitergehend werden drittens Zusammenhänge mit dem affektiven Befinden nach Sportaktivitäten ermittelt.

Methoden: An der Ambulanten Assessment-Studie nahmen 46 Freizeitsportler (25 Frauen; $M_{\text{Alter}} = 32$) über sieben Tage teil. Aktivitätsparameter wurden objektiv erfasst (Akzelerometrie, EKG). Affektives Befinden, situative Ziele und wahrgenommene Anstrengung wurden smartphone-basiert erfragt.

Ergebnisse: Die Ergebnisse mehrebenenanalytischer Regressionsmodelle bestätigten die situative Heterogenität des affektiven Befindens (z. B. $ICC_{\text{Valenz}} = 0.48$), der situativen Ziele (z. B. $ICC_{\text{Aktivierung}} = 0.59$) sowie der Aktivitätsparameter (z. B. $ICC_{\text{Aktivitätsdosis}} = 0.21$). Weiter konnte z.B. beobachtet werden, dass stärker ausgeprägten Zielen zur Gewichtsregulation und Aktivierung eine höhere Aktivitätsdosis folgte. Diese höhere Aktivitätsdosis ging mit einer höheren positiven Aktivierung nach Sportaktivitäten einher. Hingegen fiel bei höher wahrgenommener Anstrengung das Ruheempfinden nach Sportaktivitäten geringer aus.

Schlussfolgerung: Die Ergebnisse zeigen, dass affektives Befinden, spezifische Ziele vor der Sportaktivität sowie die Aktivitätsgestaltung intraindividuell variieren. Sie unterstreichen die Bedeutung situativer Merkmale, wenn es um befindensregulatives Potenzial sportlicher Aktivität geht.

4.3 Manuskript 3: Physical-Activity-Related Mood Regulation and the Activity-Affect-Association

Sudeck, G., Jeckel, S., & Schubert, T. (2017, submitted). *The Moderating Role of Individual Differences in Physical-Activity-Related Mood Regulation for the Activity-Affect-Association in Real-Life Situations*.

Ziel: Körperliche Aktivität unter Alltagsbedingungen ist positiv mit affektivem Befinden bei Erwachsenen assoziiert. Dies variiert jedoch, wenn die unterschiedlichen Affekt-Dimensionen betrachtet werden. Während Reviews über die Assoziation zwischen körperlicher Aktivität und affektivem Befinden unter Alltagsbedingungen positive Effekte für affektive Valenz und positive Aktivierung festhalten, sind die Befunde für das Ruheempfinden uneinheitlich. Das Ziel der vorliegenden Studie war es deshalb, unter Alltagsbedingungen die moderierende Rolle der Steuerungskompetenz zur bewegungsbezogenen Befindensregulation für die Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden zu untersuchen.

Methode: Insgesamt nahmen 37 Frauen und 27 Männer an der Studie teil, in der tägliche körperliche Aktivität über Akzelerometer erfasst sowie elektronische Tagebücher über Smartphones eingesetzt wurden, um affektives Befinden wiederholt an jedem Studientag abzufragen. Es wurden Mehrebenenanalysen durchgeführt, um within-person Effekte von körperlich-sportlicher Aktivität auf affektives Befinden zu berechnen, sowie Cross-Level-Interaktionen zwischen körperlicher Aktivität (within-person Level) und der bewegungsbezogenen Befindensregulation (between-person Level).

Ergebnisse: Es zeigen sich signifikante Cross-Level-Interaktionseffekte zwischen körperlich-sportlicher Aktivität und der Kompetenz zur bewegungsbezogenen Befindensregulation für die Dimensionen Ruhe ($p < .01$) und Valenz ($p = .04$).

Schlussfolgerung: Individuelle Unterschiede in der Steuerungskompetenz für bewegungsbezogene Befindensregulation konnten als Moderator für die Assoziation zwischen körperlicher Aktivität und affektivem Befinden unter Alltagsbedingungen identifiziert werden. Demzufolge sollten bei der Förderung des individuellen Bewegungsverhaltens sowie der Gesundheitsbildung diese individuellen Unterschiede in bewegungsbezogenen Komponenten der Gesundheitskompetenz berücksichtigt werden, um so maßgeschneiderte interventionsbasierte Ansätze entwickeln zu können.

5 ABSCHLIESSENDE DISKUSSION

Positive Effekte von körperlich-sportlicher Aktivität auf das affektive Befinden sind metaanalytisch gut dokumentiert (Netz et al., 2005). Entgegen diesem lange als sehr positiv dargestellten Zusammenhang wurde in individuums-bezogenen Analysen festgestellt, dass sich Personen nach körperlich-sportlichen Aktivitäten teilweise unwohl fühlen (Backhouse et al., 2007). So scheint ein großes befindensregulatives Potential körperlich-sportlicher Aktivitäten zu bestehen, jedoch müssen mögliche Einflussfaktoren sowie die Übertragung in den Alltag der Personen mitberücksichtigt werden.

Angesichts des theoretischen Hintergrundes behandelt die vorliegende Dissertation die bestehenden Lücken im Forschungsstand und zielt darauf ab, ein besseres Verständnis des befindensregulativen Potentials körperlich-sportlicher Aktivitäten im Alltagskontext zu ermöglichen. *Manuskript 1* betrachtet differenziert rein körperliche Alltagsaktivitäten und Sportaktivitäten und unterscheidet zwischen akuten und nachhaltigen Assoziationen mit affektivem Befinden. *Manuskript 2* untersucht bezüglich sportlicher Aktivitäten im Alltagskontext die situative Variabilität spezifischer Ziele, der Aktivitätsgestaltung sowie des affektiven Befindens und Assoziationen zwischen diesen Variablen, um mögliche Einflussfaktoren für befindensregulatives Potential zu identifizieren. *Manuskript 3* beleuchtet das befindensregulative Potential rein körperlicher Alltagsaktivitäten und fokussiert dabei besonders die individuelle Kompetenz der bewegungsbezogenen Befindensregulation als moderierenden personalen Faktor.

In diesem Kapitel folgt eine abschließende Diskussion der Ergebnisse der vorliegenden Dissertation. In Abschnitt 5.1 werden die Hauptergebnisse der drei Manuskripte zusammengefasst und diskutiert. Abschnitt 5.2 zeigt die Stärken und Limitationen dieser Dissertation auf. In Abschnitt 5.3. werden praktische Implikationen angedacht. Die Diskussion endet im Abschnitt 5.4 mit allgemeinen Schlussfolgerungen und möglichen Perspektiven für zukünftige Forschungsvorhaben.

5.1 Zusammenfassung und Diskussion der Hauptergebnisse

Die vorliegende Dissertation hatte zum Ziel, durch eine differenzierte Aktivitätsbetrachtung sowie die Identifikation möglicher Einflussfaktoren das befindensregulative Potential von körperlich-sportlichen Aktivitäten im Alltag zu untersuchen. Folgende *Hauptergebnisse* lassen sich festhalten: (a) sowohl körperliche Alltagsaktivitäten als auch

Sportaktivitäten im Alltag haben das Potential affektives Befinden akut als auch nachgelagert (bis zum Ende des Tages) zu verbessern, wobei für körperliche Alltagsaktivitäten Einschränkungen hinsichtlich der Befindensdimensionen gemacht werden müssen (*Manuskript 1*), (b) eine situative Betrachtung der Sportaktivitäten im Alltagskontext zeigt, dass affektives Befinden, spezifische Ziele vor der Sportaktivität und die Aktivitätsgestaltung intraindividuell variieren und substantiell unterschiedlich mit der Ausprägung des befindensregulativen Potentials sportlicher Aktivitäten assoziiert sind (*Manuskript 2*); und (c) für das befindensregulative Potential bei körperlichen Alltagsaktivitäten spielt eine Interaktion aus bewegungsbezogener Befindensregulationskompetenz und körperlicher Alltagsaktivität eine wichtige Rolle (*Manuskript 3*). Im Folgenden sollen die Forschungsfragen der vorliegenden Dissertation, die in Kapitel 3 dargestellt wurden, ausführlicher beantwortet werden. Die Hauptergebnisse der drei Manuskripte, die dieser Dissertation zu Grunde liegen, werden dazu erläutert und diskutiert. Eine Ergebnisübersicht gibt Tabelle 1.

Tab. 1: Ergebnisübersicht für die Assoziationen zwischen den jeweiligen Prädiktoren aus den Manuskripten und den drei Dimensionen des affektiven Befindens

	VALENZ	**RUHE**	**POSITIVE AKTIVIERUNG**
Manuskript 1			
SA akut	+	+	+
SA abend	+	+	+
KAA akut	+		+
KAA abend	+	+	
Manuskript 2			
SA Merkmale			
%HFmax			
Aktivitätsdosis			+
RPE		-	-
SGs			
SGhealth			
SGbody-weight			
SGactivation		+	
SGstressreg/distract			
Manuskript 3			
KA akut	+		+
KAxPAMR	+	+	

Anmerkungen: SA = Sportaktivität, KAA = körperliche Alltagsaktivität, %HFmax = prozentualer Anteil an der maximalen Herzfrequenz, SG = situative Ziele; RPE = Rating of Perceived Exertion, KA = körperliche Aktivität, PAMR = bewegungsbezogene Befindensregulation

In Studie 1 (*Manuskript 1* und *Manuskript 2*) wurden wie beschrieben durch Ambulantes Assessment über sieben aufeinander folgende Tage Daten von 46 Personen er-

fasst. Körperlich-sportliche Aktivität wurde dabei objektiv über einen Akzelerometer aufgezeichnet, der zusätzlich mit einem EKG-Sensor ausgestattet war, so dass über die gesamte Tragezeit auch ein EKG-Signal erfasst wurde. Smartphone-basiert wurde mehrmals täglich sowie vor und nach jeder Sportaktivität das affektive Befinden erfragt. Vor diesen Sportaktivitäten machten die Personen außerdem Angaben zu ihren situativen Zielen für das Sporttreiben und nach der Sportaktivität zum subjektiven Anstrengungsempfinden während des Sporttreibens. Die Angabe über Sportart und Dauer der Sportaktivität in einem Aktivitätsprotokoll an jedem Abend komplettierte die Erhebungen.

In Studie 2 (*Manuskript* 3) wurde ebenfalls über Ambulantes Assessment die Assoziation zwischen körperlicher Alltagsaktivität und affektivem Befinden analysiert. Die individuelle Fähigkeit zur Befindensregulation durch Bewegung wurde als moderierende Variable in die Analysen aufgenommen, in die insgesamt 780 Befragungen von 64 Personen eingingen. Die körperliche Alltagsaktivität wurde objektiv durch Akzelerometrie erfasst und das affektive Befinden wurde smartphone-basiert jeweils vor und nach der Aktivität erhoben. Die individuelle Fähigkeit zur Befindensregulation durch Bewegung wurde über einen Fragebogen zu Beginn der Studie erfasst.

Akute Effekte körperlicher Alltagsaktivität und Sportaktivität auf affektives Befinden

Eine differenzierte Betrachtung von körperlicher Alltagsaktivität und sportlicher Aktivität (*Manuskript* 1) zeigt, dass zum einen bestehende Befunde über einen grundsätzlich positiven akuten Zusammenhang zwischen Sportaktivitäten und affektivem Befinden optimistisch auf den Alltag von Personen übertragen werden können und zum anderen bestehende Befunde über akute positive Effekte von körperlicher Aktivität auf affektives Befinden bestätigt werden können, wenn es sich um rein körperliche Alltagsaktivität handelt. Die Ergebnisse bezüglich der akuten positiven Effekte von Sportaktivitäten auf affektives Befinden (*Fragestellung 1*) können für alle drei Dimensionen (Valenz, Ruhe, positive Aktivierung) bestätigt werden (siehe Tab. 1). So kann die bislang begrenzte Generalisierbarkeit der bestehenden positiven Effekte von sportlichen Aktivitäten aus Laborstudien (Liao et al., 2015) insofern erweitert werden, dass auch für selbständig geplante und im Alltag durchgeführte Sportaktivitäten ein großer Effekt auf das affektive Befinden der Personen besteht. Angesichts der akuten positiven Effekte von rein körperlicher Alltagsaktivität auf affektives Befinden (*Fragestellung 2*) können bisherige Befunde zu körperlich-sportlicher Aktivität erweitert werden. So bleiben die positiven Ef-

fekte auch dann bestehen, wenn Sportaktivitäten nicht berücksichtigt werden. Die positiven Befunde sind somit tatsächlich auf rein körperliche Alltagsaktivitäten zurückzuführen und nicht etwa auf eine Mischung aus Sportaktivitäten und körperlicher Alltagsaktivität. In Übereinstimmung mit dem Review von Liao et al. (2015) unterstreichen die Ergebnisse, dass körperlich-sportliche Aktivität mit positivem Affekt sowie höherer positiver Aktivierung verbunden ist. In Studie 1 konnten moderate Assoziationen mit den Dimensionen Valenz und positive Aktivierung festgestellt werden, jedoch gab es keine akuten positiven Assoziationen zwischen körperlicher Alltagsaktivität und dem Ruheempfinden.

In *Manuskript 3* (Studie 2), das eine Replikation dieser eigenen Befunde ermöglicht, zeigt sich für die akuten Effekte von körperlicher Aktivität auf die drei Befindensdimensionen ein vergleichbares Bild (siehe Tab. 1). Die Ergebnisse zeigen, dass sich Personen generell aktivierter und energiegeladener (positive Aktivierung) und auch wohler und zufriedener (Valenz) fühlen, wenn eine körperlich aktivere Phase als für sie im Alltag üblich, hinter ihnen liegt. Auch die kleinen bis mittleren Effektstärken sind vergleichbar mit denen aus Studie 1 (*Manuskript 1*). Für das Ruheempfinden konnten –wie bereits in *Manuskript 1* – keine within-person Effekte von körperlicher Aktivität nachgewiesen werden. Der bislang inkonsistente Forschungsstand bezüglich dieser Affekt Dimension (Liao et al., 2015) kann somit nicht bestätigt werden.

Basierend auf diesem Ergebnismuster, können theoretische Implikationen für die bisherigen in der Literatur diskutierten Wirkmechanismen bezüglich der Effekte von körperlich-sportlicher Aktivität auf affektives Befinden (z.B. Lehnert et al., 2012) abgeleitet werden. Für die Effekte auf Valenz und positive Aktivierung kommen unabhängig vom Aktivitätstyp vor allem neurophysiologische Erklärungsansätze in Frage (z.B. thermogenic hypothesis, Koltyn, 1997; endocannabinioid hypothesis, Sparling et al., 2003). Sie begründen die positiven Effekte durch akute physiologische Anpassungen an körperlich-sportliche Aktivität und die damit verbundenen Veränderungen von positivem Affekt oder dem Gefühl von Aktiviertheit. Da die vorliegenden Ergebnisse akute Effekte auf das Ruhe-Erleben nur für Sportaktivitäten feststellen konnten, spielt der Aktivitätstyp hier vermutlich eine größere Rolle. Das bewusste Sporttreiben in der Freizeit, das subjektiv auch als Sportaktivität definiert wird, hat ein größeres Time-Out-Potenzial. Körperliche Alltagsaktivität kann dagegen auch inmitten von stressreichen oder problemorientierten Erledigungen stattfinden. Um einen Time-Out-Effekt auch für körperliche Alltagsaktivitäten entdecken zu können, müssten die Aktivitäten vermutlich weiter ausdifferenziert

betrachtet werden, indem beispielsweise nur Aktivitäten mit spezifischer Erholungsintention (z.B. bei Spaziergängen) betrachtet werden würden.

Moderierende Rolle der Fähigkeit zur bewegungsbezogener Befindensregulation für die Aktivitäts-Affekt-Assoziation

Die Befunde für die Dimension Ruhe stellten einen Ausgangspunkt für die wesentliche *Fragestellung* in *Manuskript 3* dar, inwiefern die Steuerungskompetenz für bewegungsbezogene Befindensregulation den Effekt von körperlicher Aktivität auf das Ruheempfinden moderiert. Die Items des eingesetzten Fragebogens spiegeln vor allem wider, ob Personen sich selbst als im Stande sehen, negativem Affekt (sich niedergeschlagen fühlen, depressive Stimmungslage) und negativer Aktivierung (Stress, innerer Angespanntheit) durch körperliche Aktivität entgegen zu wirken.

Das Ergebnismuster der durchgeführten Cross-Level-Interaktionen (*Manuskript 3*) bekräftigt eine Bedeutung der individuellen Steuerungskompetenz in Abhängigkeit der einzelnen Affektdimensionen (siehe Tab. 1) Der größte Interaktionseffekt zeigt sich für die Dimension Ruhe. Dabei ist vor allem zu erwähnen, dass sich eine gegenläufige Assoziation bei Menschen mit hoher im Vergleich zu niedriger Steuerungskompetenz für bewegungsbezogene Befindensregulation zeigt: Menschen mit hoher Steuerungskompetenz profitieren von körperlich aktiveren Perioden im Blick auf das Ruheempfinden und die Entspanntheit. Personen mit niedriger Steuerungskompetenz fühlen sich dagegen in inaktiven Phasen am ruhigsten und entspanntesten, wohingegen sie in für sie aktiveren Perioden unruhiger und angespannter sind. Selbst bei einem vergleichsweise geringen Aktivitätsniveau (Bereiche des Gehens), zeigen sich bereits Unterschiede in Höhe mittlerer Effektstärken zwischen Menschen mit hoher und niedriger Steuerungskompetenz. Dieses Ergebnismuster verdeutlicht, dass die in bisherigen Studien ermittelten Effekte körperlicher Aktivität auf das Ruheerleben von unterschiedlichen Faktoren (z.B. der Zusammensetzung der Stichprobe einer Studie) mit beeinflusst werden und daher sehr variabel ausfallen können. Für die Affektdimension Valenz sieht das Ergebnismuster der Cross-Level-Interaktion etwas anders aus. Die grundsätzlich positive Assoziation zwischen körperlicher Aktivität und Valenz wird durch die individuelle Steuerungskompetenz moderiert (Tab. 1), so dass Menschen mit hoher Steuerungskompetenz am stärksten von aktiven Phasen im Alltag profitieren. Für die Dimension der positiven Aktivierung sind keine Interaktionseffekte zu beobachten (Tab. 1). Eine mögliche Erklärung könnte zum Teil auch darin liegen, dass diese Dimension mit dem eingesetzten Erhebungsverfahren für

die Kompetenz zur bewegungsbezogenen Befindensregulation am wenigsten direkt angesprochen wird.

Insgesamt bekräftigt das Befundmuster für die *Fragestellung* (*Manuskript 3*) die Bedeutung individueller Kompetenzen im Hinblick auf positive Effekte von körperlicher Aktivität auf affektives Befinden (vor allem bezüglich akuter Verbesserungen des Ruheempfindens und der Reduktion von negativer Aktivierung sowie akuter Verbesserungen von Valenz).

Intraindividuelle Variabilität erhobener Parameter

Aufbauend auf den positiven akuten Effekten von Sportaktivitäten auf affektives Befinden (*Manuskript 1*) wurden in *Manuskript 2* die in den Alltag integrierten Sportarten genauer analysiert, um mögliche Einflussfaktoren auf das befindensregulative Potenzial zu identifizieren. Zunächst wurde überprüft, inwiefern die situativen Ziele, die Aktivitätscharakteristika (Aktivitätsdosis, %HFmax, RPE) und das affektive Befinden intraindividuelle Variabilität aufweisen (*Fragestellung 1*). Die Ergebnisse zeigen Heterogenität innerhalb der Personen für alle erhobenen Parameter. Diese Ergebnisse bestätigen somit die Befunde von Unick et al. (2015), dass selbst innerhalb einer Person eine Variabilität in den affektiven Reaktionen nach Sportaktivitäten besteht. Bei den situativen Zielen für Sportaktivitäten weist die intraindividuelle Variabilität darauf hin, dass eine Person nicht grundsätzlich gleiche Ziele bezüglich ihres Sporttreibens hat. Es zeigt sich jedoch auch, dass diese Variabilität innerhalb der Personen je nach Ziel unterschiedlich stark ausgeprägt ist. Es scheint plausibel, dass eher extrinsisch motivierte Gesundheitsaspekte wie die Regulation des Körpergewichts weniger situativ innerhalb der einzelnen Personen variieren. Die höchste intraindividuelle Variabilität besteht für das situative Ziel der Ablenkung und Stressregulation. Dies steht im Einklang mit der Hypothese von Allmer (1996), der die Erholungsintention als situationsspezifisch charakterisiert. Unterschiede bestehen zwischen den objektiv analysierten Aktivitätscharakteristika (Aktivitätsdosis und Herzfrequenz), die als sehr situativ variabel bezeichnet werden können, und dem subjektiv erhobenen Parameter der wahrgenommenen Anstrengung, der geringere Werte hat. Bei der Interpretation dieser Ergebnisse sollte berücksichtigt werden, dass die objektiven Parameter mehrfach während der Aktivität erfasst wurden, der subjektive Parameter nur als einzelne post-Messung.

Um die situative Variabilität der Aktivitätscharakteristika besser erklären zu können, wurden in *Fragestellung 2* (*Manuskript 2*) die Assoziationen zwischen den situativen

Zielen vor der Aktivität und den Aktivitätscharakteristika analysiert. Die Ergebnisse bestätigen die Bedeutung kognitiver Faktoren für die Ausprägung der Aktivitätscharakteristika. So ist das situative Ziel der Gewichtsregulation, das auf einer eher introjezierten Motivationslage beruht (Lehnert et al., 2011) mit einer höheren Aktivitätsdosis assoziiert. Dieses subjektive Ziel scheint für die Teilnehmer durch einen höheren Energieverbrauch erreichbar zu sein, was eben diese höher gewählte Aktivitätsdosis hervorruft. Dieses Ergebnis stimmt mit den Befunden von Duncan et al. (2010) überein, die positive Assoziationen zwischen Introjektion und der Intensität von Sportaktivitäten in einer Querschnittserhebung herausfanden. Darüber hinaus ist das situative Ziel der Aktivierung, das als eher intrinsisch beschrieben werden kann (Lehnert et al., 2011), ebenfalls mit höherer Aktivitätsdosis assoziiert. Eine mögliche Erklärung könnte sein, dass die Sportaktivität selbst mehr Anreize bietet und deshalb länger bzw. intensiver ausgeführt wird.

Bei der Interpretation der Ergebnisse ist auch hier zu berücksichtigen, dass der Aktivitätstyp die Aktivitätsdosis insofern beeinflusst, dass Ausdaueraktivitäten besser durch das eingesetzte Verfahren der Akzelerometrie abgebildet werden können als beispielsweise Krafttraining mit Gewichten (z.B. Gabrys et al., 2015).

Akute Effekte spezifischer Ziele und Aktivitätscharakteristika auf affektives Befindens

Ausgehend von den analysierten Befunden über die Variabilität der Parameter und über die Effekte auf die Ausprägungen der Aktivitätscharakteristika, wurde die Frage bezüglich der Assoziationen zwischen situativen Zielen vor Sportaktivitäten bzw. Aktivitätscharakteristika und affektivem Befinden nach der Aktivität analysiert (*Fragestellung 3, Manuskript 2*). Dabei kann für beide Teilfragestellungen zunächst berichtet werden, dass für Valenz keine Assoziationen bestehen (siehe Tab. 1). Dies ist insofern ein interessantes Ergebnis, da die bisherige Forschung zu affektiven Reaktionen, häufig die Dimension Valenz in den Blick nimmt (z.B. Ekkekakis et al., 2011). Inwiefern hier die Verwendung des Mehrdimensionalen Befindlichkeitsfragebogens (MDBF; Wilhelm & Schoebi, 2007) der etwas andere Adjektive-Paare (*wohl-unwohl* und *zufrieden-unzufrieden*) verwendet als in der ansonsten häufig eingesetzte Feeling Scale (*gut-schlecht*; Hardy & Rejeski, 1989) eine Rolle spielt, ist nur schwer abzuschätzen. Auch in anderen Studien, die ebenfalls den MDBF verwendeten, zeigten sich grundsätzlich positive Effekte von Sportaktivitäten auf Valenz (z.B. Sudeck & Conzelmann, 2014; Kanning, 2013).

