Positive affective variables and physical activity: mediating effects, intervention techniques, and measurement

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Summary

Numerous studies suggest that physical inactivity can increase the possibilities of non-communicable diseases, such as diabetes, cardiovascular disease and some cancers. However, globally, 28% of adults and 81% of adolescents are not physically active enough. An empirical study indicates that approximately 50% of participants drop out of exercise programs within the first six months. Together with the fact that the health benefits cannot be maintained without regular physical activity, the public health burden of physical inactivity becomes even more pronounced. Although the psychological processes of participation and adherence to physical activity are major issues in sport and exercise psychology, there are still no sound solutions nor strategies to address them. Glanz & Bishop (2010) stated that theories are key for implementing interventions. Over the last three decades, four behavior change theories have been widely used to explore the initiation and maintenance of physical activity: the Theory of Planned Behavior, Self-determination Theory, Trans-theoretical Model and Social Cognitive Theory. However, a meta-analysis study suggested that these theories can only predict about 20% of physical activity variations (Amireault et al., 2013). Ekkekakis and Zenko (2016) argued that all these four theories can be classified as cognitivist theories. In these four theories, affective variables are either completely ignored or considered to be subordinate to the cognitive system. The idea that affective variables can be independent of general intelligence and act as a motivational force outside of cognitivism is ignored. In addition, the role of affective variables has been emphasized by affective heuristics as well as by a range of physical activity change theories which were developed based on dual-process models (e.g., Affective-reflective Theory, Physical Activity Adoption and Maintenance Model, and the Integrated Behavior Change Model). Given these backgrounds (the widespread of physical inactivity in our society; the role of affective variables in changing physical activity not having been explored fully), we have conducted a series of studies around affective variables and physical activity.

In **Study 1**, we focused on clarifying two concepts and exploring one research question. These two concepts are: a) what are “positive affective variables”: following Russell’s Circumplex Model (1980), we generalized non-negative affect, emotions, feelings, moods, and affective attitudes and used the term “positive affective variables” to refer to them; b) what is “physical activity”: lifestyle or recreational bodily movement produced by skeletal muscles that requires energy expenditure. With these two concepts clarified, we found that although the role of positive affective variables in physical activity has received increasing attention, none of the literature has systematically reviewed and quantified their mediating role. Hence, we conducted Study 1 - a meta-analysis - to address this question. This study was carried out to investigate the association between interventions and physical activity, using positive affective variables as mediating variables in healthy populations. The search strategy yielded 1732 papers potentially relevant to this study; 40 of these studies met the data extraction criteria for the meta-analysis mediation analysis. The extracted correlation

coefficient data were analyzed using two-stage structural equation modelling (TSSEM) in R to show that PAVs partially mediated the relationship between the intervention and physical activity. The results have been published in *Frontiers in Psychology*.

In **Study 2**, we sought to determine: which intervention techniques are effective/ ineffective in changing positive affective variables or physical activity? Complying with the PRISMA protocol, we scoured five electronic databases by April 1, 2020. The search identified 1,742 articles and 37 studies (49 datasets) that met our inclusion criteria. The random effects model in the Comprehensive Meta-Analysis Version 3 program was employed to conduct the analyses. Through this meta-analysis review, we found that: using the 'teaching the use of prompts/cues', 'facilitating social comparison' and 'providing information about general behavioral consequences' strategies had a positive impact on positive affective or physical activity outcomes; using the 'barrier identification/problem solving' and 'planning social support/social change' strategies had a negative impact on positive affective variables or physical activity outcomes. Although there were heterogeneities in the results of this study, it also has considerable implications for guiding future research on such interventions. The results have been published in *Frontiers in Psychology*.

In **Study 3**, we sought to explore a measure of a positive affective variable. Many researchers have highlighted the role of affective variables, in particular physical activity enjoyment (PA enjoyment), in physical activity. Therefore, it is of great interest to explore the measurement of PA enjoyment among young people. Hence, we conducted Study 3. The first problem we encountered when carrying out this study was that there was not yet a consensus on how to define PA enjoyment. In general, enjoyment can be regarded as an emotion. There has been a long debate about how to define emotions. One study collected a long list of definitions of emotions, but none of them have been universally accepted. However, most researchers agree that emotions always represent a valued state of relatively short duration and are associated with an object, person or activity. The Component Process Model of Emotion stated that there are five components of emotion: cognitive appraisals, physiological responses, action tendencies, motor performance, and feelings (also known as subjective experiences). These components are recursively influenced by the appraisal process, facilitating their consistency and synchrony. All these changes are then integrated and centrally represented as feelings, which are then further classified and labelled as emotional terms (e.g., PA enjoyment). In other words, the feeling component is considered to be the most central component of emotion, which distinguishes it from other mental states. Based on these theoretical considerations, we define PA enjoyment as "positive valanced emotion directed towards PA linked to subjective experiences such as fun, pleasure, and joy." Currently, the Physical Activity Enjoyment Scale (PACES) is the most widely used instrument for measuring PA enjoyment. The original version of the scale was developed by Kendzierski and DeCarlo (1991), and several versions have been developed. However, all these different versions of the PACES have, more or less, limitations, such as an inadequate conceptualization of PA enjoyment or the methodological issues with positively or negatively worded items. To address these limitations, we felt it would be useful to develop a simplified scale based on the most

widely used 16-item PACES, using the definition of PA enjoyment mentioned above as a starting point. Against these backgrounds, a preliminary Physical Activity Enjoyment Scale-Short (PACES-S) was developed, using content analysis (expert validity), driven by the Component Process Model, and measured its psychometric properties (construct validity, internal consistency, test-retest reliability, and concurrent validity) on the basis of two studies (Study 1 n=182; Study 2 n=3219). Four of the original 16 items were included in this one-dimensional PACES-S ("I enjoy it", "I find it pleasurable", "It is very pleasant", "It feels good"). The exploratory and validation factor analyses identified and supported its factorial validity ($\chi 2$ = 53.62, df = 2, p < 0.001; *RMSEA* = 0.073; *CFI* = 0.99; *RFI* = 0.96; *NFI* = 0.99; *TLI* = 0.96; *IFI* = 0.99). The PACES-S also showed good test-retest reliability (r = 0.76), internal consistency (a = 0.82-0.88), and concurrent validity. In summary, the PACES-S is a good instrument for measuring PA enjoyment with good reliability and validity, showing comparable measurement properties to the 16-item PACES. It has very positive implications for future intervention studies and data surveys with large samples of German adolescents. This study has been published in the *International Journal of Environmental Research and Public Health*.

In conclusion, by reflecting on cognitivist theories, this doctorial investigation focused its interests beyond cognitivism, i.e., hedonism and Dual-Process Models (System 1). A series of essential explorations have ensued. In Study 1, we determined the mediating role of PAVs in PA interventions. In Study 2, we identified several intervention techniques that had positive or negative effects on PAVs or PA. In Study 3, we developed and validated a new PA enjoyment measure, the PACES-S. Overall, as a systematic investigation of PAVs (PA enjoyment) and PA, this dissertation explored step-by-step a mechanism of PA intervention, strategies to improve PA, and how to measure PA enjoyment accurately. We hope that these groundworks, findings, and prospects can provide some evidence and ideas to support and inspire future PA surveys, interventions, and theory research.

Zusammenfassung

Zahlreiche Studien deuten darauf hin, dass körperliche Inaktivität das Risiko für nicht übertragbare Krankheiten wie Diabetes, Herz-Kreislauf-Erkrankungen und einige Krebsarten erhöhen kann. Weltweit sind jedoch 28 % der Erwachsenen und 81 % der Jugendlichen nicht ausreichend körperlich aktiv. Eine empirische Studie zeigt, dass etwa 50 % der Teilnehmer an Bewegungsprogrammen innerhalb der ersten sechs Monate wieder aussteigen. Zusammen mit der Tatsache, dass die gesundheitlichen Vorteile ohne regelmäßige körperliche Aktivität nicht aufrechterhalten werden können, wird die Belastung der öffentlichen Gesundheit durch körperliche Inaktivität noch deutlicher. Obwohl die psychologischen Prozesse der Teilnahme an und des Festhaltens an körperlicher Aktivität wichtige Themen in der Sport- und Bewegungspsychologie sind, gibt es immer noch keine fundierten Lösungen oder Strategien, um sie anzugehen. Glanz & Bishop (2010) stellten fest, dass Theorien der Schlüssel zur Umsetzung von Interventionen sind. In den letzten drei Jahrzehnten wurden vier Theorien zur Verhaltensänderung häufig verwendet, um die Aufnahme und Aufrechterhaltung körperlicher Aktivität zu untersuchen: die Theorie des geplanten Verhaltens, die Selbstbestimmungstheorie, das trans-theoretische Modell und die sozial-kognitive Theorie. Eine Meta-Analyse ergab jedoch, dass diese Theorien nur etwa 20 % der Schwankungen bei der körperlichen Aktivität vorhersagen können (Amireault et al., 2013). Ekkekakis und Zenko (2016) argumentierten, dass alle diese vier Theorien als kognitivistische Theorien eingestuft werden können. In diesen vier Theorien werden affektive Variablen entweder vollständig ignoriert oder als dem kognitiven System untergeordnet betrachtet. Die Vorstellung, dass affektive Variablen unabhängig von der allgemeinen Intelligenz sein und als motivierende Kraft außerhalb des Kognitivismus wirken können, wird ignoriert. Darüber hinaus wurde die Rolle affektiver Variablen durch affektive Heuristiken sowie durch eine Reihe von Theorien zur Veränderung der körperlichen Aktivität hervorgehoben, die auf der Grundlage von Dual-Prozess-Modellen entwickelt wurden (z. B. die affektiv-reflexive Theorie, das Physical Activity Adoption and Maintenance Model und das Integrated Behavior Change Model). Vor diesem Hintergrund (weit verbreitete körperliche Inaktivität in unserer Gesellschaft; die Rolle affektiver Variablen bei der Veränderung körperlicher Aktivität ist noch nicht vollständig erforscht) haben wir eine Reihe von Studien zu affektiven Variablen und körperlicher Aktivität durchgeführt.

In **Studie 1** haben wir uns darauf konzentriert, zwei Konzepte zu erklären und eine Forschungsfrage zu untersuchen. Diese beiden Konzepte sind: a) was sind "positive affektive Variablen": In Anlehnung an Russells Circumplex-Modell (1980) haben wir nicht-negativen Affekt, Emotionen, Gefühle, Stimmungen und affektive Einstellungen verallgemeinert und den Begriff "positive affektive Variablen" verwendet, um sie zu bezeichnen; b) was ist "körperliche Aktivität": Lebensstil oder körperliche Bewegung in der Freizeit, die von Skelettmuskeln erzeugt wird und Energieaufwand erfordert. Nach der Darstellung dieser beiden Begriffe stellten wir fest, dass die Rolle der positiven affektiven Variablen bei der körperlichen Aktivität zwar zunehmend

Beachtung findet, dass aber in der Literatur keine systematische Überprüfung und Quantifizierung ihrer vermittelnden Rolle vorgenommen wurde. Daher haben wir Studie 1 - eine Meta-Analyse - durchgeführt, um diese Frage zu klären. Diese Studie wurde durchgeführt, um den Zusammenhang zwischen Interventionen und körperlicher Aktivität zu untersuchen, wobei positive affektive Variablen als vermittelnde Variablen in gesunden Bevölkerungsgruppen verwendet wurden. Die Suchstrategie ergab 1732 Arbeiten, die für diese Studie potenziell relevant waren; 40 dieser Studien erfüllten die Datenextraktionskriterien für die Mediationsanalyse der Meta-Analyse. Die extrahierten Korrelationskoeffizientendaten wurden mit Hilfe der zweistufigen Strukturgleichungsmodellierung (TSSEM) in R analysiert, um zu zeigen, dass PAVs teilweise die Beziehung zwischen der Intervention und der körperlichen Aktivität vermitteln. Die Ergebnisse wurden in Frontiers in Psychology veröffentlicht.

In **Studie 2** wollten wir herausfinden, welche Interventionstechniken bei der Veränderung positiver affektiver Variablen oder körperlicher Aktivität wirksam/unwirksam sind. In Übereinstimmung mit dem PRISMA-Protokoll durchsuchten wir bis zum 1. April 2020 fünf elektronische Datenbanken. Die Suche ergab 1.742 Artikel und 37 Studien (49 Datensätze), die unsere Einschlusskriterien erfüllten. Zur Durchführung der Analysen wurde das Modell der zufälligen Effekte im Programm Comprehensive Meta-Analysis Version 3 verwendet. Die Meta-Analyse ergab, dass die Strategien "Erlernen der Verwendung von Prompts/Cues", "Erleichterung des sozialen Vergleichs" und "Bereitstellung von Informationen über allgemeine Verhaltensfolgen" einen positiven Einfluss auf positive affektive oder körperliche Aktivitätsergebnisse hatten; die Strategien "Identifizierung von Hindernissen/Problemlösung" und "Planung sozialer Unterstützung/sozialer Veränderungen" hatten einen negativen Einfluss auf positive affektive Variablen oder körperliche Aktivitätsergebnisse. Trotz der Heterogenität der Ergebnisse dieser Studie hat sie auch erhebliche Auswirkungen auf die künftige Forschung zu solchen Interventionen. Die Ergebnisse wurden in Frontiers in Psychology veröffentlicht.

In **Studie 3** wollten wir ein Maß für eine positive affektive Variable untersuchen. Viele Forscher haben die Rolle affektiver Variablen, insbesondere der Freude an körperlicher Aktivität (PA enjoyment), bei körperlicher Aktivität hervorgehoben. Daher ist es von großem Interesse, die Messung der Freude an körperlicher Aktivität bei jungen Menschen zu untersuchen. Aus diesem Grund haben wir Studie 3 durchgeführt. Das erste Problem, auf das wir bei der Durchführung dieser Studie stießen, war, dass es noch keinen Konsens darüber gab, wie Freude an körperlicher Aktivität zu definieren ist. Im Allgemeinen kann Freude als eine Emotion betrachtet werden. Es gibt eine lange Debatte darüber, wie Emotionen zu definieren sind. In einer Studie wurde eine lange Liste von Definitionen von Emotionen zusammengestellt, aber keine davon wurde allgemein akzeptiert. Die meisten Forscher sind sich jedoch einig, dass Emotionen immer einen bewerteten Zustand von relativ kurzer Dauer darstellen und mit einem Objekt, einer Person oder einer Aktivität verbunden sind. Das Component Process Model of Emotion besagt, dass es fünf Komponenten von Emotionen gibt: kognitive Bewertungen, physiologische Reaktionen, Handlungstendenzen, motorische Leistungen und Gefühle (auch als subjektive Erfahrungen bekannt). Diese

Komponenten werden durch den Beurteilungsprozess rekursiv beeinflusst, was ihre Konsistenz und Synchronität erleichtert. Alle diese Veränderungen werden dann integriert und zentral als Gefühle dargestellt, die dann weiter klassifiziert und als emotionale Begriffe bezeichnet werden (z. B. Freude an der PA). Mit anderen Worten: Die Gefühlskomponente wird als die zentralste Komponente der Emotion angesehen, die sie von anderen mentalen Zuständen unterscheidet. Auf der Grundlage dieser theoretischen Überlegungen definieren wir Freude an körperlicher Aktivität als "positiv bewertete Emotion, die auf körperliche Aktivität gerichtet ist und mit subjektiven Erfahrungen wie Spaß, Vergnügen und Freude verbunden ist". Derzeit ist die Physical Activity Enjoyment Scale (PACES) das am häufigsten verwendete Instrument zur Messung der Freude an körperlicher Aktivität. Die ursprüngliche Version der Skala wurde von Kendzierski und DeCarlo (1991) entwickelt, und es wurden mehrere Versionen entwickelt. All diese verschiedenen Versionen der PACES weisen jedoch mehr oder weniger Einschränkungen auf, wie z. B. eine unzureichende Konzeptualisierung von PA-Freude oder die methodischen Probleme mit positiv oder negativ formulierten Items. Um diesen Einschränkungen zu begegnen, hielten wir es für sinnvoll, eine vereinfachte Skala zu entwickeln, die auf der am weitesten verbreiteten PACES mit 16 Items basiert und die oben erwähnte Definition von Freude an körperlicher Aktivität als Ausgangspunkt verwendet. Vor diesem Hintergrund wurde eine vorläufige Physical Activity Enjoyment Scale-Short (PACES-S) mit Hilfe einer Inhaltsanalyse (Expertenvalidität) entwickelt, die sich auf das Component Process Model stützt, und ihre psychometrischen Eigenschaften (Konstruktvalidität, interne Konsistenz, Test-Retest-Reliabilität und konkurrierende Validität) auf der Grundlage von zwei Studien (Studie 1 n=182; Studie 2 n=3219) gemessen. Vier der ursprünglich 16 Items wurden in dieses eindimensionale PACES-S aufgenommen ("Ich genieße es", "Ich finde es angenehm", "Es ist sehr angenehm", "Es fühlt sich gut an"). Die explorativen und validierenden Faktorenanalysen ergaben und unterstützten seine faktorielle Validität ($\chi 2 = 53.62$, $df = 2$, $p < 0.001$; RMSEA = 0.073; CFI = 0.99; RFI = 0.96; NFI = 0.99; TLI = 0.96; IFI = 0.99). Der PACES-S zeigte auch eine gute Test-Retest-Reliabilität (r = 0.76), interne Konsistenz (a = 0.82-0.88) und gleichzeitige Gültigkeit. Zusammenfassend lässt sich sagen, dass der PACES-S ein gutes Instrument zur Messung des PA-Genusses mit guter Zuverlässigkeit und Validität ist und vergleichbare Messeigenschaften wie der 16-Item-PACES aufweist. Es hat sehr positive Implikationen für zukünftige Interventionsstudien und Datenerhebungen mit großen Stichproben deutscher Jugendlicher. Diese Studie ist im International Journal of Environmental Research and Public Health veröffentlicht worden.

Zusammenfassend lässt sich sagen, dass diese Doktorarbeit durch die Reflexion kognitivistischer Theorien ihre Interessen über den Kognitivismus hinaus fokussiert hat, d. h. auf Hedonismus und Dual-Process-Modelle (System 1). Daraufhin wurde eine Reihe von wesentlichen Untersuchungen durchgeführt. In Studie 1 haben wir die vermittelnde Rolle von PAVs bei PA-Interventionen ermittelt. In Studie 2 identifizierten wir mehrere Interventionstechniken, die positive oder negative Auswirkungen auf PAVs oder PA hatten. In Studie 3 entwickelten und validierten wir ein neues Maß für das PA-Vergnügen, den PACES-S. Insgesamt hat diese Dissertation als systematische

Untersuchung von PAV (PA-Genuss) und PA Schritt für Schritt einen Mechanismus der PA-Intervention, Strategien zur Verbesserung von PA und die genaue Messung des PA-Genusses untersucht. Wir hoffen, dass diese Vorarbeiten, Ergebnisse und Aussichten einige Belege und Ideen liefern können, die künftige PA-Erhebungen, Interventionen und theoretische Forschungen unterstützen und inspirieren.

Contents

Preface

Parts of this dissertation have been published. Hence, the following chapters are available to be read independently.

Chapter 2: Chen, C., Finne, E., Kopp, A., & Jekauc, D. (2020). Can Positive Affective Variables Mediate Intervention Effects on Physical Activity? A Systematic Review and Meta-analysis. *Frontiers in psychology*, 11, 2907. https://doi.org/10.3389/fpsyg.2020.587757

Chapter 3: Chen, C., Finne, E., Kopp, A., & Jekauc, D. (2021). What Intervention Techniques Are Effective in Changing Positive Affective Variables and Physical Activity? A Systematic Review and Meta-Analysis. Frontiers in Psychology, 12, 2197. https://doi.org/10.3389/fpsyg.2021.628993

Chapter 4: Chen, C., Weyland, S., Fritsch, J., Woll, A., Niessner, C., Burchartz, A., ... & Jekauc, D. (2021). A Short Version of the Physical Activity Enjoyment Scale: Development and Psychometric Properties. *International Journal of Environmental Research and Public Health*, 18(21), 11035. https://doi.org/10.3390/ijerph182111035

Chapter 1

General introduction

Physical activity (PA) has been classified as bodily movement and energy expenditure generated by skeletal muscles (Caspersen et al., 1985). Numerous studies suggest that regular PA can help prevent and control non-communicable diseases, like diabetes, cardiovascular disease, and some cancers (World Health Organization, 2020). It also helps to reduce sub-health states, such as maintaining a healthy weight, improving muscle, bone, and joint health, mental health, quality of life, and well-being. It is estimated that if the inactive population were to be reduced by 10% worldwide, more than half a million deaths could be prevented each year (Lee et al., 2012). The latest WHO guidelines recommend that healthy adults engage in at least 150 to 300 minutes of moderate-intensity aerobic PA (or 75 to 150 minutes of vigorous aerobic activity or a combination thereof), supplemented by muscle-strengthening activities at least two days per week (Organization, 2020). Healthy children or adolescents should maintain at least 60 minutes of moderate-intensity aerobic activity per day, supplemented by vigorous-intensity activities and muscle and bone-strengthening activities at least three times per week (Organization, 2020). However, globally, 28% of adults (Guthold et al., 2018) and 81% of adolescents (Guthold et al., 2020) are not physically active enough. Furthermore, an empirical study indicated that approximately 50% of participants drop out of exercise programs within the first six months (Annesi, 2003). Together with the fact that the health benefits cannot be maintained without regular PA (Kim et al., 2017), the public health burden of physical inactivity becomes even more pronounced.

Meanwhile, we often hear words like, “I keep doing exercise because it makes me feel happy.” The complex relationship between affective variables and PA is a constant topic. People feel different affective variables from PA, and various affective variables can affect PA initiation or maintenance. Exploring the mechanisms and effects of affective variables on PA may have tremendous implications for addressing the public health problems caused by inadequate PA in modern society. For these reasons, in the following general introduction, we collated literature developments regarding three major questions:

- The inspirations for this doctoral research topic: the deficiencies of cognitivist theories in PA intervention applications; other theories have affirmed the importance of affective variables for PA interventions: affect heuristic, PA-related Dual-Process Models.
- Key concepts in this doctoral research: the definition of “(positive) affective variables (PAVs)” as well as of “PA enjoyment.”
- The gaps in existing researches: inconsistent results of the mediating mechanisms of positive affective variables (PAVs) between intervention and PA in empirical studies; insufficient exploration of the effectiveness of intervention techniques for

PA and PAVs' intervention; deficiencies in different versions of the Physical Activity Enjoyment Scales. And what could we do?