Bezüglich der situativen Ziele zeigten sich positive Assoziationen zwischen dem situativen Ziel der Aktivierung und dem Ruheempfinden (siehe Tab. 1). Dies bestätigt die

situativ analysierten Ergebnisse von Guérin, Fortier und Sweet (2013), dass intrinsische Motive mit positivem affektivem Befinden nach Sportaktivitäten assoziiert sind. Für die Interpretation dieses Ergebnisses ist zu beachten, dass sowohl intraindividuelle als auch interindividuelle Unterschiede berücksichtigt werden müssen, da das situative Ziel der Aktivierung beispielsweise weniger personenstabil ist als das Ziel der Gewichtsregulation (vgl. auch Abschnitt zur Variabilität der situativen Ziele, S. 31 – *Fragestellung 1, Manuskript 2*).

Die Analyse möglicher Assoziationen zwischen Aktivitätscharakteristika und affektivem Befinden nach Sportaktivitäten zeigt unterschiedliche Ergebnisse für subjektiv und objektiv erhobene Aktivitätsparameter. Für Personen, die die Sportaktivität als subjektiv anstrengend wahrnahmen, folgte ein geringeres Ruheempfinden sowie geringere positive Aktivierung. Diese Ergebnisse sind nicht konsistent mit den Befunden anderer Studien, die positive Assoziationen zwischen wahrgenommener Anstrengung und positivem Affekt feststellten (Guérin et al., 2013). Wenn die Aktivität mit einer höheren Aktivitätsdosis durchgeführt wurde, fühlten sich Personen positiv aktivierter (siehe Tab. 1). Auch dieser Befund steht nicht im Einklang mit den Ergebnissen anderer Studien, die inverse Assoziationen zwischen Aktivitätsdosis und positiver Aktivierung nach Sportaktivitäten berichten (Reed & Ones, 2006).

Eine mögliche Erklärung wäre, dass anstrengende bis sehr intensive Aktivitäten, bei denen negative Assoziationen meist in anderen Studien bestehen, weniger häufig bei Sportaktivitäten, die im Alltag integriert sind, vorkommen. Darüber hinaus könnte ein anderes Phänomen eine mögliche Erklärung für die positiven Assoziationen zwischen der objektiv erhobenen Aktivitätsdosis und der positiven Aktivierung geben, das von Ekkekakis, Parfitt und Petruzzello (2011) beschrieben wird. Demnach entsteht bei selbstgewählten Intensitäten über eine kognitive Bewertung ein Gefühl von Autonomie und Kontrolle, welches sich positiv auf die positive Aktivierung auswirkt. Des Weiteren muss bei der Interpretation der Ergebnisse berücksichtigt werden, dass die Unterschiede zwischen objektiv und subjektiv erhobenen Aktivitätsparametern auch dadurch zustande kommen können, dass Personen sportliche Belastungen subjektiv sehr unterschiedlich bewerten können. Persönliche Dispositionen bezüglich der Toleranz und der Einstellung gegenüber Intensitäten von sportlicher Aktivität, die interindividuell sehr verschieden ausgeprägt sein können, müssen also berücksichtigt werden (Ekkekakis, Hall & Petruzzello, 2005).

Nachhaltige Assoziationen zwischen körperlicher Alltagsaktivität / Sportaktivität und affektivem Befinden

Neben den akuten Effekten körperlicher Alltagsaktivität und Sportaktivität auf das affektive Befinden, besteht darüber hinaus ein Forschungsdesiderat zur Rolle von körperlich-sportlicher Aktivität auf dynamische Aspekte des affektiven Befindens (Lehnert et al., 2012; Reed & Buck, 2009). Mit der Bearbeitung der *Fragestellung 3* (*Manuskript 1*) sollte deshalb das Wissen darüber erweitert werden, wie lange derartige Effekte anhalten können. Die Ergebnisse zeigen für sportliche Aktivitäten, die während des Tages ausgeführt wurden, positive Assoziationen zum Befinden am Ende eines Tages (siehe Tab. 1), die eine moderate Effektstärke aufweisen. Der durchschnittliche Abstand von ca. 6 Stunden zwischen einer Sportaktivität und der letzten Befindensabfrage am Tag geht über die bisher bekannten drei Stunden anhaltender Effekte hinaus (Wichers et al., 2011; Guérin et al., 2013). Für den über den Tag kumulierten zeitlichen Umfang an körperlichen Alltagsaktivitäten mit mindestens moderater Intensität zeigen sich ebenfalls positive Assoziationen mit Valenz und dem Ruhe-Erleben.

Jedoch deutet dieses Ergebnismuster in Verbindung mit den akuten Effekten körperlicher Alltagsaktivität (*Fragestellung 1, Manuskript 1)* unterschiedliche Wirkprozesse für die beiden Affektdimensionen an. Während die Ergebnisse für die Valenz (akut und nachhaltig positiv) eher von einem anhaltenden Effekt bis zum Abend sprechen, scheinen für das Ruhe-Erleben (akut nicht signifikant aber negativ, nachhaltig positiv) vielmehr kognitive Verarbeitungsprozesse am Ende des Tages bedeutsam. Es scheint plausibel, dass Personen am Ende eines – z.B. durch Termine und Erledigungen bedingt – körperlich aktiven und/oder stressreichen Tages mit einem Gefühl der Entspannung und Ruhe auf das Erledigte zurückblicken bzw. mit Erleichterung auf den gemeisterten Tag schauen. Bezüglich der diskutierten Wirkmechanismen für die Assoziation zwischen körperlich-sportlicher Aktivität und affektivem Befinden (z. B. Lehnert et al., 2012) wären demnach eher psychologische Erklärungen zu bevorzugen, wobei insbesondere die mastery hypothesis bedeutsam erscheint (Bandura, 1986).

5.2 Stärken und Limitationen

Bei genauer Betrachtung der durchgeführten Studien ergeben sich einige Stärken sowie auch Limitationen der vorliegenden Dissertation. Dieses Kapitel dient dazu, diese genauer in den Blick zu nehmen.

Eine gewichtige Stärke ist sicherlich, dass bei der Datenerhebung in beiden der Dissertation zu Grunde liegenden Ambulanten Assessment Studien hohe methodologische Standards realisiert wurden. Körperlich-sportliche Aktivitäten wurden durch eine Kombination aus objektiver (Akzelerometrie, Herzfrequenzdaten) und subjektiver Erhebungsmethoden (selbstberichtete sportliche Aktivitäten) erfasst. In Verbindung mit einer smartphone-basierten Erfragung des Befindens und der situativen Ziele anhand eines validierten Verfahrens kann die Studie eine hohe Qualität in der Adäquatheit der Erhebungsverfahren vorweisen (Kanning et al., 2013; Liao et al., 2015). Auch zur Erfassung der individuellen Kompetenz für bewegungsbezogene Befindensregulation wurde ein etablierter, validierter Fragebogen eingesetzt (Sudeck & Pfeifer, 2016).

Manuskript 1, 2 und *3* begegnen der Forderung von Liao und Kollegen (2015), die in ihrem Forschungsüberblick kritisch feststellten, dass der Großteil der Studien ausschließlich mit Studierenden und teilweise nur über ein bis zwei Tage realisiert wurde. In der vorliegenden Studie konnte ein erweiterter Personenkreis mit einer größeren Altersspanne und vielfältigerer beruflicher Tätigkeit einbezogen werden. Zudem wurden die Erhebungen über sieben (*Manuskript 1* und *2*) bzw. vier Tage (*Manuskript 3*) verteilt, so dass der Einfluss der Spezifik eines bestimmten Untersuchungstages reduziert werden konnte. Der Mehrwert von *Manuskript 1* liegt insbesondere in der simultanen Analyse von sportlichen Aktivitäten und körperlichen Alltagsaktivitäten. So haben die Aussagen über Assoziationen der beiden Aktivitätstypen mit affektivem Befinden als Grundlage die gleiche Studie, d.h. die gleiche Personengruppe, die jeweils den gleichen Alltag hatte. *Manuskript 2* berücksichtigt durchschnittlich drei Sportaktivitäten pro Person, was der Forderung von Unick und Kollegen (2015) entspricht, mehr als eine Sportaktivität pro Person in die Analysen einzuschließen. So können nicht nur Unterschiede zwischen den Personen, sondern auch innerhalb von Personen, also situationsspezifisch, berücksichtigt werden. *Manuskript 3* begegnet der Forderung von Liao und Kollegen (2015) zuverlässige Informationen über Studienausfälle zu berichten. So beendeten lediglich zwei Personen die Studie frühzeitig und ein Akzelerometer ging verloren. Aufgrund technischer Probleme konnten fünf weitere Personen nicht in die Analysen eingeschlossen werden. Die Compliance mit den elektronischen Tagebüchern lag bei sehr zufriedenstellenden 85%.

Obgleich die vorliegende Dissertation nicht ohne Limitationen ist, legt sie die Grundlage für zukünftige Forschungsvorhaben im Bereich der situativen Analyse von körperlich-sportlicher Aktivität und affektivem Befinden im Alltag. Es können folgende

drei *Hauptlimitationen* identifiziert werden. Erstens muss bezüglich der Teilnehmer festgehalten werden, dass es sich für diese Analysen einerseits um eine relativ kleine Untersuchungsgruppe handelt, die zudem als eher aktiv beschrieben werden kann (*Manuskript 1*, *2* und *3*). Zweitens kann durch die Durchführung der Studien im Alltag nicht ausgeschlossen werden, dass durch die Studienteilnahme der normale Alltagsablauf einer Person beeinflusst wurde bzw. zahlreiche Faktoren bestimmte Abläufe im Alltag beeinflussen, die nicht alle erhoben bzw. berücksichtigt werden konnten (*Manuskript 1*, *2* und *3*). Drittens besteht eine Limitation auf methodischer Ebene darin, dass durch die Erfassung der körperlich-sportlichen Aktivität durch Akzelerometrie bzw. Herzfrequenz-Sensor nicht alle Aktivitätsformen / Sportarten gleich gut abgebildet werden können (*Manuskript 1* und *2*). Im Folgenden werden diese Hauptlimitationen näher spezifiziert.

Die Anzahl der rekrutierten Teilnehmer (46) ist als eine Limitation einzustufen (*Manuskript 1* und 2). Dennoch liegt diese Zahl nahe den empfohlenen 50 Level-2 Einheiten für Schätzungen mit festen Effekten (Nezlek, Schröder-Abé & Schütz, 2006). Diese Anzahl der Level-2 Einheiten ist wichtiger als eine hohe Anzahl an Level-1 Einheiten – die in dieser Studie mit durchschnittlich drei Einheiten sicherlich als niedrig einzustufen ist – wenn es um präzise Schätzungen geht (Niall, Stadler & Laurenceau, 2012). Vor allem wenn es um die Bedeutung individueller Faktoren bzw. die Differenzierung zwischen inter- und intraindividuellen Einflussfaktoren für die Assoziation zwischen körperlich-sportlichen Aktivitäten und affektivem Befinden geht, sollten zukünftige Studien dies mit einer größeren Stichprobe realisieren (Liao et al., 2015). Ebenfalls bezogen auf die Stichprobe ist bei der Interpretation der Ergebnisse (*Manuskript 1*, *2* und *3*) zu berücksichtigen, dass es sich um eine vermeintlich aktive Gruppe handelt. Obgleich die interessierenden Haupteffekte jeweils für potenzielle Störgrößen kontrolliert wurden, könnten die Studienergebnisse in Zusammenhang mit den Eigenschaften der Stichprobe stehen und können nicht auf inaktive Personen übertragen werden. Allerdings war dieser Aspekt gerade für die Analysen in *Manuskript 2* von Vorteil, da dadurch mehr Sportaktivitäten pro Person in die Analysen aufgenommen werden konnten. Dadurch können die Aussagen über situationsspezifische Einflussfaktoren auf die Heterogenität im affektiven Befinden nach Sportaktivitäten präziser ausfallen.

Eine weitere Limitation, die es zu berücksichtigen gilt, ist die mögliche Beeinflussung des Aktivitätsverhaltens der Personen durch die Verwendung des Studien-Equipments (*Manuskript 1*, *2* und *3*). Obwohl alle Teilnehmer instruiert wurden, ihrem

Alltag ganz gewöhnlich nachzugehen, kann eine mögliche Reaktivität nicht ausgeschlossen werden. Darüber hinaus kann ebenfalls nicht ausgeschlossen werden, dass die verstärkte Selbstbeobachtung während der Studienteilnahme Einflüsse auf die Befindensabfragen auslösten. Dies ist vor allem für *Manuskript 1* für die Befindensbefragungen am Ende des Tages kritisch zu reflektieren, da diese zeitlich nahe zur Bearbeitung des Aktivitätsprotokolls manuell auszulösen waren. Es fand sich für das Befinden am Abend jedoch nicht nur eine Beziehung zu den Sportaktivitäten des Tages, sondern ebenfalls für das Ausmaß der moderaten körperlichen Alltagsaktivität, dessen Erfassung für den Probanden nicht explizit ersichtlich war. Es erscheint daher unwahrscheinlich, dass die ermittelten Assoziationen am Ende des Tages allein auf Artefakte durch die Selbstbeobachtung zurückgeführt werden müssen.

Eine ähnliche Limitation betrifft die Selbstbeobachtung und –einschätzung für die Steuerungskompetenz für die bewegungsbezogene Befindensregulation (*Manuskript 3*). In der Gesundheitskompetenzforschung sind derartige Selbsteinschätzungsverfahren weit verbreitet, da sie sehr ökonomisch einsetzbar sind (Altin, Finke, Kautz-Freimuth & Stock, 2014). Dennoch ist ein kritischer Blick auf die subjektiven Erhebungsmethoden für die Steuerungskompetenz zu werfen, da unklar bleibt, in welchem Maße die Kompetenzeinschätzungen tatsächlich einem kompetenten Entscheiden und Verhalten entsprechen. Kombinierte Lösungen zur Kompetenzerfassung mit objektiven und subjektiven Verfahren wären deshalb anzustreben. Dennoch geben die vorliegenden Studienergebnisse eine Basis, die diesen testökonomischen Einsatz des Selbsteinschätzungsverfahrens rechtfertigt, da offensichtlich ausreichend Informationen erfasst werden, um einen Beitrag zur Aufklärung der Assoziation zwischen objektiv erfassten körperlichen Aktivitäten und affektiven Befindenszuständen im Alltag leisten zu können.

Zur Analyse der nachgelagerten Effekte von körperlicher Alltagsaktivität bzw. Sportaktivität (*Manuskript 1*) wurden die Befragungen am Ende des Tages herangezogen. Als nachgelagert wird demnach eine durchschnittliche Zeitspanne von 6 Stunden verstanden. Gewinnbringend wäre sicherlich, wenn zukünftige Analysen einen noch längeren Zeitraum berücksichtigen könnten. Die Befindensabfrage am Morgen des nächsten Tages, als nachhaltiger Wert, könnte beispielsweise weitere Effekte auf das Befinden darstellen. Hierzu sollten individuelle Merkmale wie z.B. die Schlafqualität Berücksichtigung finden. Reid et al. (2010) konnten positive Effekte moderater sportlicher Aktivität

auf die Schlafqualität und depressive Symptomatik bei Älteren zeigen. So könnte beispielsweise die Sportaktivität am Tag die Schlafqualität verbessern, was sich wiederum auf ein verbessertes Befinden am nächsten Tag auswirken würde.

In der zugrundeliegenden Studie wurden vor allem quantitative Aspekte körperlich-sportlicher Aktivität fokussiert. Da sich jedoch nicht alle Sportarten (*Manuskript 2*) gleichermaßen gut durch Akzelerometrie oder Herzfrequenz-Sensor erfassen bzw. abbilden lassen und um die Vielfalt der Sportarten entsprechend zu berücksichtigen, sollten zukünftige Studien den jeweiligen Aktivitätstyp (in Form z.B. der Sportarten) oder auch das Umfeld der Teilnehmer (z.B. soziale Faktoren) mehr in die Analysen einbeziehen.

Insgesamt betrachtet, kann die vorliegende Dissertation einen Beitrag zum aktuellen Forschungsstand bezüglich des befindensregulativen Potentials von körperlicher Alltagsaktivität und sportlicher Aktivität, die im Alltag integriert ist, leisten.

5.3 Praktische Implikationen

Die vorliegende Dissertation erlaubt es wichtige Schlussfolgerungen für das Wissen über die Assoziationen zwischen körperlich-sportlicher Aktivität und affektivem Befinden zu ziehen, die im Folgenden zusammengefasst und erläutert werden.

Zunächst kann die Grundaussage, dass körperlich-sportliche Aktivität positive Effekte auf affektives Befinden hat, im Mittel bestätigt und dahingehend erweitert werden, dass dies akut für sowohl rein sportliche Aktivitäten als auch für körperliche Alltagsaktivität zutreffend ist (*Manuskript 1*). Dabei ist insbesondere zu berücksichtigen, dass für die Analysen in *Manuskript 1* weder Intensität noch Dauer der Sportaktivitäten berücksichtigt wurden. Die individuelle Bedeutungszuschreibung einer Aktivität als Sportaktivität ist demnach nicht zu vernachlässigen, was gerade für eher inaktivere Menschen relevant sein könnte. So muss es nicht immer bedeuten, dass Sport automatisch mit einer hohen Intensität oder Dauer gleichgesetzt werden muss, um tatsächlich als Sport zu gelten und einen akuten Einfluss auf affektives Befinden zu haben. Demgegenüber stehen die Befunde zur rein körperlichen Alltagsaktivität, die zwar geringere Effektstärken, jedoch ebenfalls positive Effekte zeigen (für die Affekt-Dimensionen Valenz und Positive Aktivierung). So kann also festgehalten werden, dass rein körperliche Alltagsaktivität ebenfalls zur Befindensregulation eingesetzt werden könnte. Allerdings sind hierbei individuelle Einflussfaktoren, wie die beispielsweise in *Manuskript 3* analysierte Fähigkeit zur bewegungsbezogenen Befindensregulation zu berücksichtigen.

Manuskript 2 kann das Wissen bezüglich der heterogenen Effekte von affektiven Reaktionen nach Sportaktivitäten erweitern, da die Studie situative Einflussfaktoren im Zusammenspiel mit Sportaktivitäten analysierte, die im Alltag von Personen integriert waren. Drei Hauptimplikationen können hieraus abgeleitet werden. Erstens können die Ergebnisse Hinweise für den Fitness- und Gesundheitssport geben, da situative Ziele, die auch Erwartungen beeinflussen, mit der Ausprägung von Aktivitätscharakteristika assoziiert werden. Wenn eine Person beispielsweise mit dem Ziel ihr Körpergewicht zu regulieren, die Empfehlung für eine niedrige Aktivitätsdosis erhält (im Einklang mit gesundheitsorientierten Bewegungsempfehlungen), dann sollten sich Trainer darüber im Klaren sein, dass dies eventuell im Gegensatz zu den individuellen Zielen und Erwartungen an ein optimal strukturiertes Sportprogramm steht. Zweitens unterstreichen die Studienergebnisse aus *Manuskript 2* die Bedeutung von Empfehlungen für Personen, deren Ziel es ist, ihr Befinden zu regulieren. Das Erholungsverhalten kann grundsätzlich als individuell variierend charakterisiert werden (Allmer, 1996), insbesondere die Erholungsintention der Ablenkung und Stressregulation. Als Konsequenz sollte für motivbasierte Aktivitätsempfehlungen vor allem für Personen, die eine Erholungsintention verfolgen, das situative Ausmaß der Motivation berücksichtigt werden. Drittens betonen die Ergebnisse, dass es von Bedeutung ist, dass Personen sich einerseits ihrer (situativ variierenden) Ziele bewusst sind und andererseits auch ihrer Fähigkeit, Sportaktivitäten entsprechend zu wählen und zu steuern (Sudeck & Pfeifer, 2016). Für Trainer, Teilnehmer sowie Personen, die selbständig sportlich aktiv sind, bedeutet dies, dass es wichtig ist zu wissen, wie mit den oben erwähnten möglichen Unterschieden zwischen der subjektiven Anstrengungswahrnehmung (CR10, Borg, 1998) und den objektiv erfassten Daten bei bestimmten Sportaktivitäten (z.B. Krafttraining) umgegangen werden sollte. Um die immer wieder eingeforderte Steuerungskompetenz zu fördern, empfiehlt das Positionspapier der ACSM (Garber et al., 2011) die feeling scale, die ein Maß der affektiven Valenz darstellt (Hardy & Rejeski, 1989), als sekundäre Methode für Personen einzusetzen, die ihre Intensität selbst regulieren möchten.

Manuskript 3 liefert Implikationen für die Interventionsforschung im Bereich der individuumsbasierten Förderung körperlicher Aktivität und Gesundheitsbildung. So ist zukünftig zu klären, in welchem Maße die Steuerungskompetenz mit Bezug zu psychischer Gesundheit und Wohlbefinden gezielt durch Interventionen angesteuert werden kann. Beispielsweise könnten verstärkt kurze Instrumentarien zur Erfassung des affektiven Befindens bei körperlicher Aktivität eingesetzt werden. Dies ist für die subjektive

Einschätzung der körperlichen Beanspruchung (z.B. RPE; Borg, 1998) bereits weit verbreitet zur Schulung der eigenständigen Belastungssteuerung. Darüber hinaus könnten Strategien zum Einsatz körperlicher Aktivitäten für den Umgang mit Stress im Alltag entwickelt werden. In Verbindung damit wären Interventionsansätze zu prüfen, die das Verständnis für subjektiv relevante Zusammenhänge zwischen körperlicher Aktivität und psychischer Gesundheit und Wohlbefinden fördern können.

5.4 Schlussfolgerung und Perspektive

Körperlich-sportliche Aktivität wird von nationalen als auch internationalen Institutionen (z.B. World Health Organisation, WHO) empfohlen, um neben der physischen Gesundheit auch positiven Einfluss auf das subjektive Wohlbefinden zu nehmen. Die vorliegende Dissertation zeigt, dass sowohl körperliche Alltagsaktivitäten als auch Sportaktivitäten akut als auch noch am Ende eines Tages befindensregulatives Potential haben und kann diese Empfehlungen durch Befunde, die auch im Alltag erbracht wurden, bereichern. Zusätzlich können durch die Ergebnisse bestehende Empfehlungen durch die Differenzierung der Aktivität bekräftigt und erweitert werden und somit die Gesundheitsverhaltensförderung unterstützen.

Die Aussage, dass Sportaktivitäten nur für manche Personen positive affektive Reaktionen hervorrufen, muss dahingehend erweitert werden, dass selbst innerhalb einer Person Variabilität der affektiven Reaktionen besteht. Die analysierten Assoziationen erweisen sich als komplexes Zusammenspiel verschiedener möglicher Einflussfaktoren. So ist eine weitere Erkenntnis, dass auch Ziele sowie die Ausprägung der Aktivitätscharakteristika innerhalb von Personen situativ variieren und bei Aussagen über die Assoziation zwischen sportlicher Aktivität und affektivem Befinden berücksichtigt werden müssen. Für das Ruheerleben und den Abbau von negativer Aktivierung sind noch stärker individuelle Unterschiede zu berücksichtigen, wobei die individuelle Steuerungskompetenz für bewegungsbezogene Befindensregulation als ein moderierender personaler Faktor identifiziert werden konnte.

Ambulantes Assessment erwies sich als adäquates Erhebungsverfahren, um Daten im natürlichen Alltag von Personen zu erfassen. Die Identifikation von Prozessen, die alltägliches affektives Befinden verbessern können, sind sowohl von Bedeutung für die einzelnen Personen selbst als auch für die Gesellschaft. Es wird angesichts der für die Probanden vergleichsweise aufwändigen Studienteilnahme jedoch eine Herausforderung

bleiben, adäquate Strategien zur Rekrutierung von Personengruppen zu generieren, die möglichst verallgemeinerbare Erkenntnisse erlauben.

Die Ergebnisse dieser Dissertation stellen relevantes Hintergrundwissen für zukünftige Forschungsvorhaben dar, um optimierte, wissenschaftlich fundierte, individualisierte Aktivitätsempfehlungen generieren zu können.

6 LITERATURVERZEICHNIS

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7 ANHANG

Es folgen die dieser Dissertation zugrundeliegenden Manuskripte in der publizierten Version (Manuskript 1 und 2) und in der zur Begutachtung eingereichten Version (Manuskript 3) sowie die Eigenständigkeitserklärung. Eine Erklärung über die eigenständigen Anteile der Autorin an den jeweiligen Manuskripten ist der Dissertation als gesondertes Dokument beigelegt.

Im Einband der Arbeit befindet sich eine CD-ROM mit einer digitalen Version der vorliegenden Dissertation inklusive der drei der Dissertation zugrundeliegenden Manuskripte.

Manuskript 1: Physical Activity and Affective Well-Being in Everyday Life

Jeckel, S. & Sudeck, G. (2016). Physical activity and affective well-being in everyday life: Comparing sport activities and daily physical activities regarding acute and sustainable associations. *Zeitschrift für Gesundheitspsychologie – European Journal of Health Psychology, 24* (3), 130-144. DOI: 10.1026/0943-8149/a000163

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Original Article

Physical Activity and Affective Well-Being in Everyday Life

Comparing Sport Activities and Daily Physical Activities Regarding Acute and Sustainable Associations

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Abstract: Multiple studies verified the acute positive effects of physical activity on affective well-being, focusing on sport activities in laboratory settings or supervised programs. This study builds on existing ambulatory assessment studies that indicate positive associations between physical activity and affective well-being (valence, energetic arousal) in everyday life and explicitly differentiates between sport activities and daily physical activities. Moreover, the sustainability of effects is explored. For 7 days, 21 men and 25 women (M_{age} = 32 years) participated in the study. Physical activity was captured objectively by an accelerometer and additionally with an activity diary. Affective well-being was gathered via a smartphone multiple times per day. Multilevel analyses revealed positive effects on affective well-being (valence, calmness, energetic arousal) for sport activities included in the daily routine. Daily physical activity showed acute positive effects for valence and energetic arousal but not for calmness. However, at the day's end, sport activities and daily physical activity were positively associated with valence and calmness. This study gives further background knowledge for activity recommendations based on the affect-regulating potential of physical activity.

Keywords: ambulatory assessment, daily physical activity, sport activity, affective well-being

Körperlich-sportliche Aktivität und Befinden im Alltag. Differenzierte Analyse von Sportaktivitäten und körperlichen Alltagsaktivitäten hinsichtlich akuter und anhaltender Assoziationen

Zusammenfassung: Viele Studien belegen akute positive Effekte von körperlicher Aktivität auf affektives Befinden, allerdings häufig in Laborstudien oder strukturierten Sportprogrammen. Die vorliegende Studie baut auf bestehende ambulante Assessment-Studien auf, die auf positive Beziehungen zwischen körperlicher Aktivität und affektivem Befinden (Valenz, positive Aktivierung) im Alltagskontext hindeuten und differenziert explizit zwischen Sportaktivitäten und körperlichen Alltagsaktivitäten. Zudem wird die Nachhaltigkeit von Assoziationen analysiert. Über 7 Tage nahmen 21 Männer und 25 Frauen (M_{Alter} = 32) teil. Körperliche Aktivität wurde objektiv durch Akzelerometrie sowie zusätzlich durch ein Aktivitätsprotokoll erfasst. Affektives Befinden wurde mehrfach täglich über ein Smartphone erfragt. Mehrebenenanalysen konnten akute positive Effekte von Sportaktivitäten auf das affektive Befinden (Valenz, Ruhe, positive Aktivierung) auch im Alltagssetting replizieren. Körperliche Alltagsaktivität zeigte akute positive Effekte auf Valenz und positive Aktivierung, nicht auf das Ruhe-Erleben. Am Ende des Tages zeigten sich für Sportaktivitäten und körperliche Alltagsaktivität für Valenz und Ruhe positive Assoziationen. Dies bietet weiteres Hintergrundwissen für Aktivitätsempfehlungen die auf befindungsregulativem Potenzial von körperlicher Aktivität basieren.

Schlüsselwörter: Ambulantes Assessment, körperliche Alltagsaktivität, Sportaktivität, affektives Befinden

Over recent decades, research has established that physical activity is beneficial for health and well-being. The World Health Organization (WHO, 2010) recommends at least 150 min per week of physical activities with at least moderate intensities to gain beneficial effects regarding one's physical and psychological health. Different reviews show that physical activity and affective well-being are positively associated (Arent, Landers, & Etnier, 2000; Netz et al., 2005; Reed & Buck, 2009; Reed & Ones, 2006). Moreover, physical activity can contribute to a reduction of negative affect (Rethorst, Wipfli, & Landers, 2009). Current studies are focused on a diverse spectrum of physical activity that can be performed in different activity types and domains (Strath et al., 2013). To get a distinct understanding of the associations between physical activity and affective well-being, a precise determination of the physical activity in question is required. On that basis, it needs to be analyzed whether the associations are different with respect to the different activity types and domains.

Physical activity is the broader term for a variety of activities. These physical activities have one thing in common: They result in a substantial increase in energy

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expenditure due to skeletal muscle effort (Caspersen, Powell, & Christenson, 1985).

Specific subsets are *sport activity* and *daily physical activity*. *Sport activity* means structured physical activities during leisure time with increased energy expenditures. The term *sport activity* includes more than merely traditional sports, which are often associated with competition and performance, and is neutral relating to underlying behavioral motives (Fuchs, 2003). For this study, a broader range of sport activities is intended, to include activities performed for their own sake (fun, enjoyment) or for personal (performance), social (socializing), or health (physical fitness, well-being) reasons. A specific kind of sport activity is *supervised exercise programs* in the health and recreational sector. Such exercise programs, in which endurance, strength training, and playful activities are combined in supervised sessions, are very widespread in German-speaking countries (Brehm, Sygusch, Schönung, & Hahn, 2005). *Daily physical activities* can be delimited from sport activities. Their increased energy expenditures are realized in different activity domains, namely, in the household (e.g., cleaning), transportation (e.g., taking the bicycle to work), at work (e.g., as a craftsman), or during leisure time (e.g., going for a walk, excluding sport activities).

Numerous studies have analyzed the acute effects of standardized physical loads in laboratory settings (e.g., treadmill or ergometer), which makes it possible to establish the role of intensity and duration of physical activity in changes in affective well-being (e.g., Ekkekakis, Parfitt, & Petruzello, 2011; Reed & Ones, 2006). For example, the meta-analysis of Reed and Ones (2006), which summarizes the results of 158 studies, indicates the highest activity-induced effects on positive-activated affect for low intensities and for durations of up to 35 min.

Other studies on physical activity and affective well-being have been conducted in supervised exercise programs. Various studies were able to report on a relatively strong acute improvement of affective well-being for participants of such exercise programs. Abele and Brehm (1993) reported in their review about an enhancement of positive affect and an increase in calmness as acute effects after subjects' involvement in supervised exercise programs.

Affective responses to behavior as well as the behavior itself vary widely between the laboratory setting and the context of daily routine, thus making it difficult to establish the external validity of laboratory studies (Bussmann, Ebner-Priemer, & Fahrenberg, 2009). Moreover, the ecological validity of studies on participation in supervised exercise programs can be limited. In these programs, conditions are more prescribed to participants than is the case in an individual's daily life, where people have situational preferences that might be codetermined by actual affective well-being (Kanning, Ebner-Priemer, & Schlicht, 2013). Participants themselves do not choose what type of activity (endurance training, fitness class, etc.) they will be doing. Moreover, they cannot fully autonomously decide when these kinds of sport activities are performed during their daily lives. Although there are many positive findings, this research deficit makes it difficult to transfer empirical findings to people's daily lives (Liao, Shonkoff, & Dunton, 2015). During the past few years, more studies have analyzed the association of physical activity and affective well-being in the context of daily routines. In a current review, Liao and colleagues (2015) summarize 12 studies that have a leading question from the field of acute effects of physical activity on affective well-being in daily life. While the sporadic studies that were conducted before 2010 usually used self-reported information on physical activities gathered with electronic or paper–pencil diaries, six out of eight studies since 2010 have used accelerometers to capture physical activity. As a consequence, the extent and intensity of physical activity over the entire day can be included in the analyses. Electronic surveys of affective well-being during the day (e.g., via smartphones) are increasingly used. Accordingly, in reference to capturing the physical activity and affective well-being associated with everyday life, recommended ambulatory assessment strategies are implemented (Kanning et al., 2013).

In the summary of the findings regarding basic affect dimensions, Liao and colleagues (2015) conclude the following:

a) Physical activity is consistently linked to an enhancement of positive affects.
b) Findings are inconsistent for a reduction of negative affects through physical activity.
c) Findings for an increase in energetic arousal following physical activity are relatively consistent.
d) The effects of physical activity on the feeling of calmness can be described as inconclusive.

Besides these partly still inconsistent results concerning the different dimensions of affective well-being, the current state of research leaves some unanswered questions that are important for understanding the relationship between physical activity and affective well-being in a daily routine. First, most studies do not distinguish between different subsets of physical activity. However, sport activities and daily physical activity may be associated differently with affective well-being so that a separate investigation seems important. Currently, accelerometer-based studies cannot satisfactorily capture this information about the different subsets of physical activity,

the type of activity, or the domain (Gabrys et al., 2015). Hence, in studies, combinations of accelerometer data and self-reports, which are seldom used, should be utilized so that daily physical activities (e.g., walking for grocery shopping) can be distinguished from sport activities during leisure time (e.g., Nordic walking). Second, the question of the sustainability of acute effects remains mostly unresolved. Only a few studies cover this important criterion for the potential of regulating affective well-being through physical activity. In a sample of physically active mothers, Guérin, Fortier, and Sweet (2013) were able to ascertain a positive association between the activity and valence as well as energetic arousal 3 hr after a physically active period. Likewise, Wichers et al. (2012) reported 3 hr of sustained positive effects of physically active periods. Although these studies suggest a certain sustainability of the effects of physical activity on affective well-being for some hours, more knowledge is needed regarding the durability of the effects of physical activity within daily routines (Reed & Buck, 2009).

The present study aims toward (a) further distinction among the different domains of physical activity and (b) answers to the question of sustainability. According to the stated research desideratum on the association between physical activity and affective well-being in daily life, this analysis should make it possible to distinguish between daily physical activity and sport activities. The sustainability of acute effects of physical activity on affective well-being will be analyzed by considering the association between affective well-being at the end of the day and both domains of physical activity during the day.

Specifically, on the basis of an ambulatory assessment study with young and middle-aged adults for 7 days, the analyses will elaborate on the following research questions:

Q1. Positive acute effects of sport activities on subsequent affective well-being have usually been determined based on the proposition of a supervised exercise program or an experimentally induced activity in a laboratory setting. Research Question 1 goes further into whether these findings can be transferred onto sport activities that are part of a person's daily routine and are realized during a person's leisure time under natural conditions.

Q2. The findings for acute positive effects of physical activity on valence and energetic arousal are consistent when the physical activity is ascertained by accelerometers. Research Question 2 assesses the unsolved question of whether that effect can still be found for daily physical activity when sport activities are excluded.

Q3. The third research question asks to what extent are sport activities and daily physical activities still related to affective well-being at the end of the day.

For these three research questions and in order to make a contribution toward filling the gap left by inconsistent findings (Q2) or insufficient findings (Q3), we analyze the basic dimensions of affective well-being: valence, calmness, and energetic arousal.

Method

Participants

The sample consisted of 25 women and 21 men ($N = 46$) between 21 and 59 years of age ($M_{age} = 32$ years; $SD_{age} = 10.2$). Among them were 31 employees (67%), nine university students working part-time (20%), and six university students (13%). For the selection of suitable participants, a screening questionnaire was used. It contained the screening regarding the stage model of exercise behavior (the modified and shortened version of the "Stadien Flussdiagramm" by Fuchs, 2001) as well as sociodemographic data (age, gender, employment status). An inclusion criterion was that people were young adults or middle-aged adults (older than 18 but not yet retired) and did sport activities sporadically or regularly (at least once a week) so that the probability was given for at least one sport activity during the week of observation. Individuals were excluded if they were competitive athletes or were enrolled in sports sciences with fixed sport classes. These criteria were chosen because an activity's behavior should not be influenced by a commitment to a competitive team or due to course requirements.

Procedure and Design

Participants were recruited through the individual addresses of the study assistants at the university as well as their private environment. Persons who met the inclusion and exclusion criteria and who were interested in participating were invited to come to the study office. They usually came to the study office on Fridays where they got information in written form about the study goals and procedure. Participation was voluntary and could be cancelled without reasons and without incurring any personal disadvantage. After receiving the information, participants gave their written informed consent. Participants did not receive financial compensation or any other reward. For a further characterization of the sample, information on their sport activity habits and perceived stress was gathered via questionnaire. Subsequently, the

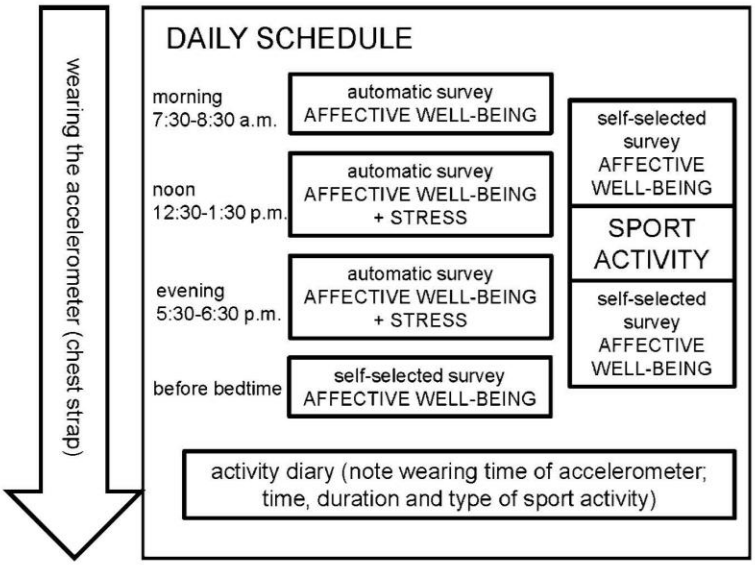

Figure 1. An overview of the participants daily schedule for every study day.

study equipment was handed out and the study assistants explained and demonstrated its usage. It consisted of a smartphone (including power cable), a printed two-sided activity diary, and a chest strap with an accelerometer and a one-channel electrocardiogram (ECG) with a corresponding charging station. Participants were instructed to take off the accelerometer when sleeping, swimming, or taking a shower. More data were assessed objectively (body size and body weight) that were relevant for analyzing the objective physical activity data later. The ambulatory assessment study lasted 7 days, usually beginning on the following Monday morning with the first prompt (7:30–8:30 a.m.). The study ended on the following Sunday evening at 10:30 p.m., so that in total data were collected for 6 days and 15 hr. Participants noted in the activity diary when they put on or took off the chest strap, so that the actual daily wearing time could be identified. Additionally, the wearing times were synchronized with the heart rate signal. Participants were alerted by the smartphone to answer the questions on their affective well-being three times per day and on their perceived stress two times per day. These prompts had specific time frames: 7:30–8:30 a.m., 12:30–1:30 p.m., and 5:30–6:30 p.m. (see Fig. 1). The participants did not know the exact time of the prompt, which could not be influenced either. For weekends, the time frame for the first prompt was postponed by 1 hr (8:30–9:30 a.m.). If participants missed a prompt or were not able to answer the questions at that moment, they were reminded four times, 5 min apart. Participants also had to select a questionnaire on their own, just before they went to bed. This survey contained questions only on their affective well-being. If participants were involved in sport activities on a given day, they had to select additional questionnaires on the smartphone prior to the sport activity and immediately afterward. Questions on their affective well-being were part of these questionnaires so that changes could be registered. Participants were instructed to answer these questions as close in time to the sport activity as possible. Every evening, participants noted in their activity diary if and for how long they had done any sport activity on that day. After the end of the study, participants were invited to the study office again to return the study equipment.

All captured data were stored on the smartphone and the accelerometer and were downloaded to a server by the study assistants. All data were pseudonymized so that data sources of one person were gathered based on a code number. Therefore, it was not possible to draw conclusions about individual participants during the analysis.

Measures

Physical Activity

Physical activity was recorded by a triaxial accelerometer (ekgMove, movisens GmbH, Karlsruhe, Germany) attached to the chest with a strap. The accelerometric data were

assessed over the whole wearing time of a study day[1]. In general, accelerometer data were processed in 1-min intervals. Later, the energy expenditure was calculated in relation to the energy expenditure at rest and converted into metabolic equivalents (METs; for more information, see Anastasopoulou, Tansella, Stumpp, Shammas, & Hey, 2012). The MET estimations were used to classify the physical activity into different categories of intensity. Commonly, the categories are defined as *sedentary* (< 1.5 MET), *light* (1.5–2.99 MET), *moderate* (3–5.99 MET), and *vigorous* (≥ 6 MET; Puyau, Adolph, Vohra, Zakeri & Butte, 2004; Wong, Colley, Conner, Gorber, & Tremblay, 2011).

To analyze the different research questions, different indicators for physical activity have been generated. For the acute effects of daily physical activity (Q2), no MET threshold was set for the relevant time interval of 15 min ahead of a prompt. The average intensity of the activity in this time period (in MET) was used. To allow comparability with other studies using acute time intervals, we followed the common procedure in accordance with these previous studies (e.g., von Haaren, Haertel, Stumpp, Hey, & Ebner-Priemer, 2015). Considering the longer time interval that was needed for the analysis of associations between daily physical activity and affective well-being at the end of a day (Q3), a minimum threshold for activity intensity was chosen. The focus was on the categories *moderate* and *vigorous* according to the recommendations for health-enhancing physical activity of the WHO (2010). Therefore, the 1-min time intervals that people spent within these MET categories were summed up and examined in relation to the time that participants were wearing the accelerometer on that day. Accordingly, this physical activity outcome unit represents the percentage of minutes in the specific activity categories in relation to the wearing time on that day. Time intervals that contained sport activities that also exceeded that MET threshold were excluded (for the exact procedure, see the data analysis).

Sport Activity

Sport activity was assessed via a paper-pencil activity documentation form that was conceptualized in accordance with the questionnaire used to assess physical and sport activities (BSA-F; Fuchs, Klaperski, Gerber, & Seelig, 2015). Participants recorded at the end of every day whether they did any sport activity. They received a definition of *sport activity* at the beginning of the study, which was included on the activity diary, to distinguish it from daily physical activity. Additionally, the diary contained information on the kind of activity, the duration, and the time of the day. On that basis, we ensured that participants only named sport activities that they performed during their leisure time. Participants named endurance activities (54%), strength and fitness training (e.g., back pain prevention program; 20%), combined endurance and strength training (e.g., Tae Bo, Power Plate; 15%), and team sports (11%). Following this procedure, there was no overlap with daily physical activities such as taking the bike to work or gardening. These self-reports were compared with the objectively assessed data of the accelerometer and ECG signal[2]. In doing so, there was no evidence for information that could not be associated with the objective activity data. Sport activity in minutes per day was examined in relation to the time that participants were wearing the accelerometer on that day (Q3). This indicator for the volume of sport activity per day is based on the subjectively defined sport activities that did not have any minimum threshold for intensity. The amount of sport activities performed in the categories of sedentary or light is on average 1.4 min (0.2%) of the daily wearing time.

Affective Well-Being

The current affective state was assessed via a smartphone (HTC Touch Diamond T5353) and the software MyExperience (movisens GmbH, Karlsruhe, Germany). The German short version (Wilhelm & Schoebi, 2007) of the Multidimensional Mood Questionnaire (MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997) was installed on the diaries. The short version contains two binary pairs of adjectives for valence (*unwell–well*; *discontent–content*), calmness (*tense–relaxed; agitated–calm*), and energetic arousal (*tired–awake*; *without energy–full of energy*). The scale was developed and validated especially for assessing affective states within daily life routines. Participants rated their momentary affective state by continuing the sentence, "At this moment, I feel ..." on a 7-point scale (0–6), so that higher scores indicated higher values for valence, calmness, and energetic arousal. Wilhelm and Schoebi (2007) investigated homogeneity at the between-person and the within-person level. The level-specific reliability coefficients for the between-person level were 0.92 for valence and 0.90 for calmness and energetic arousal. The reliability coefficients for the within-person level were 0.70 for valence and calmness and 0.77 for

[1] Additionally, the noted wearing time could be compared with the objectively collected data.

[2] As mentioned in the procedures, the study equipment included a chest strap with an accelerometer and a one-channel ECG. Based on the ECG signal, the heart rate was assessed during the whole wearing time of a study day. For the comparison of the self-reports and the objective activity data, we selected the time period of self-reported sport activities. For this time period, we checked the heart rate data given as mean heart rate of the 1-min intervals as well as diagrammatic representations of the ECG signal.

energetic arousal. Based on this, both reliabilities resulted in satisfactory internal consistencies.

Further Measures

At the beginning of the study, we gathered more information on participants' sport activity habits. Therefore, the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003; German version, Thurn, 2011) was used. It consists of 12 items and was answered on a scale ranging from 1 (*I do not agree*) to 5 (*I totally agree*). According to Gardener, de Brujn, and Lally (2011), a cut-off value (SRHI ≥ 3.3) was used for dividing participants into those with and without habits. Moreover, the perceived stress questionnaire (PSQ-20; Fliege, Rose, Arck, Levenstein, & Klapp, 2001) was applied, consisting of 20 items with answers ranging from 1 (*almost never*) to 4 (*usually*), so that higher mean values indicate higher perceived stress. Acute perceived stress was assessed with the smartphone questionnaire via two items, according to Bertrams, Unger, and Dickhäuser (2011; Study 3). Following the questions on affective state, the acute perceived stress and time pressure on that day were assessed ("Please give an estimation of your overall stress today" and "... of your time pressure today"). Both items were answered on a 7-point scale ranging from 1 (*very low*) to 7 (*very high*). Higher mean values indicated higher acute perceived stress.

Data Analyses

Indications in the literature for a minimum wearing time in order to get valid accelerometer data were between 6 and 12 hr (Herrmann, Barreira, Kang, & Ainsworth, 2010). The inclusion criterion for 1 day was set as at least 9 hr of wearing the accelerometer (Ø 13.6 hr wearing time, per person, per day).[3] Moreover, all data from the smartphone questionnaires were excluded from the analyses if participants answered the prompts but did not wear the accelerometer on the chest strap. The analyses for the three research questions were based on multilevel modeling procedures using the statistical program HLM 7.0 (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011), which makes it possible to consider the hierarchical structure of the data. The multiple measures of affective well-being, sport activities, daily physical activities and perceived stress define the lower level of the hierarchy (Level 1). These components were nested in the subjects who define the higher level of the hierarchy (Level 2). A total of 46 participants did 139 sport activities. We used these date to elaborate on the first research question. Data were collected from 46 participants on 7 days to answer Research Questions 2 and 3. Using HLM makes it possible to have different numbers of measurements per person as well as to deal with missing values (Hoffman & Rovine, 2007). We used restricted maximum likelihood estimations for the multilevel analyses. The α-level of the tests was set to $p < .05$.

For analyzing the acute effects of sport activities (SA) on the three basic affect dimensions – valence, calmness, and energetic arousal (Q1) – separate models were used. Therefore, sport activities as an event were dummy-coded (before sport = 0, after sport = 1). These dummy-coded recording times were associated with the specific score of the dependent variables (valence, calmness, energetic arousal) so that the unstandardized regression coefficient represents the mean difference between the data before and after the sport activity. It can be tested for statistical significance considering the hierarchical data structure ($\alpha_{krit} = .05$; Heck, Thomas, & Tabata, 2013).

To analyze the acute effects of daily physical activity (DPA; Q2), the daily questionnaires were used at noon and in the evenings. To determine the physical activity prior to these questionnaires, the average intensity (in MET) of the activity was used 15 min before the prompts, which were assessed via the accelerometer. This time frame of 15 min and the methodological procedure were set according to previous studies (e.g., Schwerdtfeger, Eberhardt, & Chmitorz, 2008; von Haaren et al., 2015). If the participants did any sport activity during the 15 min prior to the prompts, these data were excluded. Therefore, the given information from the activity diary was checked in order to guarantee the intended differentiation of the different subsets of physical activity. Multilevel modeling was again done separately for each of the basic affect dimensions.

For analyzing the effects of SA and DPA at the end of the day (Q3), the last assessment of affective well-being was used as a dependent variable. If the participants forgot to fill out the questionnaire before going to bed, we were able to use the questionnaire in the evening with the last observation carried forward method, (LOCF; e.g., Hamer & Simpson, 2009), but only if there was no sport activity afterward. The daily wearing time of the accelerometer was adjusted according to the time of the last questionnaire of the day. As mentioned, the 1-min time intervals that people spent in the MET categories *moderate* and *vigorous* were summed up and examined in relation to the time that participants were wearing the

[3] In a more recent position paper by Gabrys et al. (2015), a daily wearing time of 10 hr is recommended. In this study 9 days (3%) with a wearing time between 9 and 10 hr were included.

accelerometer on that day. Again, separate models were analyzed for the dependent variables valence and calmness. We did not take energetic arousal into account at the day's end because a distinct drop of energetic arousal was expected when participants went to bed; therefore, no substantial associations between physical activity during the day and energetic arousal at the end of the day could be analyzed (Table 1; see Gauvin & Spence, 1996).