1 Escape from cognitivism: the unfavorable commonality in mainstream physical activity change theories

Although the psychological process of participation and adherence to PA is a primary question in exercise psychology and has been extensively investigated, worldwide inactivity has not been well addressed. Research reviews on changing various health behaviors have shown that theories are critical to implementing interventions (Glanz & Bishop, 2010). Over the past nearly three decades, four behavior change theories have been widely used to explore the initiation and maintenance of PA behaviors: the Theory of Planned Behavior (TPB; Ajzen, 1991), the Self-Determination Theory (SDT; Edward L. Deci et al., 1994), the Trans-theoretical Model (TTM; J. O. Prochaska & Velicer, 1997), and the Social Cognitive Theory (SCT; Bandura, 1998). However, a meta-analysis study pointed out that these theories can only predict about 20% of PA maintenance variations (Amireault et al., 2013). Accordingly, psychological theorists have pointed out that these theories suffer from two drawbacks: (1) essentially, they overlap to a large extent and merely use different terms to describe common constructs (Bandura, 2004); (2) these constructs are all cognitive appraisals and therefore tend to have considerable common variance. To present these two deficiencies more concretely, Ekkekakis and Zenko (2016) enumerated some of these constructs and related research questions:

> What is my *perception* of threat? What is my *perceived* possible benefit from initiating the healthy behavior or the cost from neglecting it? What is the *perceived* confidence in my ability to carry out the recommended behavior? What are the *perceived* expectations or likely support of important others? (p. 393-394)

Therefore, Ekkekakis and Zenko (2016) categorize these four cognitivist theories.

The mind-as-computer analogy greatly inspires cognitivist theories. This analogy regards diverse psychological input as information, and psychological and behavior decision processes as using the information to perform algorithms on computers, based on unique rules (Gigerenzer & Goldstein, 1996). In other words, these theories assume that human beings are capable of collecting and storing any relevant information, then processing it in a rational and predictable manner, and generating PA behavior based on that information. However, these theories are valid on two premises: (1) there is no other pathway to determine PA behavior other than these theoretical cognitive processes, and (2) if the PA behavior is not well facilitated, it can be corrected by providing additional, more accurate information to the process (Ekkekakis & Zenko, 2016). In turn, this implies that affective constructs are overlooked in these four public health theories. In detail, this occurs in two ways: (1) the affective constructs have been wholly omitted; (2) the affective constructs have been subordinated to the omnipotent cognitive

apparatus. For example, within the TPB, Ajzen and Fishbein (2005) argued that human behavior is rational and that people's behavioral intentions align with the beliefs that perform the behavior; and that irrational behavior results from belief bias due to insufficient or flawed information input. Similarly, in SCT, human behavior is considered to be the result of weighing the effort required, the corresponding risks and benefits, and the subjective probability of obtaining the desired outcome (Bandura, 1986, p. 19). And irrational behavior can be explained by four reasons: underdeveloped cognitive systems, inadequate information, incomplete consideration of available options, or misunderstanding of information. Although the transformation model does not state that all behaviors are rational (James O. Prochaska, 2008, p. 847), it is still cognitivist in nature. As James O. Prochaska et al. (1994, p. 44) pose, the critical point of behavioral improvement is that an individual assesses and identifies that the anticipated advantages of the behavior would outweigh the anticipated disadvantages. And the reason for irrational behaviors in this model is an incomplete information input (e.g., not fully recognizing the advantages and disadvantages of PA). Finally, we come to SDT, which is commonly described as a motivational or humanistic theory rather than a cognitive theory. For many sports psychologists it is distinct from the other three theories, because it assigns a central role to intrinsic motivation, a construct that is typically operationalized by evaluating the degree of enjoyment associated with behavioral choices. However, Ekkekakis and Zenko (2016, pp. 397–399) argued that SDT integrates goal setting (meaningful rationale/information) (Edward L. Deci et al., 1994; Moller et al., 2006; Rigby et al., 2014; Ryan et al., 1997) into the symbolic representations of cognitivism (E. L. Deci, 1975, p. 16), and cognitive appraisal underpins the whole fundamental constructs (autonomy, competence, relatedness) of this theory. In addition, it claimed that affective constructs constitute information that is subject to cognitive processing rather than directly influencing behavior (E. L. Deci, 1975, p. 97; Ekkekakis & Zenko, 2016, p. 401). For these reasons, Ekkekakis and Zenko concluded that SDT is also fundamentally cognitivist.

In conclusion, among the four theories of PA change described above, affective variables have either been entirely omitted or subordinated to cognitive devices. And the idea that affective variables can be independent of general intelligence and act as motivational forces beyond cognitivism (e.g., momentary affect linked to PA; Ekkekakis, 2017) has been overlooked.

2 The importance of (positive) affective variables in physical activity

Researchers increasingly recognize the importance of affective variables in PA. Next, we will illustrate the importance of affective variables (which can also be described as 'affective heuristic' or 'affective response') in PA by outlining the affect heuristic and the Dual-Process Models associated with PA.

2.1 Affect heuristic

The affective heuristics (Finucane et al., 2000; Slovic et al., 2007) have received particular attention in the promotion of PA. The affective heuristic allows people to rely on their initial affective response to a stimulus to make effective judgments and decisions. Conceptually, the affective heuristic is analog to the somatic marker hypothesis (Damasio, 1994). The hypothesis states that somatic marking may increase the accuracy and efficiency of the decision-making process (Damasio, 1994, p. 173). Through learning, experiences are 'labeled' as positive or negative and predict possible future consequences. Somatic markers can influence complex decision-making, be it either consciously or unconsciously.

In general, decisions can be divided into two types of processes: the first is where the affective heuristic can occur independently of a more effortful cognitive assessment; the second is where the cognitive assessment occurs more slowly and can either endorse or override the initial affective heuristic response (Slovic et al., 2002). PA behavior was more likely to occur when a person had an immediate positive affective response to an exercise-related stimulus; and vice versa. Research has supported the notion that the affective response is the first reaction to a stimulus and occurs prior to complex cognitive assessment. Zajonc, an early and strong proponent of the importance of affective variables in decision making, argued that affective responses (variables) to stimuli are often the initial response, automatically occurring and then guiding information processing and judgment (1980). Affective variables can help us quickly and effectively guide the direction of decisions in complex, uncertain environments (Mellers, 2000).、

2.2 Dual-Process Models

With the cognitive revolution, the conceptualization of "dual processes", referred to by post-cognitivist theorizations, may address the above-mentioned theoretical issue. From a modern historical perspective, the Dual-Process Models of human reasoning and related higher cognitive processes, such as judgment and decision making, is thought to derive primarily from the development of two discourses (Frankish & Evans, 2009, p. 14): (1) Reber's Dual-Process Theory of learning, which distinguished between implicit and explicit learning processes (Reber, 1993); (2) the dual-process descriptions of deductive reasoning, which distinguished between unconscious and conscious processes and referred to them as "type 1" and "type 2" processing, respectively (J. St BT Evans, 1977; Jonathan St BT Evans, 1989; J. St BT Evans & Lynch, 1973; J. St BT Evans & Wason, 1976; Lucas & Ball, 2005). In particular, J. St. BT Evans (1977) observed that logical processes appear to be in competition with non-logical biases in determining the behavior of diverse deductive reasoning tasks. Since then, psychological researchers have proposed several dual-process theories on various topics, such as deductive reasoning, social judgment, and decision making. Although these theories vary in forms, they share a commonality: they propose two different processing mechanisms for a given task (Jonathan St BT Evans & Frankish, 2009, p. 2). These two processes (labeled as "System 1" and "System 2"; Stanovich, 1999) employ

different procedures and may produce different and sometimes conflicting results. System 1 uses algorithms and prescriptive rules, which are relatively slow, laborious, analytical, and require conscious control, whereas System 2 is intuitive, fast, affective, mostly automatic, and less likely to be conscious (Slovic et al., 2004). So far, the Dual-Process Models have inspired two PA-related theories, namely the Affective-Reflective Theory (ART; Brand & Ekkekakis, 2018) and the Physical Activity Adoption and Maintenance Model (PAAMM; Strobach et al., 2020).

The ART (Brand & Ekkekakis, 2018) overlaps with the affective heuristic and somatic marker hypotheses and serves as a promising dual-process theory for explaining and facilitating PA. This theory posits that stimuli associated with PA (e.g., thoughts about PA, cues to PA, memories of PA sessions, images associated with PA) trigger automatic associations and the automatic positive or negative affective responses associated with PA. The elicitation of automatic associations and affective responses is rapid, unaffected by the cognitive appraisal, and is a consequence of Type I processing. These initial responses appear to occur without input from the higher cognitive control system, with affective responses determining Type I processes. Likewise, the PAAMM (Strobach et al., 2020) highlights the role of automatic, affective heuristic responses. These affective responses are categorized as implicit processes that arise spontaneously and are not reliant on thoughtful deliberation. In detail, the PAAMM assumes that implicit processes (e.g., affective variable) are the default responses underlying explicit processes (i.e., intentions, trait self-regulation, executive functions) (Brand & Ekkekakis, 2018). The implicit process may influence the explicit system depending on the strength of affective responses and the availability of self-regulatory capacity (Strack & Deutsch, 2004). If self-regulatory capacity is adequate, then the implicit process (e.g., affective variable) may influence but not overwhelm explicit processing; if the availability of self-regulatory capacity is low, the implicit process is expected to dominate behavior. The implicit process (affective response) plays an essential role in initiating and maintaining PA, especially during maintenance. Altogether, both the ART and PAAMM emphasize that automatic, affective variables are influential in PA behavior.

3 The definitions of (positive) affective variables and enjoyment

A vital prerequisite for exploring PA as a hedonic experience is to fully understand and distinguish the varying affective variables.

3.1 The definition of (positive) affective variables

In general, this dissertation considers affective variables to encompass affect, emotion, mood, feeling, and affective attitude (Chen et al., 2020, 2021). These notions are often used interchangeably in empirical studies (Batson et al., 1992), and they all have positive and negative dimensions (Cacioppo & Gardner, 1999; Watson et al., 1999).

Broadly speaking, "affect is the experiential state of feeling and is a collective term describing feeling states such as emotion and mood" (Gellman & Turner, 2013). Although this view considers emotion, mood, and feeling all to be affect, it does not mean that these concepts are indistinguishable. The main differences between emotions and moods are the variation in duration and intensity (emotions are fairly brief and intense, moods last considerably longer but are not that intense) and whether they are caused by a specific occurrence or event (emotions are responses to specific external stimuli, moods tend to be more diffuse in nature). The concept of attitude is slightly different. It is considered to represent relatively enduring beliefs and preferences about a particular organism and contains cognitive, affective, and motivational components (Breckler, 1984). Although theorists have emphasized that these notions should be treated separately (Ostrom, 1969), it is challenging to rigorously distinguish them in empirical studies (Batson et al., 1992). Therefore, we generalized these notions as "affective variables."

Watson et al. (1999) and Cacioppo and Gardner (1999) pointed out that affective variables can be conceptualized in the form of several independent dimensions, such as positive and negative activation. Results from existing empirical studies (including some neuroscience studies) suggested that the relationship between the approach-avoidance distinction and behavior is applicable to the positive and negative affect variables and PA (Davidson, 2003; Lochbaum & Stevenson, 2014; Watson et al., 1999). Fredrickson's Broaden-and-build Theory (Compton, 2005, pp. 23–40) also mentioned the positive impact of positive affect variables on PA: positive affect variables build a set of endogenous resources, which in turn amplify the positive affect variables experienced in positive health behaviors and ultimately reinforce non-conscious motivation. Therefore, the mechanisms and applications of positive affect variables and interventions are worth exploring, both from a theoretical as well as a practical perspective. Following Russell's Circumplex Model (1980), we generalized non-negative affect, emotions, feelings, moods, and affective attitudes and used the term "PAVs" to refer to them.

3.2 The definition of physical activity enjoyment

The PA enjoyment can generally be seen as an emotion. The Component Process Model states that an emotion contains five components (K. R. Scherer, 1987): a subjective experience, physiological responses, cognitive appraisal, action tendencies, and motor expressions. These components gradually have consistency and synchrony over repetitive evaluation processes (K. R. Scherer, 1987; Klaus R. Scherer, 2001). Further, they are integrated and centrally expressed as subjective experiences (Klaus R. Scherer, 2001), which are then further categorized and labeled as emotional terms (e.g., enjoyment). The subjective experience component is considered to be the most central component of emotion and the primary distinction between emotion and other psychological states (Klaus R. Scherer, 2005). Thus, in this dissertation, PA enjoyment was defined as positive valanced emotion directed towards PA linked to subjective experiences, such as fun, pleasure, and joy (Jekauc et al., 2020).