We differentiated in general between surveys taking place on a weekday or on the weekend (WE). This dummy-coded variable should represent the presumption that, on the weekend (value = 1), study participants have lower stress loads than on weekdays (value = 0). The data on perceived stress for the specific assessment times were used as control variables for the analysis of acute effects of daily physical activity. Accordingly, the questions related either to acute perceived stress (APS) at noon or in the evenings. For analyzing the relations to affective well-being at the end of the day, these surveys were used as a total score for perceived stress during the day, that is, daily perceived stress (DPS). Furthermore, for the acute effects of SA and DPA, we controlled for the time of day. As there were no differences between the results when time-linear and time-square effects were included in the models, the following analyses used only time-square (TIMESQ) as a control variable.

First, for each subscale (valence, calmness, energetic arousal) an unconditional model without any predictor variables was tested to separate the variance into within- and between-subject sources. An estimate of the intra-class coefficients (ICCs) was used for this. In the second step, the distinct Level-1 predictor variables (e.g., WE, SA/DPA, APS/DPS, TIMESQ) were entered into each model of the affect subscale. Additionally, we analyzed whether valence, calmness, and energetic arousal (intercept) or SA/DPA (slope) significantly varied as a function of the Level-2 predictor, the average level of each affective subscale (MEAN_AFF). These average levels of each affective subscale (valence, calmness, energetic arousal) were calculated for each person by using the surveys on affective well-being (morning, noon, evening, before going to bed) throughout the week. The equations for the hierarchical equations are as follows:

$$\text{Level 1: } Y_{ij} = \beta_{0j} + \beta_{1j}{}^{*}(\text{WE}_{ij}) + \beta_{2j}{}^{*}(\text{SA/DPA}_{ij}) + \beta_{3j}{}^{*}(\text{APS/DPS}_{ij}) + \beta_{4j}{}^{*}(\text{TIMESQ}_{ij}) + r_{ij} \quad (1)$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}{}^{*}(\text{MEAN\_AFF}_{j}) + u_{0j} \quad (2)$$

$$\text{Level 2: } \beta_{1j} = \gamma_{10} \quad (3)$$

$$\text{Level 2: } \beta_{2j} = \gamma_{20} + \gamma_{21}{}^{*}(\text{MEAN\_AFF}_{j}) \quad (4)$$

$$\text{Level 2: } \beta_{3j} = \gamma_{30} \quad (5)$$

$$\text{Level 2: } \beta_{4j} = \gamma_{40} \quad (6)$$

Level 1 represents within-subject effects. In Equation 1 the subject's response for one of the three subscales (Y_{ij}) is represented. The dependent variable Y_{ij} is defined as the average intercept of a basic affect dimension across all subjects (β_{0j}) and the four Level-1 predictors weekend (β_{1j}*WE), sport activity or daily physical activity (β_{2j}*SA/DPA), perceived stress (β_{3j}*APS/DPS), and time-squared (β_{4j}*TIMESQ). The activity variables SA and DPA, the stress variables APS and DPS, and the TIMESQ variable were centered on the person mean (group-mean centering in HLM; Snijders & Bosker, 2011). In doing so, we disaggregate the between- and the within-subject effect. The random error value for the Level-1 model is given by r_{ij}.

Level 2 represents between-person effects. Equations (2–6) include the fixed effects (γ) as the average intercepts and slopes of all participants, the average level of the affective subscale (MEAN_AFF; Equations 2 and 4) and the random effect (u_{0j}; Equation 2). The Level-2 predictor MEAN_AFF for each subscale was centered on the grand mean. All models are calculated as random-intercept-only models with a fixed slope at Level 2. The number of observations for each person suggests using an economical modeling so that random slopes are shelved owing to the data structure.

Considering the hierarchical structure of the model, an adaptation of degrees of freedom was made for the effect size estimation (Snijders & Bosker, 2011). The $N_{\text{effective}}$ of the models was calculated with Equation 7:

$$N_{\text{effective}} = Nn / [1 + (n - 1) * \rho_I] \quad (7)$$

Nn indicates the number of measurement points, *n* represents the average number of measurement points per person. Moreover, ρ_I is the ICC of the dependent variable (the basic affect dimension). The effect size *r* was calculated by using the *t*-values of the regression models and the corresponding adapted effective degrees of freedom. For interpretation, the effect size *r* was transformed into effect size *d* and conventionally classified according to Cohen (1988).

Results

Preliminary Analyses

For the analyses of the acute effects of sport activity on affective well-being (Q1), we were able to take 139 sport

Table 1. Descriptive parameters for perceived stress at noon (n = 255) and in the evening (n = 231) and for valence, calmness, energetic arousal in the different surveys before (n = 139) and after (n = 139) sport activity (Q1), during the day at noon (n = 258), in the evening (n = 232; Q2), and at the last prompt of the day (n = 275; Q3) for k = 46 participants

	M (*SD*) before sport	*M* (*SD*) after sport	*M* (*SD*) noon	*M* (*SD*) evening	*M* (*SD*) last prompt of the day
Valence	4.08 (1.09)	5.12 (0.78)	4.49 (1.08)	4.46 (1.05)	4.49 (1.02)
Calmness	3.95 (1.20)	4.51 (0.98)	4.11 (1.12)	4.19 (1.14)	4.43 (1.04)
Energetic Arousal	3.79 (1.10)	4.34 (1.00)	4.15 (1.14)	3.91 (1.14)	2.73 (1.26)
Perceived Stress	–	–	3.07 (1.36)	3.08 (1.28)	–

Table 2. ICCs for valence, calmness, and energetic arousal related to the different research questions (Q1, Q2, Q3)

	SA acute (Q1 n = 139)	DPA acute (Q2 n = 490)	SA / DPA at day's end (Q3 n = 275)
Valence	0.26	0.45	0.31
Calmness	0.39	0.40	0.36
Energetic Arousal	0.34	0.29	–

Note: ICC = intraclass coefficient; SA = sport activity; DPA = daily physical activity.

activities of 46 persons into account. On average, participants did sport activities approximately three times per week. The average duration of one sport activity was 68 min (*SD* = 43.9). The average time between pre- and postsport surveys was 84 min.

Regarding the acute effects of daily physical activity, we were able to include 490 measurement points out of a maximum number of 644 into the analyses (Q2: 7 days × 46 persons × 2 prompts at noon and in the evening). This represents 76% of possible measurement points.[4] To analyze the associations at the end of each day, 275 measurement points of a maximum number of 322 were included in the models (Q3: 7 days × 46 persons). This represents 85% of possible measurement points.[5] Participants spent 63 min (*SD* = 76 min) per day with daily physical activity of at least moderate intensity (≥ 3 MET). This represents 8% of the average wearing time of the accelerometer per day. The average volume of sport activity per day was 33 min (*SD* = 44 min, or 4% of the average wearing time). The difference between the end of a sport activity and the last survey of the day was 6 hr on average. The screening regarding the stage model of exercise behavior revealed that most of the 46 participants could be located in the stage of habituation (n = 27 or 60%). Another 17 participants could be assigned to the stage of action implementation (38%), and one person was in the fluctuation stage (2%). Considering the differentiated habit criterion on the basis of the SRHI, the sample could be divided consistently into participants with the habit (n = 21 or 46%) and without the habit (n = 25 or 54%) of doing sport activities. For this study's sample the perceived stress can be rated as low with a mean at M = 2.0 (*SD* = 0.41; min. = 1.25 and max. = 2.95).[6] Beyond that, most participants had normal weight (18 ≥ BMI ≤ 25; n = 40; 87%). One person was underweight (BMI < 18; 2%). Four participants were overweight (25 > BMI ≤ 30; 8%) and one person was obese (BMI > 30; 2%; Pate et al., 1995).

An overview of the descriptive parameters of the three basic affective dimensions can be found in Table 1. The ICCs (see Table 2) for valence, calmness, and energetic arousal show the within-subject differences in the acute effects of sport activity (74%, 61%, and 66%, respectively), the acute effects of daily physical activity (55%, 60%, and 71%, respectively) and the effects at the day's end (69% and 64%, respectively).

[4] The excluded measurement points are subdivided as follows: missing accelerometer data (–11), missing prompts at noon (–51), missing prompts in the evenings (–73), and sport activity before or during the time of the prompt (–19).

[5] The excluded measurement points are subdivided as follows: missing accelerometer data (–13), wearing time of the chest strap less than 9 hr (–24), missing prompt before going to bed (–60), and gain according to the LOCF method (+40).

[6] The sample's standardized value is at 0.35. That is comparable to the mean value of the PSQ-20 in a representative sample of the German general population, with M = 0.33 (Kocalevent et al., 2007). The cut-off values for the PSQ-30 are: low: ≤ 0.45; moderate: > 0.45 ≤ 0.60; and high: > 0.60. The values of the PSQ-30, however, correlate very highly with those of the PSQ-20 (r = .98; p < .001).

Acute Effects of Sport Activity and Daily Physical Activity on Affective Well-Being in Daily Routines

Table 3 shows *within-person effects* of sport activity for valence, calmness, and energetic arousal ($p < .001$), indicating positive associations between sport activities and the subscales of affective well-being. There were high effect sizes for valence at $d = 2.23$, for calmness at $d = 1.16$, and for energetic arousal at $d = 1.03$. The predictor weekend was positively related to valence ($p = .016$) and calmness ($p = .010$) but not to energetic arousal. There were no significant results for time-squared for the affect subscales. There were positive *within-person effects* of daily physical activity for valence ($p = .004$) and energetic arousal ($p = .016$) but not for calmness. Effect sizes were medium for valence at $d = 0.59$, small to medium for energetic arousal at $d = 0.39$. The effect size for calmness was low at $d = 0.15$ according to the nonsignificant effect. The weekend predictor was not significantly related to the affect subscales, whereas the time-square predictor had a negative relation, but only for energetic arousal ($p = .002$). Acute perceived stress (APS) was negatively related to valence ($p < .001$) and calmness ($p < .001$).

We controlled for *between-person effects* of the mean level of affective subscales on the acute effects of sport activities and daily physical activity. As shown in Table 3, the average level of the distinct affective dimension only had negative influences on the within-person effect of sport activities on valence ($p = .005$) and calmness ($p < .001$). The average level of energetic arousal was not significantly related to the effect of sport activities nor was the average level of any affect subscale significantly associated with the effects of daily physical activities.

Associations Between Daily Physical Activity and Sport Activity on Affective Well-Being at Day's End

Table 4 shows the positive *within-person associations* of sport activities on valence ($p = .007$) and calmness ($p = .010$). The effect sizes are medium for valence and calmness at $d = 0.54$ for both affect scales. Associations were found between the weekend predictor and affective well-being for valence ($p = .014$) and calmness ($p < .001$), but not for daily perceived stress (DPS). Daily physical activity was positively associated with valence ($p = .021$) and calmness ($p = .013$). The effect sizes are medium for valence at $d = 0.46$ and for calmness at $d = 0.52$. The weekend predictor was positively associated with valence ($p = .020$) and calmness ($p < .001$), whereas daily perceived stress (DPS) was not significantly associated with any affect subscale.

Again, we controlled for *between-person associations* of the mean level of affective subscales on the associations between sport activities / daily physical activity and affective well-being. As shown in Table 4, for the average level of calmness there was a negative within-person association between sport activities and calmness ($p = .015$) as well as between daily physical activities and calmness ($p = .044$). There were no significant associations between the average level of valence and the association between sport activities or daily physical activities during the day.

Discussion

In our ambulatory assessment study, physical activity was captured by combined methods of collecting objective (accelerometer, ECG) and subjective (self-reports) data. The findings of this study, using a smartphone-based assessment of affective well-being in a validated procedure, can be relied on as high quality according to the adequacy of the assessment (Kanning et al., 2013; Liao et al., 2015). The differentiation in our study between sport activities and daily physical activities can enhance the current state of research in analyzing the association between physical activity and affective well-being close to everyday life.

First, our study results show that for sport activities, existing knowledge about an average positive acute influence on affective well-being (e.g., Reed & Ones, 2006; Sudeck & Conzelmann, 2011) can be transferred optimistically into a person's regular daily routine. This statement can be made for an increase of positive affect, an increase in feelings of calmness, and an increase in positive energetic arousal. People felt better and more satisfied as well as awake and energized, relaxed, and calm after they were involved in sport activities. According to the limited generalizability of knowledge from laboratory studies (Liao et al., 2015), these results suggest that for proactively planned and realized sport activities in daily life, affective well-being can be enormously positively influenced by sport activity. Moreover, our study results show that the effect of a sport activity depends on a person's average level of affective well-being. If participants had higher average levels for valence and calmness, the enhancements for these affect subscales were lower. People experienced a greater acute enhancement of feeling better and more satisfied as well as calm and relaxed after sport activities when their average level of affective well-

Table 3. Acute effects of sport activity (n = 139) and daily physical activity (n = 490) on valence, calmness, and energetic arousal (for k = 46 participants)

Sport activity					**Daily physical activty**				
Valence					**Valence**				
	B	*SE*	*t*	*p*		B	*SE*	*t*	*p*
INTERCEPT	4.035	0.088	46.085	< .001	INTERCEPT	4.442	0.048	92.294	< .001
MEAN_VA	0.907	0.098	9.275	< .001	MEAN_VA	1.035	0.057	18.059	< .001
SA	1.040	0.098	10.617	< .001	DPA	0.143	0.049	2.936	.004
SA*MEAN_VA	-0.388	0.137	-2.819	.005	DPA*MEAN_VA	-0.024	0.071	-0.339	.735
WE	0.262	0.108	2.424	.016	WE	0.032	0.089	0.361	.718
APS	–	–	–		APS	-0.181	0.041	-4.387	< .001
TIMESQ	< 0.001	< 0.001	-0.074	.941	TIMESQ	< 0.001	< 0.001	-0.985	.325
Calmness					**Calmness**				
	B	*SE*	*t*	*p*		B	*SE*	*t*	*p*
INTERCEPT	3.855	0.095	40.771	< .001	INTERCEPT	4.118	0.042	97.592	< .001
MEAN_CA	0.944	0.091	10.393	< .001	MEAN_CA	1.039	0.041	25.186	< .001
SA	0.591	0.116	5.088	< .001	DPA	-0.057	0.074	-0.775	.439
SA*MEAN_CA	-0.290	0.087	-3.335	< .001	DPA*MEAN_CA	-0.048	0.076	-0.631	.528
WE	0.306	0.118	2.596	.010	WE	0.063	0.078	0.800	.424
APS	–	–	–	–	APS	-0.257	0.045	-5.764	< .001
TIMESQ	< 0.001	< 0.001	-0.249	.804	TIMESQ	< 0.001	< 0.001	0.180	.857
Energetic Arousal					**Energetic Arousal**				
	B	*SE*	*t*	*p*		B	*SE*	*t*	*p*
INTERCEPT	3.717	0.109	34.060	< .001	INTERCEPT	4.012	0.053	76.117	< .001
MEAN_EA	0.654	0.153	4.283	< .001	MEAN_EA	0.901	0.070	12.795	< .001
SA	0.578	0.124	4.665	< .001	DPA	0.217	0.089	2.422	.016
SA*MEAN_EA	-0.188	0.157	-1.198	.232	DPA*MEAN_EA	0.017	0.145	0.114	.909
WE	0.198	0.116	1.706	.089	WE	0.123	0.106	1.158	.248
APS	–	–	–	–	APS	-0.069	0.056	-1.223	.222
TIMESQ	< 0.001	< 0.001	0.270	.788	TIMESQ	< 0.001	< 0.001	-3.176	.002

Note: SA = sport activity (represents the comparison of measurement points before the sport activity: dummy-coding = 0, and after the sport activity: dummy-coding = 1); DPA = daily physical activity; WE = weekend; APS = acute perceived stress; TIMESQ = Time-square; Mean_VA / Mean_CA / Mean_EA = mean affective state of each subscale (Valence, Calmness, Energetic Arousal).

being was lower. These results are in line with the findings of the meta-analysis carried out by Reed and Ones (2006). However, our results reveal that the habitual level of affective well-being has some influences on the extent of the acute effects of sport activity on affective well-being and not only situational pre-activity affect.

Second, existing knowledge about the acute effects of physical activity on affective well-being can be made more specific for the field of daily physical activity. Previous accelerometer-based studies left uncertain whether positive effects on affective well-being potentially underlie a mixture of sport activities and daily physical activities. However, the results of Research Question 2 show that daily physical activity is associated with positive effects on affective well-being, even if sport activities are excluded. The more daily physical activities people performed 15 min before each smartphone survey, the better, more satisfied, awake, and energized they felt. In accordance with the literature review by Liao et al. (2015), the results support that physical activity is followed by more positive affects as well as a higher energetic arousal. In the current study we found moderate associations with the affect dimensions of valence and energetic arousal. In contrast to our finding for the acute effects of sport activities, there was no association between a person's average level of affective well-being and the acute effects of daily physical activity on the affective subscales.

Third, by contrast, there was no acute positive association between daily physical activity and feelings of calmness. The currently inconsistent findings in current re-

Table 4. Associations between sport activity and daily physical activity on valence and calmness at day's end (n = 275)

Sport activity					**Daily physical activity**				
Valence					**Valence**				
	B	*SE*	*t*	*p*		B	*SE*	*t*	*p*
INTERCEPT	4.408	0.072	61.365	< .001	INTERCEPT	4.409	0.072	61.208	< .001
MEAN_VA	0.773	0.095	8.133	< .001	MEAN_VA	0.773	0.095	8.138	< .001
SA	0.033	0.012	2.739	.007	DPA	0.016	0.007	2.327	.021
SA*MEAN_VA	-0.010	0.012	-0.867	.387	DPA*MEAN_VA	-0.003	0.009	-0.335	.738
WE	0.280	0.113	2.490	.014	WE	0.273	0.116	2.353	.020
DPS	0.067	0.054	1.225	.222	DPS	0.066	0.055	1.194	.234
Calmness					**Calmness**				
	B	*SE*	*t*	*p*		B	*SE*	*t*	*p*
INTERCEPT	4.343	0.064	67.676	< .001	INTERCEPT	4.346	0.064	67.799	< .001
MEAN_CA	0.849	0.054	15.806	< .001	MEAN_CA	0.849	0.054	15.831	< .001
SA	0.027	0.010	2.599	.010	DPA	0.014	0.005	2.519	.013
SA*MEAN_CA	-0.018	0.007	-2.453	.015	DPA*MEAN_CA	-0.011	0.005	-2.026	.044
WE	0.357	0.100	3.568	< .001	WE	0.344	0.101	3.425	< .001
DPS	0.091	0.050	1.827	.069	DPS	0.094	0.050	1.881	.061

Note: SA = sport activity; DPA = daily physical activity; DPS = daily perceived stress; WE = weekend; Mean_VA / Mean_CA = mean affective state of each subscale, $*p < .05$; $**p < .001$.

search for this affect dimension (Liao et al., 2015) is thereby diverted to a nonexistent association. When we controlled for acute perceived stress, there was a negative effect of acute perceived stress on calmness. A possible explanation for this result pattern may be that acute perceived stress has a substantial association with feeling restless and tense, which can be taken as a degree of the emotional stress reactivity (Klaperski, von Dawans, Heinrichs, & Fuchs, 2013). While reduced emotional stress reactivity could be shown for habitual aerobic activities (von Haaren et al., 2015), there seems to be no generally calming or relaxing effect of acute physical activity.

Based on the depicted results pattern for Research Questions 1 and 2, theoretical implications can be deduced regarding the exploratory approaches of the effects of physical activity on affective well-being discussed in the literature (e.g., Lehnert, Sudeck, & Conzelmann, 2012). The differing states of research are important concerning the various affect dimensions and how they relate to activity domains. In this study, an acute positive effect on valence and energetic arousal could be shown for sport activities as well as daily physical activities. Regardless of the activity domain, neurophysiologic explanatory approaches, in particular, establish an association between the acute physiologic adaptions of physical activity and changes of positive affect or energetic arousal (e.g., thermogenic hypothesis of Koltyn, 1997, and the endocannabinoid hypothesis of Sparling, Giuffrida, Piomelli, Rosskopf, & Dietrich, 2003). In comparison, a reduction of negative arousal with an increase of calmness is likely more strongly linked to characteristics of the activity domain. That is because in the current study, acute effects could only be determined for sport activities. Explanatory approaches that address a decrease in negative affects can be linked better to sport activities. Hence, the distraction hypothesis (Bahrke & Morgan, 1980) seems not to be transferred to daily physical activity. Rather, there needs to be the intention of recovery by a distraction from problems and stress perception through sport activities (e.g., Allmer, 1996; Lehnert, Sudeck, & Conzelmann, 2011). The study results confirm that there is a greater time-out potential when a sport activity is performed during leisure time and it is subjectively defined as this. By contrast, daily physical activity can take place within problem-oriented settings. In order to discover a time-out effect for daily physical activities, these activities would have to be more specified, for example, by analyzing only activities with a specific recovery intention (e.g., going for a walk or gardening). On the basis of this study, further explanatory approaches that address a reduction of negative effects would also be linked to sport activities. These would be the two-dimensional activation model (Thayer, 1978) or the transient hypofrontality hypothesis (Dietrich, 2003). However, these explanatory approaches require more intensive activities that were not differentiated explicitly in this study.

By analyzing Research Question 3, the thus-far deficient knowledge about the role of physical activity on the

dynamic aspects of affective well-being could be enhanced (Lehnert et al., 2012; Reed & Buck, 2009). Results show positive associations between affective well-being at the end of the day and daily physical activities as well as sport activities that were performed during the day. At the end of a day, people felt better, more satisfied, as well as calmer and more relaxed the more time they spent doing sport activities as well as daily physical activity during the day.

In relation to the results of Research Questions 1 and 2, we can state, first, that the strong, acute effects of sport activities on valence and calmness go along with moderate, positive associations between the duration of the sport activity during the day and affective well-being at the end of the day. The average interval of about 6 hr between a sport activity and the day's last survey exceeds the previously known 3 hr of sustainable effects. Here, Wichers and her colleagues (2012) assessed general physical activity (by an experienced sampling method – ESM), whereas Guérin and her colleagues (2013) considered self-reported physical exercise. Second, there is an acute positive effect of daily physical activity as well as a positive association between the cumulated extent of daily physical activities with at least moderate intensity and valence. Third, concerning calmness, there was a reverse association compared with acute effects on affective well-being and downstream associations at the end of the day. While there was a nonsignificant negative association between acute daily physical activity and calmness, the cumulated, at least moderate daily physical activity during the day had a positive association with calmness in the evening. This result pattern implies different mechanisms of action, depending on the affect dimensions. While the results for valence suggest a sustainable association until the end of the day, cognitive coping processes at the end of the day seem to be relevant for calmness. One can assume that at the end of a physically active and/or stressful day, people look back on the work done with a feeling of relaxation and relief for the mastered day. Regarding the exploratory approaches that are discussed in the literature for the association between physical activity and affective well-being (e.g., Lehnert et al., 2012), psychological explanations would be favored, with particular importance given to the mastery hypothesis (Bandura, 1986). This suggestion for the importance of cognitive coping processes at the end of the day is confirmed by the likewise inverse direction of the association between acute perceived stress and the current feeling of calmness (a negative association) and the association between the daily perceived stress and the feeling of calmness in the evening (a positive association). Looking at the associations at the day's end, the average affective level of calmness refers negatively to the associations between sport activities as well as between daily physical activity and calmness. The higher peoples' average feeling of calmness, the less they can enhance this feeling at the end of the day by sport activities or daily physical activity. At the day's end, people experienced greater enhancement in feeling calm and relaxed after spending more time with sport activities or daily physical activity when their average level of calmness was lower. To the best of our knowledge, these findings are not documented in the literature thus far regarding sustainable associations between sport activity or daily physical activity and affective well-being at the end of the day.

When classifying the study's results, some strengths as well as limitations need to be considered. As already stated, we realized high methodological standards for the assessment of physical activity and affective well-being as the main constructs (Kanning et al., 2013; Liao et al., 2015). By combining objective and subjective assessments for physical activity, it was possible to check the self-reported sport activities for plausibility by using the accelerometer-based and physiological data. Moreover, Liao and her colleagues critically stated in their literature review that a great number of studies were solely realized with students and some lasted for only 1 or 2 days. In the current study, an extended group of people with a greater range of age and diverse professional careers were included. Furthermore, the assessment was spread over 7 days, so that the impact of the specifics of a certain study day could be reduced. To achieve a reasonable burden for participants, fewer surveys per day were required. Thus, it is remarkable that the essential result pattern for acute associations between physical activity and affective well-being could be replicated in the main. This indicates an independence of the results from the number of assessment days as well as the surveys per day. Owing to the rather effortful participation, it will continue to be a challenge to generate adequate strategies for recruiting groups of persons that allow for the greatest possible generalizable results.

Against this background, one limitation of the current study is the total number of recruited participants. The relevance of individual preconditions for the association between physical activity and affective well-being, in particular, needs to be analyzed using a greater sample size (Liao et al., 2015). Other studies show that the association is less distinct or nonexistent for the elderly (Kanning, Ebner-Priemer, & Schlicht, 2015; Stredova, 2014) and for inactive people (von Haaren et al., 2013). Likewise, interindividual differences can be expected for the impact of sport activities on affective well-being (Backhouse, Ekkekakis, Biddle, Fosket, & Williams, 2007; Sudeck & Conzelmann, 2014). The sample recruited for this study showed a rather active lifestyle, and thus the

aim was to assess sport activities as well as daily physical activities for the same people. The results might be related to the sample's characteristics and, therefore, cannot be transferred to inactive people. Further studies will need to address this issue.

The study's design emphasized that participants should follow their daily routine to allow the consideration of the associations between physical activity and affective well-being close to everyday life. A limitation for the meaningfulness of the study is represented by the possible reactivity of the participants on the study equipment. All participants were instructed to follow their regular daily routine, regardless of their participation in the study. Nevertheless, their activity behavior could have been influenced by the study. Moreover, one cannot rule out that the enhanced self-monitoring during the study might have caused an impact on the affective well-being surveys. Such a self-affirmation with effects on affective well-being needs to be critically reflected in the surveys at the end of the day because they had to be selected close to editing the activity diary. There was an association not only between affective well-being in the evening and sport activities during the day (which was documented in the activity diary) but also for the amount of moderate daily physical activities that were not assessed distinctly. Therefore it seems unlikely that the determined associations at the end of the day are only related to the artifacts of self-monitoring. For the analysis of sustainable associations of daily physical activity or sport activity, we used the surveys at the end of the day. *Sustainable* means there is an average time interval of 6 hr. It would be worthwhile to analyze even longer time intervals in future studies. The morning survey of the following day could, as an example of sustainable value, show further associations with affective well-being. For this purpose, individual parameters such as sleep quality should also be taken into account. Reid and colleagues (2010) were able to find positive effects of moderate sport activity on sleep quality in older people. It is possible that sport activity during the day improves sleep quality, which results in an increase of affective well-being during the following day. However, there are negative associations between sport activity and sleep quality as well. Santos, Tufik, and De Mello (2007) found this in their study for very intensive or overused exercise. Therefore, it is worthwhile to explore the research question of sustainability for several days.

Although there are some limitations, the current study results can extend our knowledge of the association between physical activities in daily life and the ensuing affective well-being. These results can serve as background knowledge for the further development of recommendations for regulating affective well-being by physical activity. Additional value lies in the simultaneous analysis of sport activities and daily physical activities. On the one hand, they seem to display a comparable potential for the positive effect of feeling well and content (the dimension of valence) as well as full of energy and awake (the dimension of energetic arousal). On the other hand, specific effects need to be taken into account, because a reduction in tense and restless feelings cannot generally be reported after physical activities. Study results indicate that these effects are more likely if sport activities during leisure time have a separate position within the daily routine and sometimes have the explicit intention of recovery (Allmer, 1996).

Further studies should focus on analyzing the specific characteristics of the differing activity domains and their regulative potential for affective well-being. In doing so, individual preconditions should be considered, such as individual goals, habitual perceived stress, or a broad range of activity from physical inactivity to habitual engagement in sport activities. The current study was able to show only rudimentarily the dynamic of regulative effects on affective well-being through physical activity. It seems to be promising for further research to assess the interaction of acute, sustainable, and habitual effects by a nuanced analysis of the periods of activity or inactivity during a day or even over longer time intervals (Liao et al., 2015; Reed & Buck, 2009).

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Manuskript 2: Sport Activities in Daily Routine

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Main articles

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Sport activities in daily routine

Situational associations between individual goals, activity characteristics, and affective well-being

Introduction

Various meta-analyses have documented the acute positive effects of sport activities on affective well-being (e. g., Reed & Ones, 2006), and these positive effects have proved to be predictors of future activity (Kwan & Bryan, 2010; Bryan, Hutchison, Seals, & Allen, 2007; Ekkekakis, Hall, & Petruzzello, 2005; Carels, Berger, & Darby, 2006). However, the research has increasingly drawn attention to the fact that some people feel unwell after engaging in sport activities and that there exists a substantial interindividual variability regarding the acute effects of sport activities on affective well-being (e. g., Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007; Bixby, Spalding, & Hatfield, 2001; Ekkekakis, Parfitt, & Petruzzello, 2011; Sudeck & Conzelmann, 2014; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000; Welch, Hully, Ferguson, & Beauchamp, 2007). Therefore, it is important to identify the factors influencing acute changes in affective well-being to gain a clearer understanding of the heterogeneity of affective responses to sport activities (Rose & Parfitt, 2007, 2010). To this end, Sudeck, Schmid, and Conzelmann (2016) have discussed the relevance of within-person differences in affective responses to sport activities. While many studies measure affective responses to sport activities during a single session (e. g., Kwan & Bryan, 2010; Williams, Dunsinger, Jennings, & Marcus, 2012), intraindividual consistency in affective responses over multiple sessions is rarely taken into account. Unick et al. (2015) observed that even for multiple, standardized ergometer sessions and pre/post recording of affective well-being there are substantial within-person differences in the acute effects of sport activities on affective well-being. In particular, not much is known about the factors that determine the within-person situational heterogeneity of affective reactions to sport activities.

The article *The Big Picture of Individual Differences in Physical Activity Behavior Change: A Transdisciplinary Approach* (Bryan et al., 2011) considers the contributions of various influencing factors: a) the characteristics of sport activities (e. g., activity dose), b) physiological reaction to activity (e. g., heart rate or HR), c) subjective experiences (e. g., situational perceived exertion), and d) motivation to exercise (e. g., specific goals). Therefore, when sport activities are part of a daily routine, the manifestation of these factors can be distinguished in different situations. Sport activity in general refers to structured physical activities during leisure time with increased energy expenditures. The term includes more than merely traditional sports, which are often associated with competition and performance, and is neutral relating to underlying behavioral motives (Fuchs, 2001). In this study, a broader range of sport activities is intended, one that includes activities performed for their own sake (fun, enjoyment) or for personal (performance), social (socializing), or health (physical fitness, well-being) reasons (Fuchs, Klaperski, Gerber, & Seelig, 2015). Considering the research deficit, this paper addresses the question of to what extent situational associations in daily routines exist between goals for sport activities, activity characteristics, and affective well-being. The answer to this question can improve understanding of the heterogeneity of affective reactions to sport activities in real-life situations and can therefore be useful for recommendations for the regulation of affective well-being through sport activities and individual behavior change.

Associations between sport activities and affective well-being in real-life situations

Studies capturing affective responses to sport activities not in laboratory settings but in real-life situations are comparatively rare (Liao, Shonkoff, & Dunton, 2015). The studies that do examine real-life situations mostly consider physical activity in general and in terms of basic affect dimensions (Schimmack & Grob, 2000; Wilhelm & Schoebi, 2007) and show that for valence and energetic arousal there are consistent positive effects. Yet, regarding feelings of calmness, the study results are rather inconsistent. When comparing daily physical activity and sport activities undertaken on a daily basis, Jeckel and Sudeck (2016) observed that for sport activities positive effects with high effect sizes on calmness, valence, and energetic arousal. Therefore, sport activities undertaken daily showed rather good potential for positive effects

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on the three basic affect dimensions. Beyond that, not much is known about the specific activity characteristics that codetermine the potential to regulate one's well-being in real-life situations.

Activity dose is considered an important factor. It is a function of the intensity and duration of a sport activity (McArdle, Katch, & Katch, 2001), and conclusions about sport activity dose and affective change based on either intensity or duration alone may be misleading (He, 1998). In their meta-analysis, Reed and Ones (2006) point out that low[1] and moderate activity doses are positively associated with positive-activated affect after sport activities. In contrast, high and very high activity doses result in at least temporary reductions in positive-activated affect and in greater interindividual heterogeneity. However, many of the studies producing these results were conducted in laboratory settings.

Various studies have shown different effects on affective well-being after sport activities based on the chosen intensity. Studies employing dual-mode theory (DMT; Ekkekakis, 2009) have shown somewhat consistently that most people feel well and activated in activities with moderate intensity (55 to < 70% of the maximum heart rate HR_{max}; Norton, Norton, & Sadgrove, 2010). Yet this effect changes as the intensity exceeds a certain threshold. Therefore, individually heterogeneous well-being occurs with vigorous intensities (70 to < 90% HR_{max}), ranging from pleasant conditions to great discomfort (e. g., Ekkekakis & Acevedo, 2006; Ekkekakis et al., 2011; Schlicht & Reicherz, 2012). However, the results of the meta-analysis by Reed and Ones (2006), which summarizes the results of 158 studies, indicate that, in sum, the effects of low intensity activity (<55% of the HR_{max}) were greater than the effects of moderate and high-intensity activities.

[1] The categories for the activity doses are as follows (Reed & Ones, 2006): low ≙ 10–30 min of low intensity to 7–20 min of moderate intensity; moderate ≙ 30–40 min of moderate intensity to 20–30 min of high intensity; high ≙ 60–90 min of moderate intensity to 40–60 min of high intensity; very high ≙ 180–1400 min of moderate to 300 min of high intensity.

Regarding associations between affective well-being and subjective indicators of intensity in terms of perceived exertion, the findings are less distinct. Sudeck et al. (2016) found no within-person associations between perceived exertion (rate of perceived exertion; RPE) and affective well-being during sport activities when looking at individuals engaging in multiple sport activities. However, there are between-person associations. People who feel they generally get overexerted when engaging in sport activity report more negative well-being on average. In contrast, Guérin, Fortier, and Sweet (2013) analyzed the affective well-being of active women before, immediately after, and three hours after moderate to vigorous physical activity and found positive associations between perceived exertion and positive affect when analyzing close to daily routine. Yet, reliable statements are not possible regarding situational associations between perceived exertion and affect. It seems more likely that other individual factors codetermine these situational associations.

The role of individual goals for sport activities for affective well-being

Individual goals may be a relevant personal factor in the heterogeneity of affective responses to sport activities. One main hypothesis of DMT (Ekkekakis, 2009) is that the variability of affective responses to vigorous intensities particularly depends on cognitive factors in terms of individual goals. It is well established that people engage in sport activities for different reasons (e. g., Lehnert, Sudeck, & Conzelmann, 2011). Explicit motives and goals reflect what people want to accomplish with their intended sport activity. Therefore, this refers to the *goal contents* (Austin & Vancouver, 1996) and contains a high cognitive portion (Heckhausen & Heckhausen, 2006). Furthermore, the consideration of Vallerand's (2007) hierarchical model of motivation and the differentiation of the motives into situational, contextual, and global levels calls attention to a situation-specific view of goals. This may lead to situation-specific associations with affective well-being, as a given outcome should correspond to the level of the goal that produced it.

In their study of active women, Guérin et al. (2013) examined in daily routine the influence of situational motivation for moderate to vigorous physical activity on affective well-being after the activity. They found that intrinsic motivation is positively associated with positive affect immediately after the physical activity. In terms of specific goal contents, there have been relatively few findings to date. Referring to the above-mentioned study (Jeckel & Sudeck, 2016) that found increased calmness to be associated with sport activities compared to daily physical activity, the authors assume that a specific recovery intention distracts from problems and therefore promotes a feeling of calmness. This argument is in line with recovery theories (e. g., Allmer, 1996) that point out the importance of individual intentions of recovery actions in order to gain benefits in affective well-being.

Other studies show that intentional factors are also associated with activity characteristics (e. g., intensity). Duncan, Hall, Wilson, and Jenny (2010) assessed cross-sectional data of 1054 participants via self-report measures relating to their sport activities and behavioral regulation in exercise. The results showed that introjected regulation is positively associated with intensity. The study does not analyze situational associations. Referring to the reported study results, it would be conceivable that specific situational goals also codetermine activity characteristics. For instance, we assume that participants with the specific goal of distracting themselves from acute stress or occupational problems undertake sport activities with greater intensity. However, the current state of research does not permit established knowledge for situation-specific associations.

Research questions

One result of the described research is a stronger focus on intraindividual differences (Unick et al., 2015). The acute effects of sport activity on affective well-being can differ within persons for the

Abstract · Zusammenfassung

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Sport activities in daily routine. Situational associations between individual goals, activity characteristics, and affective well-being

Abstract

During the last few years, research interest on interindividual differences in acute affective reactions on sport activities has increased. Moreover, current studies show that besides interindividual differences, substantial intraindividual variations exist. Therefore, we assume that the potential of regulating affective well-being through sport activities varies situationally. This ambulatory assessment study analyzes affective reactions on sport activities in daily routine to identify possible factors for situational variability of changes in affective well-being. First, situational differences in affective well-being (valence, calmness, energetic arousal), goals for sport activities (e.g., regulation of body weight, activation), and activity characteristics (e.g., activity dose, perceived exertion) were analyzed. Second, associations between these parameters and activity characteristics were dissected. Third, associations with affective well-being after sport activities are identified. For 7 days, 25 women and 21 men (M_{age} = 32 years) participated. Activity characteristics were captured objectively (accelerometer, electrocardiogramm). Affective well-being, situational goals, and perceived exertion were gathered via smartphone. Multilevel analyses confirmed situational heterogeneity of affective well-being (e.g., intraclass-coefficient $ICC_{valence}$ = 0.48), situational goals (e.g., $ICC_{activation}$ = 0.59), and activity characteristics (e.g., $ICC_{activity\ dose}$ = 0.21). Furthermore, we observed that higher feelings of calmness and stronger situational goals for body weight and activation are followed by a higher activity dose. This higher activity dose comes along with higher energetic arousal after sport activities, whereas higher perceived exertion is followed by lower feelings of calmness. Study results confirm intraindividual variation of affective well-being, specific goals, and activity characteristics. They emphasize the relevance of situational characteristics for the regulation of affective well-being through sport activities.

Keywords

Ambulatory assessment · Sport activity · Affective well-being · Situational intentions · Physical Exercise

Sportaktivitäten im alltäglichen Handlungsverlauf. Situative Assoziationen zwischen individuellen Zielen, Aktivitätsgestaltung und affektivem Befinden

Zusammenfassung

In den letzten Jahren zeigt sich ein verstärktes Forschungsinteresse an interindividuellen Unterschieden in den akuten affektiven Reaktionen auf Sportaktivitäten. Aktuelle Studien zeigen neben interindividuellen Unterschieden zudem substanzielle intraindividuelle Variationen. Eine Annahme ist daher, dass das befindensregulative Potenzial sportlicher Aktivitäten situativ variiert. Die vorliegende ambulante Assessment-Studie analysiert affektive Reaktionen auf Sportaktivitäten im alltäglichen Handlungsverlauf, um mögliche Einflussfaktoren für situativ variable Befindensveränderungen zu identifizieren. Erstens wird gefragt, welche situativen Unterschiede im affektiven Befinden (Valenz, Ruhe, positive Aktivierung), in individuellen Zielen (z. B. Gewichtsregulation, Aktivierung) sowie bei Aktivitätsparametern (z. B. Aktivitätsdosis, wahrgenommene Anstrengung) bestehen. Zweitens wird geprüft, welche Assoziationen diese Merkmale mit der Gestaltung der Aktivitätsparameter aufweisen. Weitergehend werden drittens Zusammenhänge mit dem affektiven Befinden nach Sportaktivitäten ermittelt. An der Studie nahmen 46 Freizeitsportler (25 Frauen; M_{Alter} = 32) über sieben Tage teil. Aktivitätsparameter wurden objektiv erfasst (Akzelerometrie, Elektrokardiogramm). Affektives Befinden, situative Ziele und wahrgenommene Anstrengung wurden Smartphone-basiert erfragt. Die Ergebnisse mehrebenenanalytischer Regressionsmodelle bestätigten die situative Heterogenität des affektiven Befindens (z. B. Intraclass-Koeffizient ICC_{Valenz} = 0.48), der situativen Ziele (z. B. $ICC_{Aktivierung}$ = 0.59) sowie der Aktivitätsparameter (z. B. $ICC_{Aktivitätsdosis}$ = 0.21). Weiter konnte z. B. beobachtet werden, dass höherem Ruheempfinden und stärker ausgeprägten Zielen zur Gewichtsregulation und Aktivierung eine höhere Aktivitätsdosis folgte. Diese höhere Aktivitätsdosis ging mit einer höheren positiven Aktivierung nach Sportaktivitäten einher. Hingegen fiel bei höherer wahrgenommener Anstrengung das Ruheempfinden nach Sportaktivitäten geringer aus. Die Ergebnisse zeigen, dass affektives Befinden, spezifische Ziele vor der Sportaktivität sowie die Aktivitätsgestaltung intraindividuell variieren. Sie unterstreichen die Bedeutung situativer Merkmale, wenn es um befindensregulatives Potenzial sportlicher Aktivität geht.

Schlüsselwörter

Ambulantes Assessment · Sportliche Aktivität · Affektives Befinden · Situative Intentionen · Aktivitätsdosis

same sport activity in laboratory settings. We assume that variations in daily routine may be even greater, and therefore influencing factors should be identified close to everyday life, in order to be externally valid. To analyze this complex relationship between situational goals, activity characteristics, and affective well-being, the current study includes multiple sport activities per person, based on the recommendation of Unick et al. (2015). Moreover, real-life situations are required to analyze the relevance of individual and situational goals for sport activities and affective well-being in daily sports routines. This can only occur with a study that examines participants' daily life (see the position paper by Kanning, Ebner-Priemer, & Schlicht, 2013). Therefore, a seven-day ambulant assessment study was undertaken to capture situational information from everyday life relating to affective well-being before and after sport activities, situational goals for sport activities, and activity characteristics.

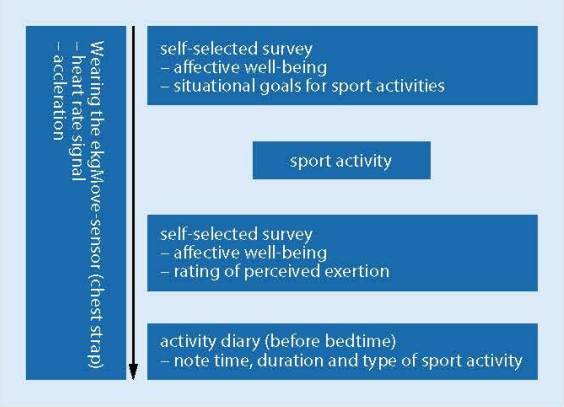

Fig. 1 ◄ Overview of the participants' daily schedule for study days with sport activities

On this methodological basis, the following specific research questions are posed:

Q1. Research Question 1 considers in a basic analysis the intraindividual variance in people's situational goals for sport activity, activity characteristics (intensity, activity dose, perceived exertion), and affective well-being across multiple sessions of sport activity in participants' daily routines.

Q2. Research Question 2 analyzes associations between situational goals for sport activities, pre-activity affective well-being, and the activity characteristics (intensity, activity dose, perceived exertion). The potential of situational goals and their associations with activity characteristics is explored. Therefore, the existing knowledge of a cross-sectional study that shows introjected regulation is associated with greater intensities could be complemented on a situational level. Moreover, pre-activity affective well-being might be related to the manifestation of activity characteristics.

Q3. Research Question 3 examines associations between activity characteristics, situational goals for sport activities, and affective well-being after sport activities. Existing studies, which are mainly laboratory studies, show positive associations for moderate intensity, negative associations for vigorous intensity, positive associations for low and moderate activity dose, and negative associations for high and very high activity dose. Initial studies indicate that for perceived exertion, associations on between-person level are negative but are positive on within-person level and for intrinsic motivation.

The aim of this study is to assess the transferability of the existing knowledge on situational associations in daily routines and, if applicable, to extend the knowledge.

Methods

Participants

The sample consisted of 25 women and 21 men between 21 and 59 years old (M_{age}= 32 years; SD_{age}= 10.2). Among them were 31 employees (67%), 9 university students working part-time (20%), and 6 university students (13%). A screening questionnaire was used to select suitable participants. It contained the screening regarding the stage model of exercise behavior (the modified and shortened version of the "Stadien Flussdiagramm" by Fuchs (2001)) and sociodemographic data (age, gender, employment status). An inclusion criterion was that participants be young adults or middle-aged adults (older than 18 but not yet retired) and engage in sport activities sporadically or regularly (at least once a week). Individuals were excluded if they were competitive athletes or were enrolled in sports sciences with fixed sport classes. These criteria were chosen because activity-related behavior should not be influenced by a commitment to a competitive team or course requirements.

Design and procedure

Participants were recruited through the individual addresses of the study assistants within the university as well as their private environment. People who met the inclusion and exclusion criteria and who were interested in participating were invited to come to the study office. They usually came to the study office on Fridays and there received written information about the study goals and procedure. According to the declaration of Helsinki, participation was voluntary and participants could withdraw for no reason without incurring any personal disadvantage. After receiving the information, participants gave their written informed consent. Participants did not receive financial compensation or any other reward. For further characterization of the sample, information on sport activity habits (self-report habit index, SRHI; Verplanken & Orbell, 2003) was gathered via questionnaire. Subsequently, the study equipment was handed out, and the study assistants explained and demonstrated its usage. The equipment consisted of a smartphone (including power cable), a printed two-sided activity diary, and a chest strap with an accelerometer and a one-channel electrocardiogram (ECG) with a corresponding charging station. Participants were instructed to take off the accelerometer when sleeping, swimming, or taking a shower. More data (body size and body weight) relevant in analyzing the objective physical activity data later were assessed objectively.[2]

The ambulant assessment study lasted seven days, usually beginning on a Monday morning with putting on the chest strap. The study ended the following Sunday evening at 10:30 p.m. so that data was collected for six days and 15 h. If participants were involved in sport activities on a given day, they had to answer questionnaires on the smartphone prior to the sport activity and immediately afterward. Questions on their situational

[2] The study design and procedure is part of a more extensive ambulant assessment study that contains several processes and analyses relating to different research questions (see also Jeckel & Sudeck, 2016).

goals (SGs) for the sport activity, their affective well-being, and their perceived exertion were included in these questionnaires (for detailed information on the questionnaires used, see the section on measures). Participants were instructed to answer these questions as close in time to the sport activity as possible. Every evening, participants noted in their activity diary if and for how long they had engaged in any sport activity that day. An overview of the participants' daily schedule for study days with sport activity can be found in Fig. 1. After the end of the study, participants were invited to the study office to return the study equipment. If any technical problems occurred during the study, participants were able to contact the study assistants and, if necessary, study equipment could be replaced so that participants could continue without any data loss.

All captured data were stored on the smartphone and the combination of ECG and activity sensor data were downloaded to a server by the study assistants. All data were pseudonymized so that data sources of each person were gathered based on a code number. Therefore, it was not possible to draw conclusions about individual participants during the analysis.

Measures

Affective well-being

The current affective state was assessed via smartphone (HTC Touch Diamond T5353) using the software MyExperience (Movisens GmbH, Karlsruhe, Germany). The German short version (Wilhelm & Schoebi, 2007) of the Multidimensional Mood Questionnaire (MDBQ) (Steyer, Schwenkmezger, Notz, & Eid, 1997) was installed on the smartphone. The short version contains two binary pairs of adjectives for valence (VA; *unwell–well*; *discontent–content*), calmness (CA; *tense–relaxed*; *agitated–calm*), and energetic arousal (EA; *tired–awake*; *without energy–full of energy*). The scale was developed and validated especially for assessing affective states in daily life routines. Participants selected either the questionnaire "before sport" or "after sport" and rated their momentary affective state by continuing the sentence "At this moment, I feel …" on a seven-point scale (0–6), so that higher scores indicated higher values for valence, calmness, and energetic arousal. Wilhelm and Schoebi (2007) investigated homogeneity at the between-person and within-person levels. The level-specific reliability coefficients for the between-person level were 0.92 for valence and 0.90 for calmness and energetic arousal. The reliability coefficients for the within-person level were 0.70 for valence and calmness and 0.77 for energetic arousal. Based on this, both reliabilities resulted in satisfactory internal consistencies.