4 The gaps in existing research

Although the research on PA interventions related to PAVs has been flourishing and deepened in the last decade, some research gaps remain.

4.1 Inconsistent results of the mediating mechanisms of positive affective variables between interventions and PA in empirical studies

Although theories such as ART, PAAMM, and Broaden-and-build Theory have affirmed the role of PAVs in PA initiation or maintenance; Lewis et al. (2002), Rhodes and Pfaeffli (2010), and Murray et al. (2018) have also reviewed multiple empirical studies and attempted to answer the question of whether PAVs can act as mediating variables between interventions and PA. Their results have been inconsistent. In detail, Lewis et al. (2002) reviewed studies of PA interventions mediated by PAVs, and two of the three included studies presented non-significant results. Murray et al. (2018) also explored mediators of behavior change maintenance in PA interventions among young and middle-aged adults, with approximately half of the included studies showing that PAVs can act as mediators of PA behavioral interventions. The other half showed no significant results. Rhodes and Pfaeffli (2010) explored mediators of change in PA behavior in non-clinical adults, and the included studies also presented mixed results. There was no synthesis of quantitative analyses to discern whether the PAVs can be used as mediating variables for interventions and PA. Therefore, a meta-analysis exploring this question was warranted.

4.2 Uncertainty about the effectiveness of each intervention technique on physical activity and positive affect variables

A large number of empirical studies (Ekkekakis et al., 2013; Ekkekakis et al., 2020; Rhodes & Kates, 2015) have demonstrated the positive effects of PAVs and PA, but which interventions are positive and effective for both PAVs and PA, and which are likely to have adverse effects on them? In 2019, Rhodes et al. explored interventions that manipulated affective judgments and subsequent PA in healthy and unhealthy adults, but no intervention technique emerged as significantly effective. Two concerns were raised: 1. the simultaneous inclusion of healthy and unhealthy populations may influence the significance of the results, as some diseases (e.g., Alzheimer's disease) may alter subjects' affect regulation (Bucks & Radford, 2004); 2. intrinsic motivation, intrinsic regulation and affect as distinct concepts probably require separate studies. Building on these, we expected to target healthy populations to understand which intervention techniques were most or least effective in manipulating PAVs and PA.

4.3 Limitations in different versions of Physical Activity Enjoyment Scales

Sport and exercise psychologists are enthusiastic about measuring the PA enjoyment, as one of the most commonly used PAVs, accurately. However, there were still a few unaddressed issues in developing the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991). For example, factor analyses of the 18-item PACES indicated that the scale was not unidimensional (Kendzierski & DeCarlo, 1991); the 16-item PACES (the most widely used version) fit a unidimensional model, but there were methodological effects behind the positively worded items (Motl et al., 2001); the 8-item PACES reported only item-total correlations without attempting to determine other psychometric properties (e.g., construct validity, test-retest reliability, and concurrent validity) (Raedeke, 2007); and the 7-item scale relied excessively on statistical techniques without assessing content validity (Dishman et al., 2005). To address these limitations, we considered that it might be helpful to develop a new, shortened scale based on a clear definition of PA enjoyment and the 16-item PACES.

5 Purpose and summary

In 2016, Rebar et al. incorporated 52 studies for a review and the results demonstrated that PA is partly regulated by non-conscious processes (e.g., automatic affective associations). The study pointed out that there were still questions requiring answers across this research area. For example: how can the conceptualization and measurement of non-conscious conditioning processes be refined, and how can non-conscious conditioning processes be used to promote PA? Besides, to improve global public health, WHO released its global action plan on PA from 2018 to 2020, with at least two of the 20 action plans emphasizing the importance of enjoying PA (World Health Organization, 2018). Given that previous work needs further refinement and that policy and theoretical scholars have pointed out the substantive importance of PAVs for PA interventions, a series of studies addressing these issues is warranted. We, therefore, planned three studies in response to the research gaps described above. The objectives of these studies were:

Study 1: To systematically review and quantitatively analyze the mediating role of PAVs in PA interventions.

Study 2: To examine each behavior change technique's effectiveness in modifying PAVs and PA.

Study 3: Using content analysis to develop a new, theory-driven short Physical Activity Enjoyment Scale and subsequently measure its psychometric properties for adolescents.

Chapter 2

Study 1: Can Positive Affective Variables Mediate Intervention Effects on Physical Activity? A Systematic Review and Meta-analysis

1 Introduction

A growing body of empirical research shows that regular physical activity (PA) is effective in improving a range of clinical and non-clinical health-related outcomes, including metabolic disorders (Denham, O'Brien, and Charchar 2016), cardiorespiratory fitness (Shuval et al. 2014), arterial stiffness (Boreham et al. 2004) and physical and psychological well-being (Penedo and Dahn 2005). Indeed, though PA is so fundamental to human's health, a minority of adults report engaging in PA at a level compatible with public health guidelines, countering the 50% of people who stop exercising within the first six months of starting an exercise program (Finne, Englert, and Jekauc 2019). Physical activity maintenance has proven to be a daunting and enduring challenge for PA and public health professionals, as the benefits of PA depend entirely on constant engagement (J. Annesi 2003). Therefore, the psychological mechanism that underlies PA persistence has come into sharp focus.

To date, the dominant theoretical approaches employed to intervene in PA include the social cognitive theory (Bandura 1998), the theory of planned behavior (Ajzen 1991), and the transtheoretical model (Prochaska and Velicer 1997). However, even as the most predictable framework, social cognitive theory, on average, can only explain 20% of the variance in PA maintenance (Jekauc et al. 2015). The dominance of these theories hinders the development of theories, because they focus merely on cognitive mechanisms and neglect the role of affective variables (Jekauc and Brand 2017). Thus, an extension of the theories for affective variables seems inevitable (Jekauc et al. 2015). Considering that many exercisers are susceptible to negative affects during PA procedures (Ekkekakis and Acevedo 2006; Rose and Parfitt 2010), an emphasis on positive affects may have a positive impact on adherence to exercise with inevitable motivational effects. Somewhat also related to this notion, Parfitt and Hughes (2009) elucidated the implications of the peak-end rule, which states that the affective experience of an exerciser can have a potent effect in guiding future participation decisions (Williams et al. 2012) via the proposed mechanism of affective memory (Fredrickson and Kahneman 1993).

Primarily, the words emotional or affective apply, to varying degrees, to an ill-defined, board, and heterogeneous aggregate of phenomena (Fehr and J. A. Russell 1984). Today, we consider the term of affect concerning a neurophysiological state that is consciously accessible as a pure primitive non-reflective feeling (J. A. Russell and Barrett 1999). In contrast, emotion refers to feelings that are typically brief, intense, and attributable to an apparent cause (Beedie, Terry, and Lane 2005). Rather than

thinking about emotional feelings in terms of categories, an alternative way to organize them is to arrange them along dimensions. Emotions can be conceptualized in the form of several dimensions, and these dimensions can be independent of each other, such as positive and negative activation (Watson et al. 1999), or positivity and negativity (Cacioppo and Gardner 1999). According to existing research, the proximity-avoidance distinction is applicable in emotions (positive and negative affective dispositions) (Watson et al. 1999), and the neurological basis for this distinction between motivation and emotion has been demonstrated through affective neuroscience (Davidson 2003). As stated by Larsen et al. (2008, 189), "motivation and valence tend to be correlated, such that positive emotions are associated with approach and negative emotions with avoidance." For these reasons, we will concentrate on affective variables, not on negative affective variables. In other words, this paper will generalize non-negative, positive affects, emotions, and feelings, and will use the term positive affective variables (PAVs) to refer to them.

The effects of PAVs have been subject to investigation in behavior change contexts, resulting in several theoretical and empirical studies. According to van Cappellen et al. (2018), the upward spiral theory of lifestyle change states that positive affect experienced during health behaviors increases incentive salience for cues associated with those behaviors, which in turn, implicitly guides attentions and the everyday decisions to repeat those behaviors. Fredrickson's broaden-and-build theory argues that positive affect builds a suite of endogenous resources, which may, in turn, amplify the positive affect experienced during positive health behaviors and strengthen the nonconscious motives. Similarly, consistent with hedonic theories of behavior (Cabanac 1992), where persistent behaviors are considered to be determined by positive reinforcement, core affective valence in response to PA has been posited as an essential determinant of future PA behavior (Bryan et al. 2007; Williams 2008). Empirical studies also supported this idea; for example, Klusmann et al. (2015) found that the fulfillment of emotional outcome expectancies emerges as a significant predictor of adoption and maintenance of PA. Similarly, Schutte et al. (2017) found that positive affective responses were associated with higher amounts of regular exercise activity and that this association was accounted for by an overlap in genetic factors influencing affective responding and exercise behavior.

In contrast to the broad evidence base for PAVs' effectiveness, relatively few studies have tested the mechanisms of PAVs in exercise interventions. Mediators have been defined as intervening variables in the causal process or pathway between intervention and PA (Diener and Emmons 1984). Given its propensity to optimize intervention effects through identifying potential psychological mechanisms underlying PA intervention, matching exercise intervention prescription to the theoretical framework, and strengthening active components of interventions during PA seems reasonable. It is a worthy venture to investigate PAV as a mediator of PA outcome (Kazdin 2007).

So far, three reviews have summarized the classification of mediators of PA (Lewis et al. 2002; J. M. Murray et al. 2018; Rhodes and Pfaeffli 2010); however, research into the mediation role of PAV have been narrow, incomplete, and problematic,

due to the somewhat limited sample size. For instance, Lewis et al. (2002) examined three studies that investigated enjoyment as a mediator of intervention and PA and indicated that two of them were not significant. J. M. Murray et al. (2018) integrated findings with experimental data to propose that the mechanism through emotion works, and wherein half of the empirical studies reported significant findings. Nonetheless, Klos et al. (2020) and Rhodes and Pfaeffli (2010) showed moderate evidence of interventions in increasing enjoyment and PA. In contrast, the mediating effect of PAV in exercise interventions remain to be examined. Therefore, the purpose of this study is twofold. First, it aims to systematically review studies of PA interventions that use PAV as the mediating variable to evaluate and provide general summaries (study, participant, measurement, and intervention characteristics) of these studies. Of which, study and participant characteristics include research setting, PA level at baseline, percentage of female subjects, sample size, and mean age; measurement characteristics include types and methods of PA and PAV measurement; intervention characteristics include theory, length of intervention, and behavior change techniques used in each study). Second, it aims to statistically synthesize evidence for the mechanism of the effect of PAV on PA outcome. The combination of statistical synthesis and narrative summaries of existing mediation findings will allow us to draw more reliable and comprehensive conclusions about how PAVs improve PA, compared to using either one of these techniques in isolation (Gu et al. 2015).

2 Methods

2.1 Search strategy

A protocol using the PRISMA standards (Moher et al. 2009) was completed before initiating the literature search (**Figure 1-1**). A comprehensive search of published studies up to 01/04/2020 was conducted using the following electronic databases: Web of Science, PubMed, PsycINFO, PsycArticle, and Psychology and Behavioral Sciences Collection. The search term was: (1) Intervention OR Trial OR Experiment; (2) Physical Activity OR Exercise; (3) Enjoy* OR Affect* OR Emotion* OR Mood* OR Feeling; (4) Mechanism* OR Mediat* OR Predict* OR Process* OR "Structural equation modelling" OR Caus* OR Path* OR Correlat* OR Relationship OR Associat*; (5) NOT (Patient* OR Cancer OR clinical OR disease* OR Illness OR Depression OR Rat OR Mouse OR Protocol OR Cell OR Bone* OR Blood OR Rehabilitation OR Disorder* Injur* OR HIV OR Carbohydrate OR Athlete* OR Player* OR Runner* OR Review OR Comment OR Therapy); (6) 1 AND 2 AND 3 AND 4 AND 5.

For inclusion, each study was required to meet the following criteria: (1) intervention studies that assessed the PAV as a putative mediator of PA; (2) studies' objectives were to increase lifestyle or recreational PA through affective variables not for competitive sports or fitness; (3) information needed to calculate effect sizes must have been made available for PAVs and PA (PA measurement could be self-reported or

objective measured, e.g., accelerometer readings); (4) participants are from a healthy population (non-clinically defined populations, obese or pregnant populations were also excluded); (5) written in English;(6) original, peer-reviewed studies. Furthermore, similar dimensions (e.g., positive affect, PA enjoyment, PE enjoyment, revitalization, positive engagement, and remembered pleasure) were identified as PAVs, and negative affective variables were excluded. We intentionally selected the shortest duration of 10 minutes for PA, given that 10 minutes is the shortest recommended duration of exercise to elicit health benefits (Edwards and Loprinzi 2019).

To evaluate mediators between intervention and PA, an additional criterion was established based on J. M. Murray et al. (2018). An included study had to involve at least one of the following: "(a) formal mediation tests, (b) examined association of putative mediators (or mediator changes) with PA outcomes (or PA changes), (c) examined intervention effects on putative mediators".

2.2 Data extraction and data analysis

Searches were completed and the eligibility of each study was determined by the first author. Abstracts were cross-checked against the inclusion criteria. Where the first author was unsure of relevance, the abstract was retained, and decisions regarding inclusion and exclusion were resolved by discussion with the last author. A study that can fulfill the data extraction criteria below is eligible for our meta-analysis.

According to Stone et al. (2019), stratification by quality in meta-analysis leads to a form of selection bias (collider stratification bias), and it is recommended for inclusion in all eligible studies rather than removing studies with low-quality ratings. Therefore, this paper does not evaluate and grade the studies' quality but includes all eligible studies.

To understand how change occurs during interventions, evaluating mediation effect is essential (i.e., how an intervention (X) influences an outcome (Y) through a mediator (M)) (Kazdin, 2007). Accordingly, we used a two-stage structural equation modeling (TSSEM) approach to test how interventions trigger the critical PA change process to influence outcomes (M. W.-L. Cheung 2014). The metaSEM package in R was used to perform our analyses (M. W.L. Cheung 2019). In the first stage, we combined the relative effect sizes into matrices to calculate a pooled correlation matrix; the second stage involved treating the pooled matrix as the observed correlation matrix and fitting a structural mediational model to the matrix to test the fit of the model to the data. The specification of any structural model in the metaSEM package is done by using two matrices, of which matrix A specifies all regression coefficients in the model, and matrix S specifies all variances and covariance in the model (McArdle and McDonald 1984). The procedure used is as explained by Jak (2015).

In the preparation phase, the bivariate correlations between X (intervention versus control/pre-intervention), intervention change in PAVs (M), and PA (Y) were extracted from each relevant study. If a study did not explicitly report bivariate correlation coefficients, we used t-statistics, F-statistics, means, standard deviations, and effect sizes to calculate bivariate correlations (Lipsey and Wilson 2001). Studies in

which only reporting regression coefficients were omitted from the mediation analysis, as results from both the existing meta-analysis and the Monte Carlo simulations revealed that beta estimation procedures were associated with potentially significant biases (Peterson and Brown 2005; Roth et al. 2018). To ensure that the observations in the sample were independent (J. E. Hunter and F. L. Schmidt 2004), only one PAV/PA outcome was selected from each study to enable bivariate correlations to be extracted. Although it would be possible to calculate mean correlations across multiple outcomes in a single study, it would not be straightforward to determine the appropriate sampling variance of averaged correlations. Besides, we collected descriptive data from the included studies, such as setting, subjects' PA level at baseline, percentage of female subjects, the theoretical basis of the intervention, and PAV and PA measurement types and methods. In particular, the PA level at baseline can be divided into four categories according to whether the subjects meet a PA guideline (which can be defined arbitrarily by each study): not meeting PA guideline at baseline, meeting PA level at baseline, mixed and unreported. In order to gain a clearer understanding of the studies' intervention methodologies, we extracted data for each study's behavior change techniques based on Michie et al. (2011) 40-item taxonomy. The coding of the behavior change techniques was also primarily done by the first author, but for those coding that could not be determined by the first author, decisions were discussed with the last author.

3 Results

3.1 Study flow and characteristics

The search strategy generated 1732 papers potentially relevant to this study; we excluded 1692 papers following the eligibility criteria (e.g., unrelated topics, chronic condition, qualitative studies, insufficient data). After initial exclusions, there were 176 articles for full-text review, of which 11 were identified by cross-referencing. Of the 40 included studies which fulfilled the data extraction criteria of meta-analytic mediation analysis (see **Figure 1-1** and **Appendix 1-3**), two included a measure of two independent subgroups (Digelidis et al. 2003; Hutchinson et al. 2018b). Hence, a total of 42 data sets were elicited for analyses.

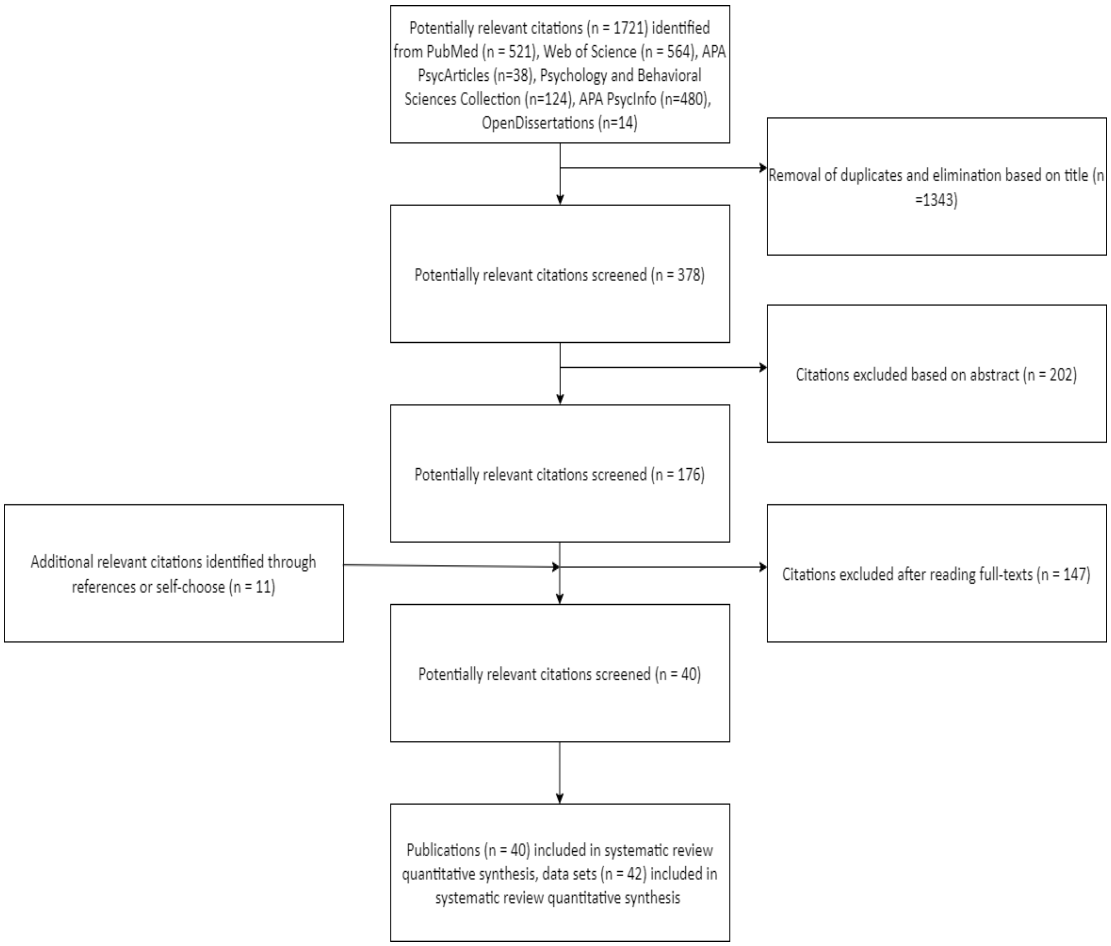

Figure 1-1. PRISMA flow diagram for articles identified, screened eligible, and included in this paper

A summary of the data from the 40 articles included in this paper is presented in **Appendix 1-1**. In terms of the participants' age, four age intervals were designed for distinguishing and classifying the mean age of each study; they are the interval of study mean age below 18 (n = 18), the interval of study mean age between 18 and 35 (n = 13), the interval of study mean age between 36 and 60 (n = 7), and the interval of study mean age over 60 (n = 2). In terms of gender distribution, just one study identified its gender as male and ten studies delimited their gender as female, the genders of the subjects in the remaining twenty-eight studies were mixed. In terms of physical activity at baseline, we marked out four classifications as "not meeting PA guidelines at baseline" (n =18), "meeting PA guideline at baseline" (n = 3), "mixed" (n = 9), and "unreported" (n = 10). Besides, the primary constructs of mediating variables (PAVs) measured in these studies were enjoyment (n = 25), affect (n = 5), affective attitude (n = 4), affective valence (n = 2), exercise-induced feeling (n = 1), remembered pleasure (n = 1), and mood state (n = 1). Thirty-six intervention studies explicitly mentioned theoretical underpinnings in their descriptions; the other four intervention studies did not mention any framework. The most commonly used theoretical frameworks were: the social cognitive theory (n =12), the self-determination theory (n = 8), the transtheoretical

model (n= 7), the theory of planned behavior (n = 7), and the dual-mode model (n = 6). Approximately 60% of the studies were conducted in schools or at universities (n=24), the remaining study settings varied (such as in laboratories, communities, outdoors, workplaces, internet, homes, gyms).

The intervention techniques employed by each study are summarized in detail in **Appendix 1-2**. According to Michie et al. (2011), the 40 studies used 2 to 17 behavior change techniques, of which five studies employed no more than three behavior change techniques, twenty-seven studies employed 4 to 10 intervention techniques, and 18 studies employed more than ten behavior change techniques. In terms of the frequency of use of each behavior change technique, the most commonly used intervention techniques were (1) provide instruction on how to perform the behavior (n=32), (2) action planning (n=25); (3) Model/demonstrate the behavior (n=24); (4) Plan social support/social change (n=23); (5) Stress management/emotional training (n=21). However, five other behavior change techniques were not employed by any of the included studies: (1) Prompt generalization of a target behavior; (2) Prompt identification as a role model/position advocate; (3) Prompt anticipated regret; (4) Fear arousal; (5) Stimulate anticipation of future rewards.

3.2 The mediating role of positive affective variables

We then report the results of the TSSEM analysis in a stepwise sequence. For calculating the pooled correlation matrix, we used the 42 correlation matrices. In a first step, we tested a fixed-effects model. The $\chi 2$ of the model with equality constraints on all correlation coefficients across studies was significant $\chi 2(45) = 196.48$, $p < 0.01$, CFI = .719, CLI = .701, and the RMSEA was larger than 0.10, indicating a bad suitability. Thus, the random-effects model seems more appropriate (Harrer et al. 2019). The total pooled sample size was 9235. The averaged correlation matrix based on the random-effects model was shown in **Table 1-1**. According to Gignac and Szodorai (2016) suggested that in interpreting statistical results, correlations of 0.10, 0.20, and 0.30 should be considered relatively small, typical, and relatively large, and we found medium-sized overall correlations between intervention and PAV ($r = 0.26$, $p < 0.01$), PAVs and PA ($r = 0.25$, $p < 0.001$), and intervention and PA ($r = 0.25$, $p < 0.001$).