Situational goals

Nine items of the Bernese Motive and Goal Inventory in Leisure and Health Sports (BMZI; Lehnert et al., 2011) were used. It is a reliable and valid instrument that is usually suitable for screening multidimensional motive profiles. We classified the nine items into the original dimensions of the BMZI as follows: health (*… to counteract physical discomfort; … especially because of health reasons*), body weight (*… to regulate weight*), distraction/stress regulation (*… to settle my thoughts; … to distract from other problems; … to release anger and petulance; … to release stress*), and activation (*… especially for enjoyment of body movement; … to replenish energy*). After selecting the "before sport" questionnaire on the smartphone, participants had to rate the answers for the sentence "At this moment, I am doing sports because …" for each of the nine items on a five-point scale, with answers ranging from *1 = not true at all* to *5 = completely true*. The mean value of each dimension was used for the statistical analysis when more than one item represented the dimension. Inter-item correlations revealed satisfactory to good internal consistencies for these dimensions (health: $r = 0.46$; distraction/stress regulation: $r = 0.39–0.71$; activation: $r = 0.33$).

Activity characteristics

Sport activity in general was assessed using a paper and pencil activity documentation form that was conceptualized in reference to the questionnaire to assess physical and sport activities (BSA-F; Fuchs et al., 2015). At the end of every day, participants recorded whether they engaged in any sport activity. They received a definition of sport activity (according to the definition of sport activity used in the BSA-F; Fuchs et al., 2015) at the beginning of the study, which was included on the activity diary, to distinguish it from any other daily physical activity. Additionally, the diary contained information on the kind of activity, duration, and time of day. On that basis, we ensured that participants only named sport activities they undertook during their leisure time. Participants named endurance activities (54%), strength and fitness training (e. g., back pain prevention program; 20%), combined endurance and strength training (e. g., Tae Bo; 15%), and team sports (11%). The self-reports were compared to the objectively assessed data of the accelerometer and the heart rate monitor. In doing so, there was no evidence of information that could not be associated with the objective activity data.

The HR and the energy expenditure were collected by a triaxial accelerometer with an ECG sensor (ekgMove, Movisens GmbH, Karlsruhe, Germany) attached to the chest with a strap. Data was stored in one-minute intervals for the relevant time of the sport activities. For the further analyses, HR and metabolic equivalent (MET) were used as medians of the one-minute intervals of the period of sport activities. This measure was used because it is more resistant to statistical outliers than the mean value. As HR represents an age-dependent variable (e. g., Gellish et al., 2007), absolute values cannot be compared for statements on intensity. For that reason, we initially estimated the HR_{max} for each participant based on a validated formula by Gellish et al. (2007). Subsequently, we translated the absolute HR values into a percentage of a person's HR_{max} (% HR_{max}). The captured energy expenditure was calculated in relation to the energy expenditure at rest and converted into METs (for more information, see Anastasopoulou, Tansella, Stumpp, Shammas, & Hey, 2012). In analyzing the research questions, these activity data represent the physiological response as *intensity* (% HR_{max}) and the objective load as *activity dose* (METh) of the sport activi-

Table 1 Distribution of the sport activities of our study sample into the different categories of exercise and physical activity intensity following Norton et al. (2010)

Intensity category	% HR_{max}		MET (median)		Perceived Exertion	
Light	<55% HR_{max}	6.2%	<3 METs	28.8%	RPE: 1–2	8.2%
Moderate	55 < 70% HR_{max}	53.4%	3 < 6 METs	29.5%	RPE: 3–4	35.1%
Vigorous	70 < 90% HR_{max}	39.7%	6 < 9 METs	23.3%	RPE: 5–6	40.3%
High	≥90% HR_{max}	0.7%	≥9 METs	18.5%	RPE: ≥7	16.4%

% HR_{max} percentage of a person's maximum heart rate, *MET* metabolic equivalent as median, *RPE* rating of perceived exertion

ties. For the latter, we calculated the product of intensity (as median MET value of a specific sport activity) and duration. For example, if a person had the median MET value of 4.6 for 70 min of jogging, the activity dose (in METh) was calculated as follows: (4.6 MET × 70 min) / 60 = 5.4 METh.

Moreover, as a *subjective measure of exertion* we collected data using the Rating Scale of Perceived Exertion (RPE). It is used to subjectively quantify an individual's perception of the physical demands of an activity. Answers were given using the Borg CR10 scale (Borg, 1998), with ratings 0 (not at all), 0.5 (very, very light), 1 (very light), 1.5, 2 (light), 2.5, 3 (moderate), 4, 5 (intense), 6, 7 (very intense), 8, 9, and 10 (extremely strong). Therefore, in the "after sports activity" questionnaire on the smartphone, participants answered the question "How exhausting was the sport activity overall?" The CR10 scales have shown reliability and validity for healthy, clinical, and athletic adult populations (Chen, Fan, & Moe, 2002). For descriptive purposes, the activity characteristics are classified according to Norton and colleagues (2010; see **Table 1**).

Data analyses

The analyses for the three research questions were based on multilevel modeling procedures using the statistical program HLM 7.0 (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011), which makes it possible to consider the hierarchical structure of the data. The multiple measures of affective well-being, SGs, and characteristics of sport activities define the lower level of the hierarchy (level 1). These components were nested within the subjects who define the higher level of the hierarchy (level 2). A total of 46 participants engaged in 133 sport activities. The number of participants in our sample is close to the recommended number of 50 level 2 units for estimations with fixed effects (Nezlek, Schröder-Abé, & Schütz, 2006). This number of level 2 units is more important for making precise and adequate estimations than a higher number of level 1 units—which is certainly low with 3 units on average in our study (Niall, Stadler, & Laurenceau, 2012). According to Raudenbush and Bryk (2002), the values of our intraclass-coefficients (ICCs) (as displayed in **Table 2**) imply a calculation via multilevel analyses that considers the nested data structure and between-person differences. Using HLM makes it possible to have different numbers of measurements per person (Hoffman & Rovine, 2007). We used restricted maximum likelihood estimations for the multilevel analyses. The α level of the tests was set to $p < 0.05$.

To answer research question Q1, an estimate of the intraclass coefficients was used. For activity characteristics (%HR_{max}, METh, RPE), affective well-being after sport activities (VA, CA, EA), and the SGs for sport activities, an unconditional model without any predictor variables was tested to separate the variance into within- and between-subject sources.

To analyze the associations between affective well-being before sport activities (VA_{pre}, CA_{pre}, EA_{pre}) and the activity characteristics (%HR_{max}, METh, RPE) (research question Q2a), separate models were used for each parameter of the sport activities. We analyzed research question Q2b in the same way but replaced affective well-being before sport with the SGs for sport activities in our model.

For research question Q3a, we analyzed the associations of the activity characteristics (%HR_{max}, METh, RPE) and affective well-being after the sport activities (VA_{post}, CA_{post}, EA_{post}). For research question Q3b, SGs before sport activities were used instead of the activity characteristics. For research questions Q3a and Q3b, separate models were used for each subscale of affective well-being.

Additionally, for questions Q3a/b, we analyzed whether VA_{post}, CA_{post}, or EA_{post} varied as a function of the level 2 predictor, the average level of each affective subscale (MEAN_AWB[3]). The following equations for the hierarchical equations of Q3a are meant as an example (the variables can be replaced as described above for the equations of the models for the other research questions):

$$\begin{aligned} \text{Level 1}: Y_{ij} = & \beta_{0j} + \beta_{1j} \\ & * (\%\,\text{HR}_{\text{max}ij}) + \beta_{2j} \\ & * (\text{MET}_{\text{hij}}) + \beta_{3j} \\ & * (\text{RPE}_{ij}) + r_{ij} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{Level 2}: \beta_{0j} = & \gamma_{00} + \gamma_{01} \\ & * (\text{MEANAWB}_j) \\ & + u_{0j} \end{aligned} \quad (2)$$

$$\text{Level 2}: \beta_{1j} = \gamma_{10} \quad (3)$$

$$\text{Level 2}: \beta_{2j} = \gamma_{20} \quad (4)$$

$$Level2: \beta_{3j} = \gamma_{30} \quad (5)$$

Level 1 represents within-subject effects. In Eqs. 1 the subject's response for one of the three basic affect dimensions (VA_{post}, CA_{post}, EA_{post}; Y_{ij}) is represented. The dependent variable Y_{ij} is defined as

[3] We did not control for time of day, as previous analyses (Jeckel & Sudeck, 2016) showed no significance for time of day for acute effects of sport activities on affective well-being. The average levels of the level 2 predictor MEAN_AWB are based on 644 data points for each affective subscale (valence, calmness, energetic arousal). They were calculated for each person using surveys on affective well-being (morning, noon, evening, before going to bed) throughout one week (for detailed information, see Jeckel & Sudeck, 2016).

Table 2 Descriptive parameters of the basic affect dimensions (valence, calmness, energetic arousal) before and after sport, the situational goals, activity characteristics, and corresponding intraclass coefficients (ICC)

	Minimum	Maximum	Mean	SD	ICC
Affective well-being before and after sport activities					
VA_{pre}	1.00	6.00	4.07	1.09	0.48
VA_{post}	2.00	6.00	5.10	0.79	0.41
CA_{pre}	1.50	6.00	3.89	1.18	0.43
CA_{post}	2.00	6.00	4.49	0.98	0.57
EA_{pre}	1.00	6.00	3.81	1.11	0.42
EA_{post}	1.50	6.00	4.33	0.97	0.35
Situational goals for sport activities					
SG_{health}	1.00	5.00	3.34	1.04	0.62
$SG_{bodyweight}$	1.00	5.00	2.95	1.34	0.80
$SG_{distraction/stress\ regulation}$	1.00	5.00	2.93	0.98	0.40
$SG_{activation}$	1.00	5.00	3.84	0.85	0.59
Activity characteristics					
Intensity (HR in bpm)	71.63	169.70	126.47	18.64	0.40
Intensity (% HR_{max})	40.69	90.36	68.90	9.53	0.32
Activity Dose (METh)	0.64	13.96	5.41	3.09	0.21
Perceived Exertion (RPE)	1.50	8.00	4.63	1.63	0.55

VA_{pre} valence before sport activities, *CA_{pre}* calmness before sport activities, *EA_{pre}* energetic arousal before sport activities, *VA_{post}* valence after sport activities, *CA_{post}* calmness after sport activities, *EA_{post}* energetic arousal after sport activities, *SG* situational goal. For detailed information on the units of measures, see the section on measures

the average intercept of a basic affect dimension across all subjects (β_{0j}) and the level 1 predictors of the activity characteristics (β_{1j} * $\%HR_{max}$), (β_{2j}*METh), and (β_{3j} * RPE). The affective subscale variables valence, calmness, and energetic arousal (VA, CA, EA), the variables of the activity characteristics ($\%HR_{max}$, METh, RPE), and the variables of the SGs were centered on the grand mean (Snijders & Bosker, 1999). The random error value for the level 1 model is given by r_{ij}.

Level 2 represents between-person effects. Eqs. 2, 3, 4, and 5 include the fixed effects (γ) as the average intercepts and slopes of all participants, the average of the participants' mean of the affective subscale (MEAN_AWB), and the random effect (u_{0j}) (Eq. 2). The level 2 predictor MEAN_AWB was centered on the grand mean. All models are calculated as random intercept only models with a fixed slope at level 2. The number of observations for each person suggests using economical modeling so that random slopes are shelved due to the data structure.

Considering the hierarchical structure of the model, an adaptation of degrees of freedom was made for the effect size estimation (Snijders & Bosker, 2011). Eq. 6 was used to calculate the $N_{effective}$ of the models:

$$N_{\text{effective}} = Nn/(1 + [n-1] * \rho_I) \quad (6)$$

Nn indicates the number of measurement points, and *n* represents the average number of measurement points per person. ρ_I is the ICC of the dependent variable (intensity, activity dose, perceived exertion/VA_{post}, CA_{post}, EA_{post}). The effect size *r* was calculated using the *t*-values of the regression models and the corresponding adapted effective degrees of freedom. For interpretation, the effect size *r* was transformed into effect size *d* and conventionally classified according to Cohen (1988).

Results

Descriptive analyses

The 46 participants recruited for the study completed 161 sport activities over the seven study days. We had to exclude five sport activities where the activity type was swimming, and another ten occasions when participants did not wear the accelerometer on the chest-strap for unknown reasons. For the remaining 146 sport activities, participants forgot to answer the pre- and post-sport activity questionnaires 13 times. Therefore, for our analyses, we were able to take complete data of 133 sport activities of 46 people into account. On average, participants engaged in sport activities approximately three times per week. The average duration of one sport activity was 68 min (*SD* = 43.9). The average time between before- and after-sport surveys was 84 min. The screening relating to the stage model of exercise behavior revealed that most of the 46 participants could be classified in the stage of habituation (*n* = 27 or 60%). Another 17 participants could be assigned to the stage of implementation (38%), and one person was in the fluctuation stage (2%). Considering the habit criterion based on the self-report habit index, the sample could be divided according the cut-off value established by Gardener, de Brujn, and Lally (2011) consistently into participants with the habit (SRHI ≥ 3.3; *n* = 21 or 46%) and without the habit (SRHI < 3.3; *n* = 25 or 54%) of engaging in sport activities. Beyond that, most participants showed normal weight (18 ≥ BMI ≤ 25; *n* = 40; 87%). One participant was underweight (BMI < 18; 2%); four participants were overweight (25 > BMI ≤ 30; 8%); and one participant was obese (BMI > 30; 2%) (referring to Pate et al., 1995).

A classification of the activity characteristics ($\%HR_{max}$, MET, RPE) into descriptive intensity categories is shown in

Table 3 Associations between affective well-being and situational goals before sport activities and activity characteristics

	Intensity (% HR_{max})		Activity Dose (METh)		Perceived Exertion (RPE)	
	B	p	B	p	B	P
Intercept	69.430	<0.001**	5.414	<0.001**	4.613	<0.001**
VA_{pre}	0.535	0.539	−0.198	0.674	−0.155	0.419
CA_{pre}	−0.269	0.729	0.811	0.006*	−0.326	0.026*
EA_{pre}	−0.321	0.694	−0.220	0.553	0.299	0.033*
Intercept	69.550	<0.001**	5.492	<0.001**	4.615	<0.001**
SG_{health}	−2.232	0.008*	−0.422	0.161	0.065	0.708
$SG_{bodyweight}$	0.722	0.286	0.584	0.021*	0.033	0.814
$SG_{distraction/stress\ regulation}$	0.216	0.799	−0.132	0.699	0.184	0.266
$SG_{activation}$	0.832	0.485	1.322	0.001*	−0.075	0.726

VA_{pre} valence before sport activities, *CA_{pre}* calmness before sport activities, *EA_{pre}* energetic arousal before sport activities, *SG* situational goal
*p <0.05; **p <0.001

Table 1.[4] An overview of the descriptive parameters of the three basic affective dimensions (before and after sport activities), the SGs for sport activities, and the activity characteristics (%HR_{max}, METh, RPE) can be found in **Table 2**.[5]

Situation-specific within-person heterogeneity

For valence, calmness, and energetic arousal (after sport activities), the ICCs imply that for the affective states after sport activity, 69%, 43%, and 65% refer to within-person differences (see **Table 2**). For the SGs for sport activities, the ICCs show a wide range, indicating that between 20% ($SG_{bodyweight}$) and 60% ($SG_{distraction/stress\ regulation}$) refer to within-person differences. The ICCs for the activity characteristics show that for intensity, activity dose, and perceived exertion, 68%, 79%, and 45% refer to within-person differences.

Associations between pre-activity affective well-being, situational goals, and activity characteristics

For intensity, **Table 3** shows a negative within-person effect of the SG health (p = 0.008). For situations when participants rated the goal of health higher by one unit, the intensity was lower by 2% of the HR_{max}. The effect size is medium, with d = 0.58. There are no associations between affective well-being and the intensity of the sport activity.

For activity dose, there are positive within-person effects of calmness (p = 0.006) and the SGs body weight (p = 0.021) and activation (p = 0.001). When participants rate the goal of activation higher by one unit, the activity dose is higher by 1.3 METh. Effect sizes are all medium, with d = 0.56 for calmness, d = 0.47 for body weight, and d = 0.66 for activation.

For perceived exertion, there is a negative within-person effect of calmness (p = 0.026) and a positive effect of energetic arousal (p = 0.033), each with medium effect sizes (d = 0.56 for calmness; d = 0.54 for energetic arousal).

Associations between activity characteristics, situational goals, and affective well-being after sport activities

Table 4 shows no within-person effects of activity characteristics or SGs for sport activities on affective valence after sport activities. For feelings of calmness after sport activities, there is a negative within-person effect of perceived exertion (p = 0.033) and a positive within-person effect of the SG of activation (p = 0.022). Effect sizes are medium, with d = 0.54 for perceived exertion and d = 0.58 for activation.

For energetic arousal, there is a positive within-person effect of activity dose (p = 0.005) and a negative within-person effect of perceived exertion (p = 0.035). The effect sizes are medium, with d = 0.64 for activity dose and d = 0.48 for perceived exertion.

For these analyses, we controlled for between-person effects of the mean level of affective subscales on the effects of affective well-being after sport activities. As shown in **Table 4**, the average levels of valence, calmness, and energetic arousal refer to affective valence, calmness, and energetic arousal after sport activities (p < 0.001) as it was expected.

Discussion

In the current ambulant assessment study, situational analyses of affective reactions after sport activities were conducted in daily life, considering specific goals and the different characteristics of different sport activities. The aim was to enhance the current state of research regarding the associations between SGs, activity characteristics, and affective well-being after real-life sport activities. Therefore, we captured activity-related data using a combination of objective characteristics (accelerometer, ECG) and subjective estimation (rating scale) in real-life situations. Affective well-being and the SGs for sport activities were gathered via smartphone. In doing this, we followed the current recommendations for methodological quality standards for the analyses of associations between physical activity and affective well-being

[4] The number of sport activities in the intensity category "light" differs among the three intensity categories. A possible explanation is that some types of activities cannot adequately be captured by accelerometers and are therefore allocated as "light," even though people find them to be quite exhausting. For example, a combination of strength training and stretching had an RPE value of 5 (≙ vigorous), but the MET value was, on average, 1.5 (≙ light).

[5] According to the definition of a sport activity (Fuchs, 2003), the range of intensities is from light to high. There are lower values of the objective activity characteristics, as some activities contain, for example, a combination of strength training and stretching, which comprise lower HR and MET values, on average.

Table 4 Associations between activity characteristics, situational goals, and affective well-being after sport activities

	VA_{post}		CA_{post}		EA_{post}	
	B	*p*	B	*p*	B	*p*
Intercept	5.113	<0.001**	4.486	<0.001**	4.291	<0.001**
Mean_AWB	0.526	<0.001**	0.594	<0.001**	0.492	<0.001**
Intensity (% HR_{max})	0.004	0.516	−0.006	0.523	−0.010	0.270
Activity Dose (METh)	0.012	0.645	0.021	0.486	0.061	0.005*
Perceived Exertion (RPE)	−0.017	0.640	−0.104	0.033*	−0.109	0.035*
Intercept	5.166	<0.001**	4.523	<0.001**	4.349	<0.001**
Mean_AWB	0.623	<0.001**	0.592	<0.001**	0.526	<0.001**
SG_{health}	−0.059	0.275	−0.029	0.714	0.102	0.233
$SG_{bodyweight}$	0.059	0.189	0.006	0.923	0.056	0.323
$SG_{distraction/stress\ regulation}$	0.006	0.938	−0.054	0.552	−0.014	0.855
$SG_{activation}$	0.040	0.656	0.245	0.022*	0.179	0.073

VA_{post} valence after sport activities, *CA_{post}* calmness after sport activities, *EA_{post}* energetic arousal after sport activities, *SG* situational goals
*$p < 0.05$; **$p < 0.001$

in daily life (Kanning et al., 2013; Liao et al., 2015).

Situation-specific within-person heterogeneity

Our study results show that for differences in affective well-being after sport activities, within-person variance predominates for valence (59%) and energetic arousal (65%). It is less distinct for calmness (43%). This confirms the results of Unick et al. (2015), that is, that even within persons there is heterogeneity in affective well-being after sport activities. Moreover, we analyzed other parameters situationally. It can be stated that SGs for sport activities vary situationally within-person as well, so that a person does not have the same goals for sport activities in general. However, the results also imply that depending on the goals, more or less situational variability can be expected. For rather extrinsically motivated health aspects, the between-person variance prevails, as the SGs *body weight* (80%) and *health* (62%) show. Therefore, participants who engage in sport activities for health reasons, to counteract physical discomfort, or to regulate their weight clarified these goals as less situationally varying. For rather intrinsic goals, such as to replenish energy or doing sports especially for enjoyment of body movement ($SG_{activation}$), between-person variance (59%) predominates. The strongest within-person variance exists for the situational goal *distraction/stress regulation* (60%). The reasons to engage in sport activities to settle one's thoughts, to distract from other problems, to release anger and petulance or stress are more situationally variable. This result confirms the hypotheses of Allmer (1996), who characterizes recovery intentions as situationally specific.

Furthermore, analyses revealed situationally variable manifestations for the three assessed parameters of sport activities. There is a great within-person variance for intensity (68%) and activity dose (79%). The result for perceived exertion is interesting, as the within-person variance is less distinct (45%). One reason for the divergent results between the objective and subjective data may be the fact that the RPE was only captured as a post-measurement after the sport activities and not during the activity. Against this, the objective characteristics (intensity, activity dose) have been assessed for the whole time of the sport activity, which may also be a source of the variation.

To sum up the results of research question 1, it can be stated that affective well-being after sport activities is not the only element that varies within persons; a within-person heterogeneity for activity characteristics and situational goals could also be identified.

Associations between pre-activity affective well-being, situational goals, and activity characteristics

To explain the situationally varying activity characteristics, in research question 2 we analyzed associations between affective well-being and SGs for sport activities and characteristics of sport activities. Affective well-being shows two patterns of relationships with the activity characteristics that occur depending on the related affect dimension. On one hand, more calm and relaxed feelings before sport activities go along with lower perceived exertion, although these more relaxed feelings are associated with a greater activity dose. This coherence cannot be explained by longer durations of sport activities (results not reported). Therefore, greater temporary opportunities for sport activities in less stressful situations cannot be established as a reason. Rather, the results indicate that in stressful conditions, relatively lower activity doses are realized and are perceived as more exerting. A further association exists for feelings of greater energetic arousal before sport activities, as there is a greater possibility to perceive the subsequent sport activity as more exerting. There are no positive associations with the objectively captured activity characteristics; therefore, the association needs to be interpreted on a level of the subjective experiences. Moreover, alternative explanations need to be discussed according to the methodological problems in the assessment of the activity for different activity types, which are addressed below. The reported results can enhance the findings of Lawton, Conner, and McEachan (2009), who stated that intentions are a significant predictor of physical activity behavior but not of affective well-being.

The current study results concerning the SGs confirm the importance of cognitive factors for activity characteristics. Therefore, our findings show that two motivational situations are associated with higher activity doses. On one hand, this applies to the SG *body weight*, which is based on a rather introjected motiva-

tion mode (Lehnert et al., 2011). For this subjective pattern of argumentation, it seems reasonable that the intended regulation of body weight may be successful with a higher energy expenditure, which in turn requires higher activity doses. On the other hand, the SG *activation* is considered as rather intrinsic (Lehnert et al., 2011), which may be associated with higher activity dose because the sport activity itself holds more appeal and is pursued longer and more intensively. For *body weight* in particular, attention should be paid to the fact that people indicate this goal as relatively stable and important across situations (see ICCs). Our results support the conclusion that it is not only a situational association but also an association on the contextual level in terms of Vallerand's hierarchic model. This complies with the results of Duncan et al. (2010), who found positive associations between introjection and the intensity of sport activities in a cross-sectional survey. Moreover, health-oriented goals situationally go along with reduced intensity of the sport activity. Self-selected intensities may be an issue and are recommended to be moderate for people engaging in health and recreational sport activities. Likewise, activity guidelines in health-oriented sport activity programs can be relevant, as they typically suggest moderate (or less intensive) loads, which are also established by the instructors. Certainly, a precise interpretation of our results is restricted because the activity type becomes important for the manifestation of the activity dose, as endurance activities can be represented better by accelerometers in terms of their actual intensity than weight training. The detected associations between individual goals and activity characteristics are all based on medium effect sizes so that substantial associations can be resumed. However, this is only applicable for the objective parameters activity dose and intensity.

A further leverage point for future studies is provided by Guérin and Fortier (2012), who analyzed the interaction between situational motivation and intensity (as RPE) of sport activities and a change in positive affect following the sport activity of running. Hierarchical regression analyses revealed a significant interaction effect between perceived exertion and introjection. At low levels of introjection, the influence of perceived exertion on the change in positive affect was considerable, with higher RPEs being associated with greater increases in positive affect.