Table 1-1. Pooled correlation coefficients (k = 42) for X (participants in post intervention vs. post-control/ pre-intervention), M (PAV) and Y (PA)

	X	M	Y
X	1		

M	0.26**	1	
Y	0.25***	0.26***	1

**$p < 0.01$, ***$p < 0.001$

In stage 2, we used the pooled correlation matrix to fit the hypothesized structural model. **Figure 1-2** displayed the path diagram of the mediational model. The path coefficient from intervention to PAV a = 0.26 (95% CI = 0.08 to 0.44), the path coefficient from PAV to PA b = 0.21 (95% CI = 0.13 to 0.28), and the direct effect from intervention to PA is small but significant (c = 0.19, 95% CI = 0.12 to 0.26). In addition, the indirect effect of intervention on PA via PAV was small (c' = 0.05, 95% CI = 0.02 to 0.10). Since zero is not included in the 95% confidence interval, the indirect effect can be considered small but significant. This provides evidence for partial mediation (Diener and Emmons 1984).

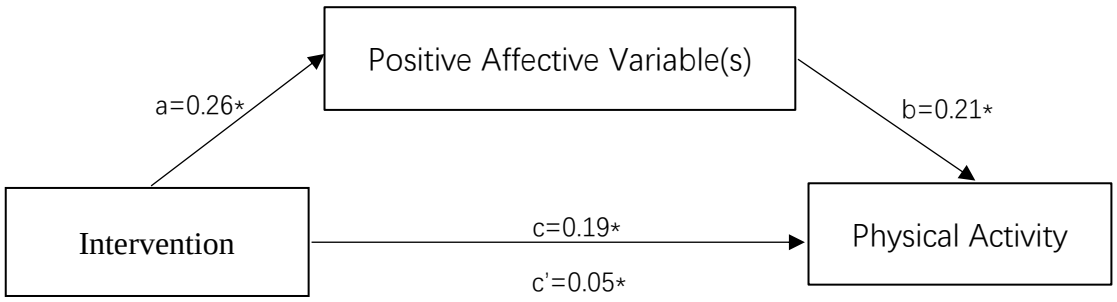

Figure 3-1. Path diagram depicting the mediational model for intervention to PA with PAV(s) as the mediator.

Notes: Values are path coefficients. *$p < 0.05$. a = "path coefficient from intervention to PAV", b = "path coefficient from PAV to PA", c = "direct effect from intervention to PA" and c' = "indirect effect from intervention to PA"

4 Discussion

These investigation's aims are twofold. First, it aims to systematically review studies of PA interventions that use PAVs as the mediating variables to evaluate and provide narrative summaries of these studies. In these 40 included studies, similar constructs (e.g., positive affect, affective attitude, PA enjoyment, vigor, activation, excitement) were grouped into PAVs to serve as mediating variables for the PA interventions. The narrative review revealed that in exploring the mediating role of the PAVs, the vast majority of studies had focused more on the role of enjoyment and less on other similar constructs (e.g., vigor, activation, excitement). Moreover, the majority of research subjects are students, limiting the diversity of subjects in such research, although it is easier for schools and universities to conduct experiments. Besides, only

one study has focused on PAV's effect on male PA outcomes, and relatively few studies have accurately analyzed the mediating role of PAVs on the male PA outcomes. So far, we have not found a comparison of the mediating effects of PAVs on PAs between males and females, and perhaps this is a direction worth exploring. Finally, the study found a considerable variation in the frequency of use of each behavior change technique in included studies, with some being utilized by more than one-third of all studies, while the other five were not utilized by any included studies. A more detailed review summarizing the effects of each behavior change technique on PAV and PA has yet to be completed; furthermore, rigorous experimental testing using factorial designs to isolate and incorporate unique techniques is also necessary.

Second, it aims to statistically synthesize evidence for the mechanism of the effect of PAV on PA outcome. To achieve this, we constructed a framework that predicted that intervention would have initial effects on the proximal outcome or mediating mechanism (PAVs) and the distal outcomes (PA). The results showed a significant and moderate effect of PAV as a mediating variable for the PA intervention, suggesting that PAV plays a unique role in determining PA. It is a juxtaposition of findings: a) intervention was positively associated with PAV; b) PAV was positively associated with PA outcome; c) intervention was positively associated with PA outcome. Those findings broadly supported the work of other studies in this area linking PAV with PA. For instance, according to Williams (2008), affective response to exercise is posited to influence exercise adherence via anticipated affective response to future exercise. Similarly, Lee, Emerson, and Williams (2016) proposed a two-pronged approach to PA promotion. They posited that more likely those strategies result in more positive affective responses to exercise as well as better adherence of participants to exercise. These findings are also consistent with the principle of hedonism, which states that individuals seek to maximize enjoyment and minimize pain (Higgins 1997). In the light of the current research findings that contemplate this principle, the primary purpose of PA promotion interventions is to facilitate enjoyment rather than physiological benefits (Nielsen et al. 2014), which seems sensible. Over the past decade, there has been an upsurge of enthusiasm for considering the role of positive emotions and affects in the prescription of PA more fully (e.g., Ekkekakis, Hargreaves, and Parfitt 2013; Ekkekakis, Hartman, and Ladwig 2020). An underlying message of these sources is that if individuals are not motivated by self-determined influences, such as enjoyment, then they are less likely to engage in long-term PA, no matter how often they are informed of its potential health benefits (Brand and Ekkekakis 2018). Therefore, exercise interventions that promote self-determination (Ryan and Deci 2000) have the potential to promote the maintenance of PA behaviors. In conjunction with previous meta-analysis reviews of affective variables or affective judgments (Nasuti and Rhodes 2013; Rhodes, S. M. Gray, and Husband 2019), and findings from previous meta-analyses of PA interventions (Conn, Hafdahl, and Mehr 2011), these studies support the central role played by PAVs.

5 Limitations and Future Research Directions

To reduce the possibility of selection bias, we used systematic and comprehensive search techniques to locate studies, although it may not be possible to identify all substantial investigations. The decision to exclude studies published in languages other than English was considered a minor limitation. Besides, this paper focuses on subjects in non-clinical states and does not explore and calculate the mediating effects of PAVs on clinical exercise interventions. Such studies would hold particular value, if they focused on clinical populations, including diabetics, the clinically obese, and other patients recovering from surgery (Hutchinson, Karageorghis, and Black 2017). Furthermore, given that most of the subjects in the studies included in this paper were female or of mixed-gender, it is also necessary to distinguish between the role of PAVs for male and female exercise in future studies.

6 Conclusion

Overall, the findings suggest that intervention can moderately increase PAV in exercisers, PAV can moderately boost PA in exercisers, intervention can slightly increase PA in exercisers, and PAV partially mediates between intervention and PA improvement. Given the summative evidence in the research literature supporting PAVs for a range of PA outcomes, it is reasonable to conclude that PAV increasement intervention has the capacity to provide considerable positive effects for exercisers to improve PA outcomes. This study has identified and highlighted that PAV can be a mediator between intervention and PA, which means that we can direct better and stronger interventions that trigger key PA change processes. Thus, it is strongly recommended that future interventions be more innovative and aim for higher fidelity with PAV as a mediator.

- **Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
- **Author Contributions:** DJ and CC contributed to conception and design of the study, and DJ supervised the entire process. CC organized the database, performed the statistical analysis, wrote the manuscript. EF and AK supported CC in data extraction and data analysis phases; DJ, EF and CC contributed to manuscript revision. All authors read and approved the submitted version.
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Chapter 3

Study 2: What Intervention Techniques are Effective in Changing Positive Affective Variables and Physical Activity? A Systematic Review and Meta-analysis

1 Introduction

Regular physical activity (PA) is highly beneficial for the prevention of premature mortality (Ekelund et al., 2016) and for physical and mental health (Penedo and Dahn, 2005). However, only a minority of modern adults report that their PA participation levels align with most public health guidelines. Besides, a further 50% of exercisers drop out within the first six months after initial participation (Finne et al., 2019). Exploring ways to promote and maintain PA is necessary because the benefits are not sustainable without consistent and regular attendance (Annesi, 2003).

1.1 The Unfavorable Commonality in Mainstream Physical Activity Change Theories

Current mainstream theoretical approaches used for PA interventions include social cognitive theory (SCT; Bandura, 1998), the theory of planned behavior (TPB; Ajzen, 1991), the trans-theoretical model (TTM; Prochaska and Velicer, 1997), and self-determination theory (SDT; Deci et al., 1994). According to SCT, PA variations are regulated by reciprocal determinations among personal cognitive factors (e.g., self-efficacy, outcome expectations, knowledge), the physical and social environment (e.g., observational learning, normative beliefs, social support, opportunities, and barriers), and behavioral factors (e.g., behavioral skills, intentions, reinforcement) (Bandura, 2004; Perry, 1999). TPB comprises three core components, namely, attitude, subjective norms, and perceived behavioral control, which together shape individuals' PA intentions and behavior (Ajzen, 1991). The TTM has concentrated on stages of change, processes of change, levels of change, self-efficacy, and temptation (Prochaska and Velicer, 1997). And SDT emphasizes the role of autonomy, competence, and relatedness for PA interventions (Deci and Ryan, 2008). All of these theories share a core attribute that stems from cognitivism. In detail, (1) they all emphasize the primacy of imagined end states (behaviors or goals) (Brand and Ekkekakis, 2018) in PA change, and (2) affective constructs are either entirely omitted or subordinated to cognitive devices, while the idea that affective constructs can serve as motivational forces outside of

cognitivism (e.g., momentary emotions associated with physical activity situations; Ekkekakis, 2017) is ignored. Consistent with these theories, PA interventions have focused primarily on techniques that provide education about PA's benefits, build perceived ability, and self-regulation to perform PA (Chase, 2015; Conn et al., 2011; Rhodes et al., 2019b). However, even as the framework predicting the highest amount of PA variance, the social cognitive theory can only explain, on average, 20% of the variation in PA maintenance (Jekauc et al., 2015). Rhodes et al. (2009a) integrated 34 PA intervention studies, and found that 85% of the findings showed that affective expectations were notable predictors of PA behavior (r = 0.43; 95% CI = 0.36 to 0.46), whereas only 35% of the findings showed that instrumental expectations were significant predictors of PA behavior (r = 0.25; 95% CI = 0.21 to 0.29). Hence, perhaps the failure to separate the affective and instrumental reflections or expectations of the intervention on PA hinders the exploration process of PA promotion (McEwan et al., 2016; Jekauc and Brand, 2017). Therefore, a more refined meta-analysis dedicated to affective variables and PA is inevitable. (Jekauc et al., 2015).

1.2 Definitions of Positive Affective Variables

In general, “affect is the experiential state of feeling and is a collective term describing feeling states such as emotion and mood” (Gellman and Turner, 2013). Affective states may vary in several aspects, such as their duration, intensity, specificity, pleasantness, and degree of arousal, and they have essential roles in regulating cognition, behavior, and social interaction. As a superordinate category, emotions and moods belong to affect. Emotions and moods differ mainly in (1) their duration: emotions are rather brief and intense experiences, and moods last somewhat longer than emotions, and (2) whether they are directed to a specific cause: emotions are reactions to specific external stimuli (i.e., objects or events) and may arise relatively automatically or after a cognitive assessment of the stimulus; moods are more diffuse in nature (Gellman and Turner, 2013). Furthermore, the concept of attitude is considered to represent relatively enduring beliefs and preferences for a particular organism and is primarily composed of cognitive, affective, and motivational components (Breckler, 1984). Contrary to the caution of theorists, namely that these concepts should be distinguished, affect, emotion, feeling, mood and affective attitude (Ostrom, 1969) are often used liberally in empirical researches (Batson et al., 1992). Thus, this paper integrated them into a generalized term as affective variables. Besides, some other theorists have noted that organizing affective variables by dimension may be more meaningful than considering them by category (Shiota, 2012; Watson et al., 1999; Cacioppo and Gardner, 1999). Thus, we generalized non-negative affect, emotion, feeling, mood, and affective attitude and use the term “positive affective variables (PAVs)” to refer to them.

1.3 Approach-Avoidance Distinction of Affective Variables and Motivation in Physical Activity

According to existing research, the approach-avoidance distinction is applicable in affective variables (positive and negative affective dispositions) (Watson et al., 1999). The neurological underpinnings have also given evidence of this linkability between motivation and emotion through affective neuroscience (Davidson 2003). As Larsen et al. (2008) stated, "motivation and valence tend to be correlated, such that positive emotions are associated with approach and negative emotions with avoidance." Consistently, it could also be shown that positive emotions (e.g., enjoyment) during PA and intrinsic motivation for PA possibly share common determinants (Wienke and Jekauc, 2016). Furthermore, several other theoretical and empirical studies also have shown that PAVs are essential determinants of PA behavior or outcomes (Rhodes et al., 2009b). Following the upward spiral theory of lifestyle change, motivation is significantly associated with positive affects experienced during healthy behaviors, and motivational salience subconsciously guides attention to these behaviors and decisions to repeat them (van Cappellen et al., 2018). Further, a recent meta-analysis emphasized that the PAV emerges as a significant mediator between intervention and PA outcomes (Chen et al., 2020). Based on these neuroscientific, theoretical, and empirical fundamentals, enhancing PAVs is more likely to facilitate physical activity than activities that rely primarily on extrinsic motivation, such as those expected to improve health and well-being (Nielsen et al., 2014).

1.4 Empirical Studies on Positive Affective Variables and Physical Activity

In recent years, there has been an upsurge of enthusiasm to consider the role of PAVs in PA prescribing more (e.g., Ekkekakis et al., 2013; Ekkekakis et al., 2020), but our knowledge of how to change PAVs and subsequent PA remains deficient. So far, Rhodes and his colleagues have conducted three reviews (Rhodes et al., 2009a; Rhodes and Kates, 2015; Rhodes et al., 2019b), which summarized the relationship between affective response/ affective judgment (i.e., thoughts about the overall pleasure/displeasure, enjoyment, and feeling states expected from enacting a behavior) and PA. Initially, through 82 correlational studies and 20 eligible experimental studies, Rhodes et al. (2009a) demonstrated a medium-effect size relationship between affective judgment and PA. A significant positive correlation between affective judgments and PA was reported in 83 out of 85 correlational samples, with a pooled r of 0.42 (95% CI = 0.37 to 0.46). A further meta-analytic synthesis was reported in 2015. It stated that positive changes in primary affective responses during moderate-intensity exercise were associated with future PA intention (Rhodes and Kates, 2015). A recent review explored interventions to manipulate adults' (of healthy and unhealthy populations) affective judgments and subsequent PA, but no technique was considered adequate (Rhodes et al., 2019b). We speculate that two main reasons influenced these results. First, it is well known that many diseases (e.g., Alzheimer's disease) can change emotional regulation (Bucks and Radford, 2004), so it is necessary to distinguish between healthy and unhealthy populations. Second, we presumed that Rhodes et al. (2019b) did not distinguish between intrinsic motivation and affect in the literature inclusion (Shah et al., 2016; Kinnafick et al., 2016; Moustaka et al., 2012; Silva et al.,

2010a; Silva et al., 2010b) leading to these outcomes. According to Weinberg and Gould (2014, pp. 139), intrinsic motivation includes knowledge, accomplishment, and stimulation, while affect is merely a part of intrinsic motivation (stimulation). Besides, we desired to exclude negative affective variables from this study. (Egloff, 1998; Reich et al., 2001). The reasons were: (1) Reich et al. (2001) conducted two experiments based on the two-factor model and the bipolar model, which showed that the cognitively more complex participants reported the mutual independence of positive and negative affect, while those with simpler cognitions reported the polarity of positive and negative affect, which meant that positive and negative affects could be differentiated for exploration; (2) as we described in the previous paragraph, the approach-avoidance distinction was also applicable in the affective variables; (3) Chen et al. (2020) distinguished between positive and negative affective variables and demonstrated the significant mediating role of PAVs in the PA intervention. Overall, we would like to implement a more nuanced meta-analysis to understand how PAVs and PA can be manipulated in healthy populations.

Considering the aforesaid, this paper included two primary objectives. First, to summarize intervention effects on PA and PAVs; second, examine each behavior change technique's effectiveness in modifying PAVs and PA and exploring potential demographic and methodological moderators. That is, we investigated (1) which methodological factors moderated the outcomes of PAVs and PA (e.g., study design, theory framework, intervention duration, measurement, number of intervention techniques used); (2) which demographic characteristics moderated the results of PAVs and PA interventions (e.g., age, gender, population setting, PA level at baseline); (3) which behavior change techniques (BCTs) were the most effective for PAVs and PA interventions.

2 Methods

2.1 Search Strategy and Inclusion Criteria

The literature search was conducted according to the PRISMA standard protocol (Moher et al., 2009) (see **Figure 2-1**). A structured electronic search strategy was used to retrieve studies published by April 1, 2020. The databases searched included Web of Science, PubMed, PsycINFO, PsycArticle, and Psychology and Behavioral Sciences Collection. The search terms were: (1) Intervention OR Trial OR Experiment; (2) Physical Activity OR Exercise; (3) Enjoy* OR Affect* OR Emotion* OR Mood* OR Feeling; (4) Mechanism* OR Mediat* OR Predict* OR Process* OR "Structural equation modeling" OR Caus* OR Path* OR Correlat* OR Relationship OR Associat*; (5) NOT (Patient* OR Cancer OR Clinical OR Disease* OR Illness OR Depression OR Rat OR Mouse OR Protocol OR Cell OR Bone* OR Blood OR Rehabilitation OR Disorder* Injur* OR HIV OR Carbohydrate OR Athlete* OR Player* OR Runner* OR Review OR Comment OR Therapy); (6) 1 AND 2 AND 3 AND 4 AND 5. Besides, more than ninety-eight percent of the search results were in English, and very few

studies were published in other languages. Hence, we only included studies published in English for the accuracy of data extraction.

The first author completed the search, and the eligibility of each study was determined by the Cochrane handbook for systematic reviews of intervention studies (Higgins et al., 2019b). Studies in which the first author was unsure whether to be included were discussed and determined with the last author. A study was eligible for our meta-analysis if it met the following criteria: (1) experimental studies assessing PAV as a dependent variable; (2) PAV was a target of the intervention; (3) studies whose goal was to increase lifestyle or recreational PA, not for competitive sports (Caspersen et al., 1985; Vanhees et al., 2005); (4) sufficient data to calculate the effect sizes (Hedges' g) of PAVs and PA; (5) participants were healthy individuals (not a clinically defined population and not pregnant). Furthermore, we intentionally chose a minimum duration of PA of 10 minutes, given that 10 minutes is the recommended minimum duration of exercise to elicit health benefits (Edwards and Loprinzi, 2019).

2.2 Data Extraction and Data Analysis

First, the risk of bias assessment was administered using the STROBE standard tool (Elm et al., 2007). The tool includes questions in a "yes" (1) or "no" (0) format (e.g., did the study report the sources and details of PA assessment; did the instruments have acceptable reliability for the specific age group?). Study qualities were assessed by the first and last authors separately, and any differences were resolved through discussion. The studies' quality was then graded as low (scores 0-2), medium (scores 3-4), or high (scores 5-6).

Next, with the supervision and guidance of the last author, the first author completed the extraction of the following data: BCTs; the PAVs' constructs, dimensions, and measurements; PA assessment methods, variables, measures; methodological data (e.g., study design, theory framework, intervention duration, measure employed, number of intervention methods used, primary intervention targeted, PA focus); demographic data (e.g., age, gender, population setting, PA level at baseline). Data for BCTs were extracted based on the 40-item taxonomy by Michie et al. (2011). Coyne et al. (2010) pointed out that several small sample studies can be included in a meta-analysis, but if a meta-analysis includes many small sample studies, it may result in a large bias in its effect size. For this reason, we classified each trial according to whether its sample size was greater than 35 (Kraemer et al., 1998; Coyne et al., 2010) and calculated the sample size as a moderator variable in the calculation.

Finally, we adopted the statistical procedure utilized by Ashford et al. (2010) and Williams and French (2011). The random-effect model in the Comprehensive Meta-Analysis Version 3 (Borenstein et al., 2014) was employed in the calculation. Based on the raw data, we employed Hedges' g to estimate effect sizes (i.e., the adjusted standardized mean difference for both PAVs data and PA data between post-test means in intervention and control group where possible, or pre and post-test means of the intervention group) (Durlak, 2009). With multiple measurement time points, we chose the first measurement taken at the end of the intervention (Higgins et al., 2019b)

because those results could maximally be influenced by different interventions and less influenced by other factors relative to the follow-up measurements. To overcome the potential unit-of-analysis error due to the inclusion of multi-arm studies, several approaches have been proposed by Higgins et al. (2019a). Specifically, when exploring the moderating effects of each methodological and demographic variable, we combined all intervention groups within a study to create a single pair-wise comparison (Higgins and Li, 2019). We then computed the summary effect for this intervention group versus the control group. However, when performing moderator analyses for BCTs, we included each pair-wise comparison separately, but shared control groups were divided into several smaller groups for the different comparisons to avoid 'double counting'. Moderator analyses were limited to categories with at least three studies. The findings' heterogeneity was examined using the Q-statistic (Higgins et al., 2003; Hedges and Pigott, 2004); a 5% cut-off was used for significance. The Q coefficient's significance represents the heterogeneity of the dataset beyond what would be expected from sampling error alone, suggesting that additional systematic factors contribute to the variance. Therefore, we performed moderator analyses to explore the causes of heterogeneity by comparing the mean variability of effect size estimates for two groups of studies characterized by the presence or absence of a specific study characteristic (e.g., a specific BCT) (Ashford et al., 2010). Finally, we explored publication bias using Egger's regression intercept (i.e., a statistical test result for funnel plot asymmetry), and a 5% cut-off was used for significance.

3 Results

3.1 Study Flow and Characteristics

The search identified 1732 articles, of which 1352 were duplicates or could be excluded based on the titles. Of the remaining 389 articles, there were 183 articles for full-text review, of which 11 were identified by cross-referencing (see **Figure 2-1**). Finally, 37 studies met our inclusion criteria (see **Appendix 2-8**), of which ten studies contained two or three subgroups (Gråstén and Yli-Piipari, 2019; Miragall et al., 2018; Noradechanunt et al., 2017; Niedermeier et al., 2017; Wang et al., 2015; Kraft et al., 2015; Fitzsimons et al., 2012; Schneider and Cooper, 2011; Focht et al., 2007; Rose and Parfitt, 2007). Due to the nature of the data to be analyzed, we included each pair-wise comparison separately when investigating BCTs' moderating effects on PAVs and PA and therefore included a total of 49 data sets. In case of multiple comparisons to the same reference group, we split the control group as described above. Meanwhile, the quality of each study is presented in **Appendix 2-1**. Of the 37 studies, six were rated as high quality, seventeen were rated as low quality, and the remaining 20 studies were rated as moderate quality.