All in all, for research question 2, our results indicate that some cognitive and affective variables before the activities are associated with the manifestation of activity characteristics that need, for example, to be considered for individually tailored activity recommendations.

Associations between situational goals, activity characteristics, and affective well-being after sport activities

For research question 3, the analysis of the associations between the activity characteristics, the SGs for sport activities and affective well-being after sport activities show that affective valence after sport activities is neither associated with activity characteristics nor with cognitive factors. This is remarkable because research on affective reactions—for example, on the basis of DMT—frequently focusses on the valence dimension (e.g., Ekkekakis et al., 2011). To what extent the MDBQ research procedure is relevant is hard to estimate. On one hand, it captures somewhat different affect adjectives with the adjective pairs *well–unwell* and *content–discontent* than the commonly used Feeling Scale (*good–bad*; Hardy & Rejeski, 1989). On the other hand, other studies that also used the bipolar MDBQ questionnaire showed generally positive effects of sport activity on affective valence (e.g., Sudeck & Conzelmann, 2014; Kanning, 2013). In our study, associations with post-activity affect occurred especially if energetic arousal was focused on as a basic dimension, that is, either relating to energetic arousal or calmness (whose antipole is negative activation).

The assumption that a recovery intention is relevant for the subsequent affect could only be partially proved by this study, namely in terms of energetic arousal. The study showed a positive association between the goal *activation* and post-activity energetic arousal. This confirms the situationally analyzed results of Guérin et al. (2013), in fact that intrinsic motives go along with positive affective well-being after sport activities. Moreover, the goal *activation* has the greatest intrinsic amount of motivation (Lehnert et al., 2011). To replenish energy or engage in sport activities especially for enjoyment of body movement are therefore goals with high intrinsic motivation and thus promote positive affective well-being. At the same time, this goal was less stable across different within-person situations than e.g. the goal *body weight*. For *activation* the between-person variance prevails (59%). Therefore, in order to precisely interpret these findings, interindividual and intraindividual differences need to be taken into account. The direct analysis of trait goals (e.g., by inclusion of the original BMZI items) and state goals (as assessed in this study) is missing here, especially in light of the low number of level 1 units. This limitation needs to be taken into account in the interpretation, and future studies should overcome it. There was no confirmation that recovery intentions such as *distraction/stress regulation* are associated with the post-activity affect of calmness (Jeckel & Sudeck, 2016). Accordingly, there is no association per se between specific recovery intentions and the post-activity affect. The relationship seems to be more complex, and therefore a closer look at the activity type or the specific aspects of distraction (e.g., to reduce negative affect, to settle one's thoughts) would be worthwhile.

The analysis of possible associations between activity characteristics and post-activity affective well-being showed divergent results for subjectively and objectively gathered activity parameters. For perceived exertion, the results showed that participants who experienced the sport activity as exhausting felt less calm and less relaxed as well as less awake and less activated after the sport activity. In contrast, the objectively assessed parameter activity dose was positively associated with energetic arousal after sport activities. Participants with a higher activity dose felt more awake and activated

afterwards. These findings were determined under control of the mean affective well-being of each individual, so that situational affective well-being after sport activities can be interpreted by referring to a participant's general affective well-being for the time of the study. A consistent classification of our findings into the few existing study results proves difficult. Neither positive associations between perceived exertion and positive affect (Guérin et al., 2013) nor inverse associations between activity dose and positive activated affect after a sport activity can be confirmed (Reed & Ones, 2006). Therefore, it must be considered that the amount of vigorous to high activity, which is the span where negative associations occur the most in other studies, is less in the context of daily life (see **Table 1**). A further possible explanation for the positive associations between the objectively captured activity dose and energetic arousal can be the phenomenon described by Ekkekakis et al. (2011), namely that because of the self-selected intensities by a cognitive appraisal, a sense of autonomy and control emerges that affects the energetic arousal positively. Moreover, the mean affective well-being was used as a control variable, which was not realized continuously in other studies. Furthermore, existing studies on that topic were often conducted in laboratory settings, so that findings can be substantially caused by the context of daily life (e.g., Ekkekakis & Backhouse, 2009; Schlicht & Reicherz, 2012).

A further contextual reason for the divergent results of the associations of the subjectively and objectively captured activity characteristics with post-activity affective well-being might be the possible interindividual differences in the subjective appraisal of activity loads. So, perceived exertion (RPE) has the greatest stability across situations in the appraisals by individual (ICC = 0.55). One needs to be mindful of the personal traits relating to tolerance for and preferences regarding exercise intensities, which can be interindividually distinct (Ekkekakis, Hall, & Petruzzello, 2005a) and generally may influence the perceived exertion. However, the low ICCs of the objective parameters could reflect actual differences in the activity characteristics, which do not reasonably occur in the same way for perceived exertion. This can have contextual reasons, such as the divergent duration of activities within persons or the different activity types of different intensities within persons. The methodological limitations must also be discussed, as they can also be a reason for the divergence between RPE and objective activity characteristics. Strength training in particular cannot be captured by accelerometers or the relative HR_{max} as good as cyclical endurance activities (e.g., Gabrys et al., 2015). The descriptive information on the activity characteristics suggests that these methodological argumentations should be addressed in the discussion. It is therefore apparent that particularly for the intensity captured by the MET estimations, there are clearly more activities with light intensities compared to the physiological reaction (HR) and subjective ratings (RPE). Moreover, *high* intensities are least captured by relative $HR_{max,}$ which can also be augmented by strength exercise. This kind of sport activity can hardly reach such high intensities in the medium trend because of the rest intervals between the exercise series.

Taken together, affective well-being after sport activities in daily routines is associated with the intrinsic motivated goal activation, which is less stable—or most varying—across situations within persons. Moreover, the objectively assessed activity characteristics and the subjective parameters show divergent result patterns according the association with affective well-being after sport activities. This needs to be considered for activity recommendations as well.

Strengths and limitations

When reviewing the study results, further strengths and limitations must be considered. We already stated that we realized high methodological standards for the assessment of activity characteristics, affective well-being, and SGs as the main constructs (Kanning et al., 2013; Liao et al., 2015). By studying participants' daily routines, we were able to capture and analyze data from real-life situations and therefore carry out situation-specific analyses that were not influenced by certain laboratory conditions. The literature (e.g., Liao et al., 2015) critically states that studies are often conducted only with students and only last one or two days. The current study included an extended group of people with a larger age range and diverse professional careers, which may result in SGs that are more different than those of a sample of university students. Moreover, the study lasted seven days in order to reduce the impact of the specifics of a certain study day and according to the recommendation of Unick et al. (2015) to ensure that more than one sport activity per person was included in our analyses. Additional value lies in the stepwise analysis that proved the existing heterogeneity of affective well-being after sport activities not only between persons but also within persons and that proved the relevance of the heterogeneity of SGs and activity characteristics as influencing factors.

As post-activity assessment time is an important consideration, participants were instructed to answer the questions on the smartphone as soon as possible after the sport activities. Reed and Ones (2006) stated in their meta-analysis that the greatest increase in positive effects is seen within five minutes after a sport activity (e.g., Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000) and lowers thereafter, though the effects remain significantly elevated above baseline for 20–30 min (e.g., Bixby et al., 2001). In our sample, the difference between pre-post activity measurement points and the duration of the sport activities was on average 16 min. Hence, the margin is within the above-stated post-activity assessment time by Reed and Ones (2006). Nevertheless, future studies should capture the end of a sport activity more exactly, so that the post-activity assessment time can be captured more precisely.

Another limitation of the current study is the rather active sample. Our study results might be related to the sample's characteristics and therefore cannot be extrapolated to inactive people, but it was beneficial for our analyses that participants on average engaged

in three sport activities per week. The more precise statements about situation-specific influencing factors for heterogeneity in affective well-being after sport activities are, the more situations can be included in the analyses. Moreover, the total number of recruited participants constitutes a further limitation, as the number of measurement points per person is below the suggested quantity. For this reason, more differentiated analyses, especially of within-person associations, could not be conducted in this study. Certainly, the power of our analyses is therefore restricted, which must be considered when interpreting the results. As a consequence, future studies analyzing situational associations should use a larger sample size and more sport activities per person. A further limitation is that participants might have changed their activity behavior due to the use of the study equipment. Although all participants were instructed to follow their regular daily routine, a possible reactivity cannot be ruled out. The main focus of our study remains on quantitative aspects of physical activity. In order to meet the possible variety of sports activities, further studies should take the activity type and participants' environment (e.g., social factors) into account.

Practical implications

Despite these limitations, the results of this explorative study can extend our knowledge of the heterogeneity of affective responses to sport activities because the study examined real-life situations. Three main implications can be drawn and will be summarized and illustrated below. First, as situational goals that affect people's accomplishment of expectations are associated with the manifestation of activity characteristics, our results reveal implications for fitness- and health-oriented sport activities. If a person with the goal of regulating body weight receives a recommendation of low activity doses (according to health-oriented activity guidelines), the instructors should be aware that this might be in conflict with his or her individual goals and expectations for ideally structured sport activities. Second, our study results underline the relevance of recommendations for persons whose goal is to regulate well-being. The recovery behavior in general can be characterized as individually varying (Allmer, 1996). This is especially true for the recovery intention of distraction and stress-regulation. As a consequence, for motive-based physical activity recommendations, the situational level of motivation should be considered, especially for people with recovery intentions (e.g., by self-observation within a first period of counseling). Third, the results emphasize the relevance of people being aware of their (situationally varying) goals and their ability to choose and adjust sport activities and activity characteristics thereupon (see Sudeck & Pfeifer, 2016 for detailed information on control competence). This includes instructors, participants, and people engaging in sport activities for themselves knowing how to deal with the above-mentioned possible differences between subjective ratings of perceived exertion (CR10, Borg, 1998) and objectively captured data for specific sport activities (e.g., strength training). Also, to meet the postulated control competence, the ACSM position stand (Garber et al., 2011) suggests using the feeling scale, which is a measure of affective valence (Hardy & Rejeski, 1989), as a secondary method for individuals seeking to self-regulate exercise intensity.

Conclusion

This predominantly explorative study gives further evidence that a situation-specific focus in determining the effect of sport activities in daily life is worth analyzing. The stepwise analysis of the current study indicates that the analysis of situation-specific interactions between the identified influencing factors seems to be promising for further research. The high SG *activation* was followed, on the one hand, by higher activity dose of the sport activity. On the other hand, participants felt more awake and activated if the activity dose was higher. Additionally, the SG *activation* is directly followed by a greater feeling of calmness. The results indicate interactions between some SGs and the activity dose. Moreover, it might be possible that, for example, there is an association between the specific recovery intention (distraction) and calmness but only for specific activity characteristics (high intensity). These kinds of research questions have been put aside due to the current sample size and the events per person. However, they can be relevant components of future research to achieve scientific optimization of individualized activity recommendations.

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Compliance with ethical guidelines

Conflict of interest. S. Jeckel and G. Sudeck state that there are no conflicts of interest.

All procedures performed in the study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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Manuskript 3: Physical-Activity-Related Mood Regulation and the Activity-Affect-Association

Sudeck, G., Jeckel, S., & Schubert, T. (2017, submitted). *Individual Differences in Physical-Activity-Related Mood Regulation moderate the Activity-Affect-Association in Real-Life Situations.*

Main Article

Individual Differences in Physical-Activity-Related Mood Regulation moderate the Activity-Affect-Association in Real-Life Situations.

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Abstract

Objective: Physical activity (PA) in daily life is positively associated with affective well-being in adults, but this relation varies with respect to different affect dimensions. While reviews on the PA-affect-association in real-life situations conclude positive effects on affective valence and energetic arousal, inconclusive results exist regarding feelings of calmness. The aim of the present study was to investigate the moderating role of PA-related mood regulation on the PA-affect-association in real-life situations. **Design:** Ecological momentary assessment study over four study days. **Method**: 37 women and 27 men completed the study in which we used accelerometers to record daily PA and e-diaries via smartphones to collect data on affective well-being repeatedly on each study day. We applied multi-level analyses to estimate within-person effects of physical activity on affective well-being as well as cross-level interactions between physical activity (within-person level) and PA-related mood regulation (between-person level). **Results**: The results revealed significant cross-level interaction effects between within-person variations of physical activity and PA-related mood regulation on the affect dimensions of calmness ($p < .01$) and affective valence ($p = .04$). **Conclusion**: Individual differences in control competences for PA-related mood regulation were identified as a moderator of the PA-affect association in real-life situations. Therefore, individual-based PA promotion and health education should recognize those individual differences in PA-related facets of health literacy in order to develop tailored interventional approaches.

Keywords: Physical activity; affective response; ecological momentary assessment; health literacy

Introduction

The positive effects of physical activity (PA) on health and well-being are well documented. According to the Global Physical Activity Recommendations (WHO, 2010), health benefits can be accomplished both through structured physical exercise and through physical activity that lead to substantial increases in energy expenditure due to skeletal muscle effort (Caspersen et al., 1985). Thus, physical activities in different contexts are relevant, ranging from leisure time to active transport and household chores to work. However, despite the potential health benefits of the different forms of PA, there is distinct physical inactivity in the adult population (European Commission, 2014). PA promotion is therefore an increasing public health challenge and an important task for health education research and practice.

Affective responses to PA play a crucial role in individual-focused approaches to PA promotion. Studies have shown that affective responses to PA predict future activity behavior up to 12 months later (for a recent review, see Rhodes and Kates, 2015). Hence, positive affective responses during and following PA can be depicted as a basis for sufficient PA levels.

Additionally, positive affective responses to PA itself can foster the improvement of psychological health and well-being (Reed and Buck, 2009). Positive affective responses provide the potential for individuals to intentionally apply PA in the regulation of their affective well-being as well as recovery processes. For example, the stress- and recovery-related goals of exercising are well known among the adult population in western countries (e.g., Markland and Ingledew, 1997), and many people use PA as a means for stress regulation and for improving their affective well-being.

Against this background, personal characteristics that co-determine affective responses to PA or the association between PA and affective well-being need to be identified. It is important to note that PA-affect-association is changeable over an individual's life course (Lee, Emerson & Wiliams, 2016). It may be based on personal experiences in formal and informal learning settings and may thus become important in the promotion of domain-specific facets of health literacy (Abel and Sommerhalder, 2015). In general, health literacy gives individuals the knowledge, motivation, and competences to take informed health decisions in everyday life to positively influence their health and well-being (e.g., Sørensen et al., 2012). Transferring these conceptions to the PA domain, individuals need specifically to integrate PA into their everyday life in a health-effective manner based on sufficient domain-specific knowledge, motivation, and competences (e.g., to optimize physical health benefits or improvements of affective well-being; Sudeck and Pfeifer, 2016).

The objective of the current study is therefore to explore the moderating role of the PA-related facets of health literacy on the association between PA and affective well-being. Given the public health challenge of PA promotion among adults, PA in daily routines and real-life environments needs to be considered for the differential analyses of PA-affect-association.

Association between physical activity and affective well-being in real-life situations

A long research tradition exists in Exercise Psychology of analyzing the acute effects of structured physical exercise on affective well-being. Different meta-analyses have been conducted that offer a mostly positive summary (e.g., Reed and Ones, 2006). Beyond this, current studies suggest a differentiated consideration of this phenomenon.

First, in regard to affective responses during and following PA, inter-individual differences in affective responses on physical exercise have been increasingly emphasized

(e.g., Backhouse et al., 2007). That is, individual factors and contextual conditions need to be taken into account for a better understanding of affective responses to physical exercise (e.g., Rose and Parfitt, 2010). Especially for less active persons or people with health problems, affective responses to physical exercise can often be negative (e.g., for obesity, Ekkekakis et al., 2010).

Second, many primary studies and overviews have focused on PA in laboratory settings, and the transferability of their findings to daily routine is not completely guaranteed. Affective responses to behavior as well as the behavior itself therefore need to be distinguished between a laboratory setting and the context of daily routine (Bussmann et al., 2009). Within the last years, as a result, the association between PA and affective well-being has been analyzed more often in real-life environments. Methods of ecological momentary assessment (EMA) have been increasingly applied to gather data on PA (e.g., via accelerometer) and affective well-being (e.g., via electronic devices such as smartphones) repeatedly and with high frequency in real-life situations (Kanning et al., 2013). These procedures enhance ecological validity as they make it possible to collect real-time data on participants' behavior and experiences in their real-life environments (Shiffmann et al., 2008).

Liao and colleagues (2015) recently summarized 12 studies that address the association between PA and affective well-being in the context of daily routines. Regarding the basic affect dimensions (e.g., Schimmack and Grob, 2000), they concluded the following:

> a) Physical activity is consistently linked to an enhancement of positive affects
>
> b) Findings are inconsistent for a reduction of negative affects through physical activity
>
> c) Findings for an increase in energetic arousal following physical activity are relatively consistent

d) The effects of physical activity on the feeling of calmness can be described as inconclusive

Liao and colleagues (2015), in their review, concluded that the question of which potential moderators influence the association between PA and affective well-being, specifically in daily routine, remains unanswered.

Physical activity-related health competence as potential personal moderator

In studies on the PA-affect-association in real-life settings, personal factors such as demographics (age, gender), habitual activity behavior (z. B. Hyde et al., 2011), physical health (body mass index, Kanning et al., 2015), and psychological health (satisfaction with life, Kanning et al., 2015; depression, Wichers et al., 2012) have been analyzed as moderating factors. But as yet, drawing distinct conclusions remains difficult with respect to rather stable personal factors.

There is therefore a gap in the knowledge on moderating personal factors from the perspective of health literacy, and domain-specific facets of health literacy may be relevant here (Abel and Sommerhalder, 2015). In the context-specific model of PA-related health competence by Sudeck and Pfeifer (2016), the context- and demand-specific nature stems from integrating PA into everyday life in a health-effective manner. As a result, close attention is paid to those demands that are important for initiating and maintaining PA *and* the targeted gearing of PA to health and well-being (Sudeck and Pfeifer, 2016).

Within this model, the individual control competence for physical loads is given the important function of the promotion of health and well-being. This individual control competence co-determines the *quality of individual PA* and not only the quality of behavior, which is usually the focus of health-psychological theories of behavior change (e.g., Theory of Planned Behavior, Ajzen, 2002). Following this understanding, people with high control

competence can gear their own PA to optimize physical health benefits and minimize health risks as well as to positively influence affective well-being and psychological health. Specifically, Sudeck and Pfeifer (2016) differentiate between control competence for physical training and control competence for PA-related mood regulation. The latter reflects a person's ability to gear their PA toward positive regulation of affective well-being, depending on their own physical and psychological condition. This includes, for instance, the ability to situationally vary physical load (e.g., based on body signals and perceived exertion) in order to ensure positive affective response to PA.

In accordance with the model, the control competence for PA-related mood regulation can be categorized as a potential moderator of the PA-affect-association. However, this assumption lacks an empirical foundation, and previous empirical studies have merely showed great inter-individual differences for adults and a positive association with the quantity of exercise behavior for control competence for PA-related mood regulation (Sudeck and Pfeifer, 2016).

Rationale

The research question of the current EMA study of young and middle-aged adults focuses on the moderating role of individual control competence for PA-related mood regulation in the PA-affect-associations in real-life situations. Persons who are able to regulate their well-being through PA should manifest a more positive association between PA and affective well-being in daily routine. Specifically, we assume that individual differences in control competence can shed light on inconsistent findings on the association between daily PA and feelings of calmness.

The EMA approach allows for repeated measurements for each person across several days and makes it possible to analyze the effect of within-person variations in PA on

affective well-being. For analysis on the moderating role of control competence, a cross-level interaction is used to evaluate whether the time-invariant, personal feature of the control competence has an effect on the PA-affect-association at the within-person level.

Methods

Participants

The targeted study group consisted of young and middle-aged adults (older than 18 years but not yet retired). We tried to include a wide range of activity level, from active to less active, in our study. The initially recruited sample consisted of 42 women and 30 men, of whom 8 subjects were eventually excluded from the main analyses (see below for reasons). The final sample comprised 37 women and 27 men between 20 and 63 years of age (see Table 1). Overall, the sample was rather physically active in respect to self-reported regular exercise behavior. While a quarter of the participants exercised less than one hour a week, the majority of participants exercised regularly for over two hours a week. Most of the participants were of normal weight (72%), and the rest of the participants were overweight (22%) or obese (6%).

>> Insert Table 1 here <<

Design and procedure

The study protocol was approved by the institutional ethics committee. Participants were recruited via leaflets and posters distributed in different buildings of a university in Germany. Interested participants were given written information about the study. To participants who gave their written informed consent, the research assistants handed out the study equipment and explained and demonstrated its usage. The equipment consisted of a smartphone (Google Nexus 5: LG, Seoul, South Korea) using the app "movisensXS" (movisens GmbH, Karlsruhe, Germany), and an accelerometer (move3 Sensor: movisens

GmbH, Karlsruhe, Germany). Information on demographics, body size, body weight, exercise behavior, and PA-related health competence was gathered via questionnaire before starting the EMA procedure.

The EMA procedure for each participant lasted four days. Participants were instructed to wear the accelerometer for at least eleven hours every day and to answer time-triggered questionnaires on the smartphone. The prompts occurred every day randomly in one-hour periods (9:30–10:30 am, 12:30–1:30 pm, 3:30–4:30 pm, and 6:30–7:30 pm). These surveys contained questions on affective well-being. If a prompt was missed or could not be answered for any reason, the alarm was repeated up to four times every five minutes. At the end of the study, participants received a financial compensation of 5€ per finished study day.

All captured data were stored on the smartphone and the accelerometer and were downloaded to a server by the study assistants. All data were pseudonymized so that data were gathered based on code numbers.

Measures

Daily physical activity (EMA). Daily PA was recorded using the accelerometer move3, attached to the right hip with a clip. Participants were instructed to take off the accelerometer when sleeping, swimming, or taking a shower. The accelerometric data were assessed over the entire wearing time of a study day. The move3 sensor measures and stores subjects' acceleration on three axes with a frequency of 64 Hz. Many papers suggest using raw acceleration data (e.g., Welk et al., 2012) for comparability of sensor output. Technically, acceleration is a physical unit expressed in m/s^2 or in the gravitational constant g (9.81 m/s^2). In this study, we used raw acceleration data (milli-g) averaged for one-minute intervals across data points during the four-day measurement period. To analyze the

association between daily PA and affective well-being, the PA values during the 15 minutes prior to each time-triggered e-diary entry were averaged and included in the analyses. For the sake of comparison, sedentary behavior (e.g., sitting) is associated with approximately 7 milli-g, walking (5km/h gait speed) with approximately 370 milli-g, and jogging (10.5 km/h gait speed) with approximately 1100 milli-g (Anastasopoulou et al., 2014).

Affective well-being (EMA). Momentary affective states were assessed using the German short version of the Multidimensional Mood Questionnaire (MDMQ; Wilhelm and Schoebi, 2007). The questionnaire contains two binary pairs of adjectives for *valence* (VA; unwell–well; discontent–content), *calmness* (CA; tense–relaxed; agitated–calm), and *energetic arousal* (EA; tired–awake; without energy–full of energy). This scale has been developed and validated especially for assessing affective states in daily life routines. Each time an alarm rang, participants answered questions on their affective state by completing the sentence, "At this moment, I feel…" on a seven-point scale (0–6), on which higher scores indicated higher values for valence, calmness, and energetic arousal. Wilhelm and Schoebi (2007) found satisfactory to good reliability coefficients at both the between-person level and the within-person level. We also found satisfying to good internal consistencies for each pair of adjectives in the present sample. At the within-person level, the estimated inter-item correlations were $r = .75$ for affective valence, $r = .60$ for calmness, and $r = .76$ for energetic arousal. At the between-person level, the estimated inter-item correlations were even higher and ranged between $r = .93$ (energetic arousal) and $r = .96$ (valence).

PA-related mood regulation (Questionnaire). PA-related mood regulation was measured using a four-item scale developed and validated by Sudeck and Pfeifer (2016). People had to rate the following statements: "*I am well able to improve my depressed mood*

by exercising," "*I am well able to work off pent-up stress and inner tension through exercise*," "*If I am feeling down, I can distract myself well through physical activity*," and "*I am able to regulate my mood through physical activity*" on a four-point scale with responses ranging from "disagree completely" (1) to "agree completely" (4). The internal consistency was good in the present sample ($\alpha = .86$), so we used the mean value of the four items for further analyses.

Regular Exercise Behavior (Questionnaire). Regular exercise behavior was captured following the self-report measure BSA-F (Fuchs et al., 2015), which contained the measurement of physical exercise and sport activity during leisure time. It is based on the participants naming the type of activities, how often they engaged in these activities, and the duration within the past four weeks. For our analyses, we used an index of regular physical exercise in hours per week.

Data analyses

Initially, 72 participants were recruited. For two participants, the smartphone data could not be evaluated due to insufficient answers to the time-triggered questionnaires. One participant lost the accelerometer device, and accelerometer downloading problems occurred for five participants. Therefore, accelerometer and smartphone data was available for a total of 64 participants. Participants answered 866 of the time-triggered questionnaires (85%). Of the answered smartphone prompts, 90% had valid accelerometer data. Therefore, 780 observations with complete data could be included in our main analyses.

Multilevel regression models were used to analyze whether daily PA and a person's control competence for PA-related mood regulation were associated with affective well-being. Additionally, a cross-level interaction (daily PA x PA-related mood regulation) was calculated. Separate models were calculated for each subscale of affective well-being (VA,

CA, EA). We used the Hierarchical Linear Modeling (HLM) Software Version 7 (SSI, Inc., IL, USA), which makes it possible to consider the hierarchical structure of the data and to have different numbers of measurements per person (Hoffman and Rovine, 2007). Restricted maximum likelihood estimations were used. The α-level of the tests was set to $p < .05$. Gender, age, BMI, and regular exercise behavior (level-2) as well as weekday and squared time of day (level-1) were included as covariates. Weekday was dummy-coded (0/1) and gender was binary-coded (women = 0, men = 1). Time of day, age, BMI, regular exercise behavior, and PA-related mood regulation were grand mean centered before being entered in the HLM. Daily PA was centered around the person mean, so that the variable in the model represented within-person variations of daily PA.

Considering the hierarchical structure of the model, an adaptation of degrees of freedom was made for the effect size estimation (Snijders and Bosker, 2011). Formula 1 was used to calculate the $N_{\text{effective}}$ of the models:

$$N_{\text{effective}} = Nn / [1 + (n - 1) * \rho_I] \quad (1)$$

Nn indicates the number of measurement points, and *n* represents the average number of measurement points per person. ρ_I is the intra-class coefficient (ICC) of the dependent variable. The effect size *r* was calculated using the *t*-values of the regression models and the corresponding adapted effective degrees of freedom. For interpretation, the effect size *r* was transformed into effect size *d* and was conventionally classified. Before the main analyses, the ICCs were calculated for the time-varying variables at level-1, namely, valence, calmness, energetic arousal, and daily PA. Additionally, the level-specific reliabilities for each affect dimension (already reported above) were calculated using Mplus Version 7.4.

Results

Descriptive analyses

For the vast majority of personal characteristics, we observed no differences between participants of the final sample and those eight participants who could not be included in the final analyses ($p > .05$). An exception occurred regarding regular physical exercise, which was significantly higher for participants of the final sample ($M = 3.47$; $SD = 2.86$) than for participants who dropped out ($M = 1.28$; $SD = 1.15$; $p < .05$).

On average, participants had 12.19 valid prompts during the four study days (see Table 1). A total of 554 (74%) prompts were answered on a weekday and 195 (26%) on the weekend. The mean accelerometer wear time was about 14 hours a day. Participants rated their PA-related mood regulation on average at 3.19 (SD = 0.67), with possible answers ranging from 1 to 4.

Descriptive parameters of the time-varying variables can be found in Table 2. The grand means of the three affect dimensions were in the middle area of the scales ranging from 0 to 6. The empirical range of person means varied between 2.40 points (valence), 2.95 (energetic arousal), and 3.20 points (calmness), indicating substantial between-person variability in the affect ratings. However, the within-person variability of the affect ratings was even higher. The ICCs indicate that 70% (valence), 71% (calmness), and 70% (energetic arousal) referred to within-person differences. The ICC of daily PA prior to the prompts was clearly lower, as only 5% referred to between-person differences.

>> Insert Table 2 here <<

Main analyses

Model results for *valence* as the dependent variable (see Table 3) revealed positive associations for the person level covariate age ($p = .001$) and for the main effect of daily PA ($p = .016$). Additionally, the cross-level interaction between daily PA and PA-related

mood regulation was of statistical significance (p = .041). The effect size for the main effect of daily PA was small-to-moderate (d = .35).

>> insert Table 3 here <<

The graphical representation of the cross-level interaction (see Figure 1a) shows that people with low control competence for PA-related mood-regulation (-1SD from the grand mean) benefitted least from PA. In contrast, people with high control competence (+1SD from the grand mean) reported lower valence when their PA deviated negatively from the person mean. To facilitate the classification of the effect, a within-person deviation from person mean of about

-75milli-g/min comes close to sedentary behavior when simplistically considering the grand mean of 76milli-g/min daily PA before the prompts. By comparison, walking is accomplished with positive deviations of about 225milli-g/min from person mean PA. In these active periods, persons with high control competence show slightly higher values for valence (approximately 0.28 points).

Model results for *calmness* as the dependent variable (see Table 3) revealed positive associations again for the person level covariate age (p <.001) as well as for time of day (p = .008). There was neither a main effect of daily PA (p = .890) nor of PA-related mood regulation (p = .308). Instead, the cross-level interaction revealed a significant positive estimate (p = .002).

A graphical representation of the cross-level interaction (see Figure 1b) shows that people with low control competence for PA-related mood regulation experienced higher feelings of calmness when PA deviated negatively from person mean. When PA was higher than the person mean, people with low control competence reported lower feelings of calmness. This picture changes for people with high control competence for PA-related mood

regulation: If PA deviates from the person mean into areas of sedentary behavior, people experience less feelings of calmness, whereas higher PA levels were associated with higher feelings of calmness. Differences between people with high compared to low control competence were approximately 0.36 points of the rating scale for calmness at physical activity values deviating -75milli-g/min from the person mean. Respectively, values for calmness were 0.48 higher for people with high compared to low control competence at PA levels deviating +225milli-g/min from the person mean.

>> Insert Figure 1 here <<

For *energetic arousal* as the dependent variable, the most significant associations with person-level covariates occurred (see Table 3). According to the main hypotheses, daily PA showed a positive association with energetic arousal (p = .020). There was neither a significant main effect of PA-related mood regulation nor a significant cross-level interaction. The effect size for the main effect of PA was small-to-moderate (d = 0.36).

Discussion

In this current EMA study, the PA-affect-association was analyzed according to recommended methodological standards that have been clarified for research questions based on within-person data (Kanning et al., 2013; Liao et al., 2015). In association with the trait-like personal feature from the area of PA-related health competence, the moderating role on the association between within-person variations of PA and affective well-being could be analyzed. In this way, related background knowledge with high ecological validity can be generated that concerns psychologically relevant processes in the intersection between individually-focused PA promotion and health education.

Our pattern of results for within-person effects of PA on affective well-being was completely in line with the current evidence available for the PA-affect-association in real-

life environments as recently summarized by Liao and colleagues (2015). We found, in general, that people feel more awake and full of energy (energetic arousal) as well as more content and well (valence) after a more physically active period than usual in their daily routine. The effects were of small-to-moderate size and could be categorized as substantial considering that the activities were embedded in the daily routine. In contrast, for the affective dimension of calmness, no within-person effect of PA was found, which corresponds to the previously inconsistent results in the research.

Moderating role of control competence for PA-specific mood regulation

The inconsistent results on the range of calmness were a starting point for the main hypothesis under study. We expected that the control competence for PA-related mood regulation would moderate the effect of PA on feelings of calmness. This assumption was based on the conception and available operationalization for this area of control competence (Sudeck and Pfeifer, 2016). The items of the questionnaire reflect in particular that persons see themselves as being able to meet negative affect (feeling down, depressed mood) and negative activation (stress, inner tension) through PA.

The result pattern of the cross-level interactions confirms a specific significance of the individual control competence depending on the distinct affect dimensions. The highest interaction effect occurred, as expected, for the dimension of calmness. It is remarkable that there is a reverse association for people with high compared to low control competence for PA-specific mood regulation: people with high control competence benefit from physically active periods regarding feelings of calmness and feeling relaxed. In comparison, people with low control competence feel most calm and relaxed in periods of sedentary behavior, whereas in more active periods they are more agitated and tense. If the activity level rises to

walking, differences with medium effect sizes are evident between people with high compared to low control competence. This result pattern implies that the determined effects of PA on feelings of calmness can vary greatly, depending on the sample of a study, and can have contributed to the inconsistent results in the research.

For the cross-level interaction for valence, the result pattern is different as it shows a basically positive association between within-person variations of PA and affective valence. However, the manifestation of the positive association is moderated by the individual control competence, so that people with high control competence benefit the most from active periods in daily routine. For the dimension of energetic arousal, there are no interaction effects. This dimension is less responsive to the assessment procedure used for the PA-specific mood regulation, making this finding reasonable. Taken together, this result pattern confirms the relevance of individual competences with regard to beneficial effects of PA on affective well-being (especially regarding acute enhancements of feelings of calmness and the reduction of negative activation as well as the acute improvements of valence).

Strengths and limitations

A strength of the current study is the EMA design, which is in accordance with methodological standards for the analysis of PA-affect-association (Kanning et al., 2013; Liao et al., 2015). We used an established scale for affect assessment and we objectively assessed PA using accelerometers. Both methods avoid biases related to retrospective assessments of affect ratings or self-reported PA (Kanning et al., 2013). We applied a multilevel modeling approach and included different confounders at both the within-person level and the between-person level. Additionally, we were able to report reliable information on withdrawals and dropouts (Liao et al., 2015). Only two persons dropped out of the study

and one accelerometer was lost. A further five persons could not be integrated into the analyses due to technical reasons. Compliance with the e-diary entries generated a satisfying value of about 85%. Despite the minor indices on a systematic bias through withdrawals and dropouts, a lower physical exercise level was detected for the eight persons who could not be included in the analyses.

There is one limitation of the study, concerning the structure of the sample. Indeed, the aim of recruiting a wide range from less active to high active people was reached. However, due to the higher number of physically active people, we have to assume a selection bias. This selection bias seems especially meaningful for the replication of the PA-affect-association, as there may exist a tendency to overestimate the effects. In fact, we controlled the interesting main effects for the regular physical exercise behavior—besides other potential confounders—but biases of the estimations due to the imbalance in this characteristic cannot be completely ruled out.

A further limitation of the current study concerns the self-assessment procedure for the control competence for PA-related mood regulation. In health literacy research, these kinds of self-assessments are prevalent as they are applicable more economically than performance-based test procedures (Altin et al., 2014). However, a critical view onto the self-report method for control competence is worthwhile, as it is unclear to which extent the self-rated competence corresponds with actually competent decision making and behavior. For example, the self-assessment procedure might represent the belief in a person's own action capabilities to gear and apply the PA in a manner that brings about specific outcomes in the area of affective well-being. This could be a specific aspect of the task self-efficacy (Rodgers et al., 2008), which indeed is an important motivational prerequisite for competent behavior but does not represent the control competence as a whole (Sudeck and Pfeifer,

2016). Therefore, a combined capturing of competence through objective and subjective procedures should be aimed for. Such types of comprehensive assessment may include information on action-related knowledge and understanding (e.g., about body reactions under physical loads or about palliative coping strategies in connection with PA) as well as action-related skills and abilities (e.g., body awareness under physical load). Nonetheless, the present research results provide a reason for the test-economic use of the self-report questionnaire to gain insights into individual differences in control competence for PA-related mood regulation.

Implications for future research

The present study does not show how the observed phenomenon of the moderating role of control competence on PA-related mood regulation may be explained more precisely. Future studies should theoretically and empirically include processes that favor people with high control competence regarding PA-affect-association. Such people possibly use more effective strategies to bring to mind positive proximal affective outcomes expectancies (Klusman et al., 2016) or to perceive higher immediate utility of PA (Lee et al., 2016) even under unpleasant conditions. Furthermore, persons with high control competence may be inclined toward a positive regulation of well-being on the basis of stress- and recovery-related goals for PA (e.g., Markland and Ingledew, 1997). In that sense, mood regulation provides an immediate functional purpose, which in humans is associated with more positive affective response to PA (Lee et al., 2016) or higher experiences of autonomy, which promotes affective responses to PA in daily routine (e.g., Kanning et al., 2012). For further clarification, information on detailed characteristics of PA (e.g., intensity), subjective experiences with PA (perceived exertion, perceived immediate utility, autonomy experiences), or intentional processes (e.g., recovery intentions) is necessary. At the same

time, it needs to be clarified, which regulation processes take place unconsciously and automatically in daily routine (e.g., Rhebar, 2017).

Further implications concern interventional research in the area of individual-based PA promotion and health education. Future research needs to clarify how control competence with regard to psychological health and well-being can be targeted in educational interventions. For example, tools to capture affective well-being during PA could be used more often. This is already carried out for subjective ratings of perceived exertion (Borg, 1998) in order to train the regulation of physical loads autonomously. Interestingly, the American College of Sports Medicine (ACSM, 2011) recently recommended to apply affective responses as a secondary method to regulate physical loads, which requires an empowerment of the physically active person with respect to action-related knowledge and competences (e.g., in order to estimate the actual affective well-being adequately as well as to notice and interpret relevant body signals appropriately). Furthermore, experience based learning approaches could be used to help people experience strategies for the application of PA in daily routine for palliative stress coping or for a more diverse perception of perceived immediate utility or positive proximal affective outcome expectancies. Combined with this, interventions need to be proved that promote knowledge and understanding for subjectively relevant associations between PA and psychological health and well-being.

Conclusion

Within-person variations of PA in daily routine are substantially related to affective valence und energetic arousal in real life situations. This is meaningful in the short term as well as long term for the initiation and maintenance of physically active behavior and for psychological health and well-being. For feelings of calmness and the reduction of negative activation through PA, individual differences need to be taken into account even more,

whereas in the current study the control competence for PA-related mood regulation can be identified as a moderating factor. For interventional approaches, it is important to acknowledge these differences in individual control competence and to consider them for tailored intervention concepts. In this process, the applied self-assessment questionnaire can provide substantial information for the domain-specific diagnostics of PA-related health competence.

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Table 1

Descriptives and Sample Characteristics

	Initial sample (N = 72)			**Final sample (N = 64)**		
Variables	% or mean (SD)	Min	Max	% or mean (SD)	Min	Max
Gender (% men)	41.7%			42.2%		
Age	35.18 (11.93)	20	63	35.47 (12.30)	20	63
Higher education entrance qualification	88.9%			87.5%		
Country of origin other than Germany	8.3%			7.8%		
Body Mass Index	23.98 (3.25)	18.29	31.48	23.9 (3.19)	18.29	31.48
Normal weight ($18 \geq BMI \leq 25$)	70.8%			71.9%		
Overweight ($25 > BMI \leq 30$)	20.9%			21.9%		
Obese (BMI > 30)	8.3%			6.2%		
Regular exercise behavior (h/week)	3.23 (2.81)	0	11.50	3.47 (2.86)	0	11.50
No Exercise	15.3%			14.1%		
≤1 h/week	12.5%			10.9%		
>1-2 h/week	16.7%			14.1%		
>2-4 h/week	20.8%			21.9%		
>4 h/week	34.7%			39.1%		
PA-related mood regulation	3.20 (0.67)	1.25	4.00	3.19 (0.67)	1.25	4.00
	EMA					
Number of valid prompts	–	–	–	12.2 (2.32)	7	16
Mean accelerometer wear time (hours)	–	–	–	14.08 (2.14)	6.20	19.68

Note: EMA = Ecological momentary assessment

Table 2

Descriptive Statistics of the Time-varying Variables

		Between-person variability				**Within-person variability**		
Variables	ICC	N	M	SD	Empirical range	n	SD	Empirical range
				Daily physical activity				
Activity in 15-min period prior prompt (milli-g/min)	.053	64	76.24	26.14	18.86–171.62	780	75.06	19.27–158.23
				Affect dimensions				
Affective valence [0-6]	.300	64	4.22	0.63	3.24–5.64	780	1.07	0.37–1.71
Calmness [0-6]	.286	64	3.96	0.65	2.45–5.68	780	1.11	0.34–1.48
Energetic arousal [0-6]	.296	64	3.77	0.73	2.32–5.27	780	1.23	0.54–1.81

Note: ICC = Intra-class correlation

Table 3

Predicting the Three Dimensions of Affective Well-being by Within-person Variations of Daily Physical Activity (DPA; Level 1), and Control Competence for PA-related mood regulation (PAMR; Level 2) and the Cross-level Interactions between DPA and PAMR controlling for Weekday, Time of Day (both Level 1) as well as Gender, Age, BMI and Regular Exercise Behavior (all Level 2) (N = 64; n = 780)

	Affective valence				**Calmness**				**Energetic arousal**			
	Est.	**SE**	***t***	***p***	**Est.**	**SE**	***t***	***p***	**Est.**	**SE**	***t***	***p***
Level 1 (within-person)												
Intercept	4.175	0.129	32.36	<.001	3.841	0.127	30.23	<.001	3.590	0.139	25.97	<.001
Weekday	-0.083	0.082	-1.02	.306	-0.084	0.084	-1.00	.320	0.082	0.094	0.87	.384
Time of day (Squared)	0.003	0.002	1.15	.250	0.006	0.002	2.64	**.008**	-0.005	0.003	-1.81	.071
Daily physical activity (DPA)	0.0011	0.0004	2.42	**.016**	<.0001	.0005	0.14	.890	0.0013	0.0005	2.57	**.011**
Level 2 (between-person)												
Gender	0.148	0.179	0.83	.412	0.158	0.172	0.921	.361	0.496	0.186	2.67	**.010**
Age	0.022	0.007	3.39	**.001**	0.028	0.006	4.413	**<.001**	0.030	0.007	4.53	**<.001**
BMI	-0.053	0.029	-1.86	.069	-0.027	0.028	-0.96	.342	-0.094	0.029	-3.12	**.003**
Regular exercise behaviour	0.005	0.028	0.17	.869	-0.002	0.027	-0.09	.927	-0.009	0.029	-0.323	.748
PA-related mood regulation (PAMR)	-0.083	0.119	-0.70	.488	-0.118	0.114	-1.03	.308	-0.054	0.123	-0.439	.662
Cross-level interaction												
DPA x PAMR	0.0013	0.0007	2.01	**.041**	0.0021	0.0007	3.08	**.002**	0.0005	0.0008	0.67	.503

Notes: Estimates (Est.) based on fixed effects (RML); significant p-values ($p < .05$) are in boldface. Weekday: dummy-coded; Gender: 0 = women; 1 = men; DPA (milli-g/min) was within-person centered and time of day, age, BMI, regular exercise behavior as well as PAMR were grand mean centered before entering in HLM 7.0.

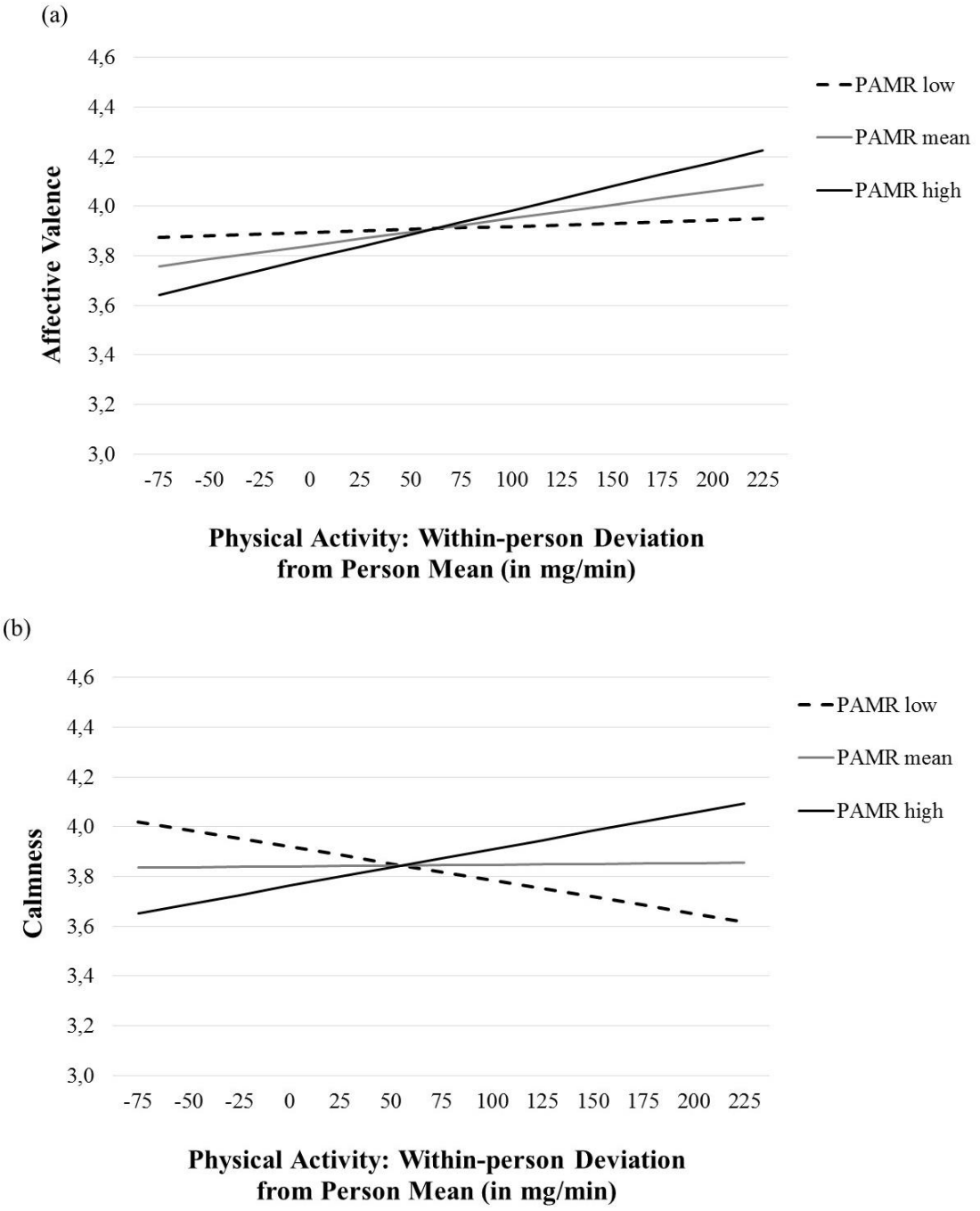

Figure 1. The cross-level effect of control competence for PA-related mood regulation (PAMR) and daily physical activity on (a) affective valence and (b) calmness. Low PAMR represents -1SD from the grand mean and high PAMR represents +1SD from the grand mean of PAMR. All other variables were included as grand mean (age, BMI, regular exercise behavior) or set to zero (representing a woman on a weekend day at the mid-time of the day [1 p.m.])

Supplementary material

The following equations represent the calculated hierarchical regression model:

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}*(\text{WEEKDAY}_{ij}) + \beta_{2j}*(\text{TIME OF DAY}^2_{ij}) + \beta_{3j}*(\text{DPA}_{ij}) + r_{ij}$ (1)

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}*(\text{GENDER}_j) + \gamma_{02}*(\text{AGE}_j) + \gamma_{03}*(\text{BMI}_j) + \gamma_{04}*(\text{RExB}) + \gamma_{05}*(\text{PAMR}_j) + u_{0j}$ (2)

Level 2: $\beta_{1j} = \gamma_{10}$ (3)

Level 2: $\beta_{2j} = \gamma_{20}$ (4)

Level 2: $\beta_{3j} = \gamma_{30} + \gamma_{31}*(\text{PAMR}_j)$ (5)

Level 1 represents within-subject effects. In equation 1, the subject's response for one of the three basic affect dimensions (VA, CA, EA; Y_{ij}) is represented. The dependent variable Y_{ij} is defined as the average intercept of a basic affect dimension across all subjects (β_{0j}) and the level 1 covariates (β_{1j}*WEEKDAY) and (β_{2j}*TIME OF DAY^2), and the main variable (β_{3j}*DPA). The random error value for the level 1 model is given by r_{ij}.

Level 2 represents between-person effects. Equations (2–5) include the fixed effects (γ) as the average intercepts and slopes of all participants. Equation 2 represents the control variables (γ_{01}*GENDER), (γ_{02}*AGE), (γ_{03}*BMI) and, (γ_{04}*RExB), the main variable (γ_{05}*PAMR) and the random effect (u_{0j}). Moreover, there is a cross-level interaction in equation 5 (γ_{31}*PAMR). All models are calculated as random intercept only models with a fixed slope at level 2.