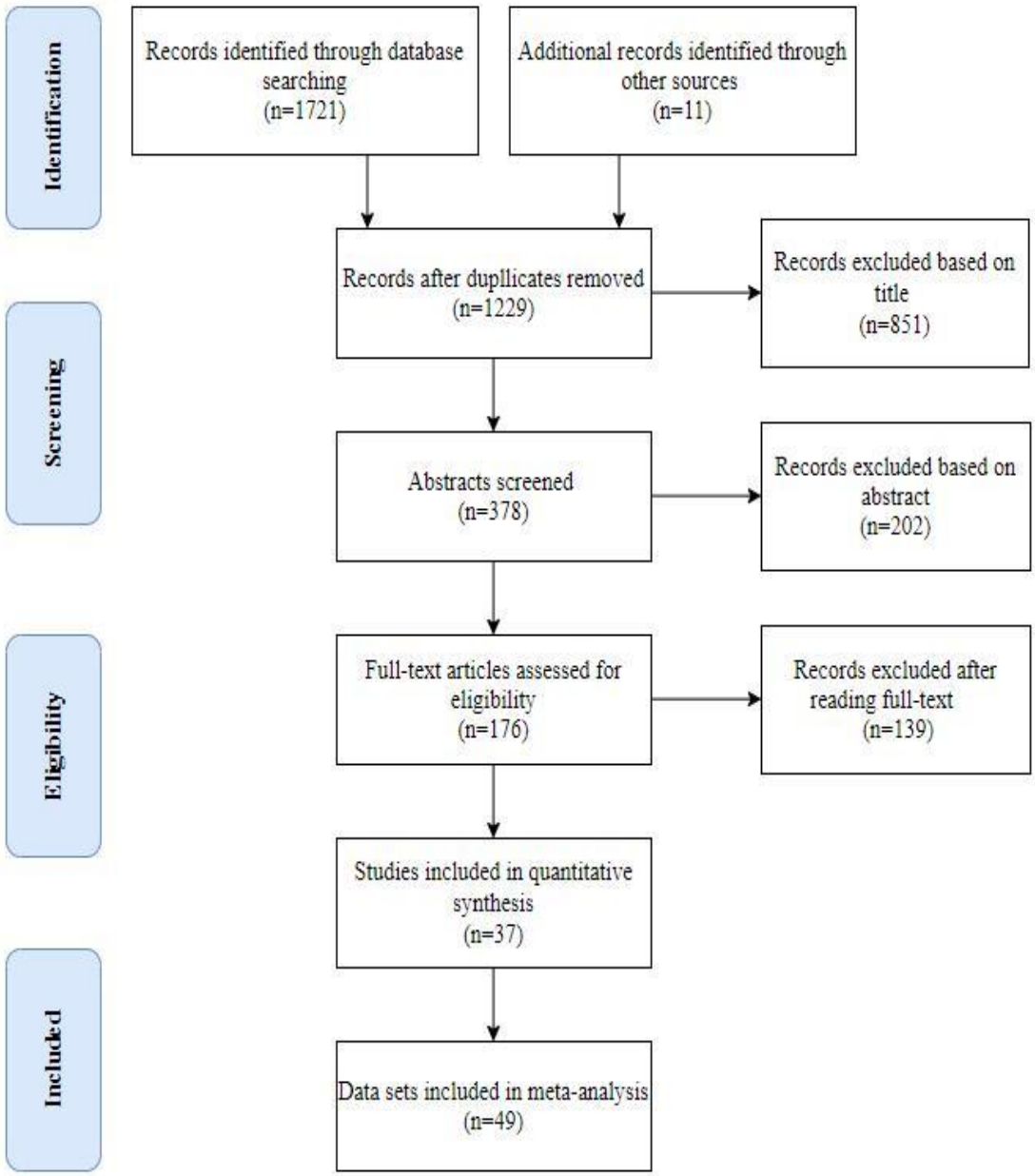

Figure 2-1. PRISMA flow diagram for articles identified, screened eligible, and included in this paper

Furthermore, the general characteristics of the 37 studies are presented in **Appendix 2-2**. Then, **Table 2--1** presents the overall study characteristics of the 37 studies. Concerning the age of the participants, four age intervals were designed to classify the mean age of each study: under 18 years (n = 15), 18 to 35 years (n = 13), 36 to 60 years (n = 7), and over 60 years (n = 2). In terms of gender distribution, only one group identified its gender as male, 11 studies defined its gender as female, and the remaining 25 studies were mixed gender. For baseline PA, we marked out four classifications as “not meeting PA guidelines at baseline” (n = 17), “meeting PA guideline at baseline” (n = 3), “mixed” (n = 9), and “unreported” (n = 8). 33 of the 37

studies stated their theoretical underpinnings, while the other four did not. In addition, 16 interventions were implemented based on multiple theoretical frameworks, and 17 interventions were based on a single theoretical framework (TTM n = 3, SCT n = 3, TPB n = 3, SDT n = 3, the dual-mode model n = 1, challenge point theory n = 1, tactical games model n = 1, affective reflective theory n = 1, the health promotion model n = 1). The intervention duration of the included individual groups ranged from less than three hours to four years, but the majority was between two and six months (n=12). Only 13 of the 37 studies randomized their subjects. Furthermore, over 55 percent of the interventions were performed in schools, colleges, and university laboratories.

Table 2-1. Overall study characteristics of 37studies

Characteristics	N of intervention groups (maximum 37)	Percentages (%)
Age		
<18	15	40.54
18-35	13	35.14
36-50	7	18.92
50-75	2	5.41
Gender		
Male	1	2.7
Female	11	29.73
Mixed	25	67.57
Sample size		
<35 participants per condition	10	27.03
⩾35 participants per condition	27	72.97
Intervention duration		
⩽3 hours	6	16.22
3 hours - 2 months	11	29.73
2- 6 months (including 2 months)	12	32.43
>6 months	8	21.62
Number of intervention methods used		
1-3 methods used	3	8.11
4-10 methods used	17	45.95
4-11 methods used	17	45.95
Setting		
School	12	32.43
University	4	10.81
Lab	4	10.81
Community	5	13.51
Other	12	32.43
The physical activity level at baseline		

Not meeting guideline	17	45.95
Meeting guideline	3	8.11
Mixed	9	24.32
Unreported	8	21.62
Positive affective variables measure		
Affect	6	16.22
Emotional state	24	64.86
Affect & emotional state	7	18.92
Positive affective variables_measurements		
The physical activity enjoyment scale	13	35.14
The positive and negative affect schedule	4	10.81
Feeling scale	3	8.11
IMI	2	5.41
Semantic differential scales of affective attitude	2	5.41
Affective attitude Likert scale	1	2.70
Profile of mood states	1	2.70
Single-item enjoyment scale	1	2.70
The PE enjoyment scale	1	2.70
VAS	1	2.70
Multiple	8	21.62
Physical activity measure		
Moderate-vigorous physical activity (objective)	2	5.41
Moderate-vigorous physical activity (subjective)	9	24.32
Steps	4	10.81
Frequency	6	16.22
Intensity	6	16.22
Multiple	10	27.03
Physical activity measurements		
Equipment usage log/ attendance list	5	13.51
HR monitoring	5	13.51
Pedometer	4	10.81
Accelerometer	3	8.11
2/3/7 day physical activity recall	3	8.11
International physical activity questionnaire	2	5.41
Leisure-time exercise questionnaire	2	5.41
Other questionnaires	8	21.62
Multiple	4	10.81
Not reported	1	2.70
Theory		
No framework explicitly mentioned	4	10.81

Social Cognitive Theory	3	8.11
The Transtheoretical Model	3	8.11
Theory of planned behavior	3	8.11
Self-Determination Theory	3	8.11
Multiple	16	43.24
Others	5	13.51
Study design		
Randomized controlled study	13	35.14
Quasi-experimental study	24	64.86
Study quality rating		
Low (1-2)	7	18.92
Medium (3-4)	24	64.86
High (5-6)	6	16.22

Note. IMI = the interest/enjoyment subscale of intrinsic motivation inventory; VAS = visual analog scale of enjoyment/ remembered pleasure

3.2 Contents of BCTs

The intervention techniques employed by each intervention group are summarized in detail in **Appendix 2-5**. According to Michie et al. (2011), the 49 independent intervention groups used 2 to 17 intervention techniques, of which seven interventions employed no more than three intervention techniques, twenty-two interventions employed 4 to 10 intervention techniques, and 20 studies employed more than ten intervention techniques. Further, **Table 2-2** presents the frequency of use of each intervention technique across all included studies. The most frequently used intervention techniques were (1) provide instruction on how to perform the behavior (83.67%), (2) provide instruction on when and where to perform the behavior (81.63%); (3) action planning (57.14%), and model/demonstrate the behavior (57.14%). Six intervention techniques were not employed by any of the included studies: (1) shaping; (2) prompt generalization of a target behavior; (3) prompt identification as a role model/position advocate; (4) prompt anticipated regret; (5) fear arousal; (6) stimulate anticipation of future rewards. Five other intervention techniques were rarely used: (1) provide information on consequences of behavior to individual (4.08%); (2) prompting focus on past success (4.08%); (3) agree behavioral contract (4.08%); (4) provide rewards contingent on effort or progress towards behavior (2.04%); (5) provide rewards contingent on successful behavior (2.04%).

Table 2-2. Frequencies of intervention techniques that were used in the intervention groups in meta-analytic analyses

Techniques		Number of intervention groups (maximum 49)	Percentages (%)
1	Provide information on consequences of behavior in general	15	30.61
2	Provide information on consequences of behavior to individual	2	4.08
3	Provide information about others' approval	9	18.37
4	Provide normative information about others' behavior	5	10.20
5	Goal setting (behavior)	19	38.78
6	Goal setting (outcome)	6	12.24
7	Action planning	28	57.14
8	Barrier identification/problem solving	18	36.73
9	Set graded tasks	10	20.41
10	Prompt review of behavioral goals	13	26.53
11	Prompt review of outcome goals	3	6.12
12	Provide rewards contingent on effort or progress towards behavior	1	2.04
13	Provide rewards contingent on successful behavior	1	2.04
14	Shaping	0	0
15	Prompt generalization of a target behavior	0	0
16	Prompt self-monitoring of behavior	24	48.98
17	Prompt self-monitoring of behavioral outcome	4	8.16
18	Prompting focus on past success	2	4.08
19	Provide feedback on performance	20	40.82
20	Provide instruction on when and where to perform the behavior	40	81.63
21	Provide instruction on how to perform the behavior	41	83.67
22	Model/demonstrate the behavior	28	57.14
23	Teach to use prompts/cues	6	12.24
24	Environmental restructuring	15	30.61
25	Agree behavioral contract	2	4.08
26	Prompt practice	7	14.29
27	Use of follow-up prompts	3	6.12
28	Facilitate social comparison	4	8.16
29	Plan social support/social change	25	51.02
30	Prompt identification as a role model/position advocate	0	0
31	Prompt anticipated regret	0	0
32	Fear arousal	0	0

33	Prompt self-talk	4	8.16
34	Prompt use of imagery	9	18.37
35	Relapse prevention/coping planning	3	6.12
36	Stress management/ emotional training	24	48.98
37	Motivational interviewing	6	12.24
38	Time management	4	8.16
39	General communication skills training	5	10.20
40	Stimulate anticipation of future rewards	0	0

3.3 Characteristics of PAVs

Appendix 2-3 and **Table 2-3** presents the constructs, dimensions, and measurements of each study's PAVs. First, PAVs could be categorized into two broad constructs of affects and emotional states (Shouse, 2005), with several studies measuring both of them. The dimensions of affect included "affective valence" and "positive affect," and the measurement methods were "feeling scale (FS)" and "positive and negative scale (PANAS)." Emotional states were further categorized as "enjoyment," "pleasure," "exercise-induced feeling," "affective attitude," and "mood state." There were various dimensions and methods to measure emotional states, and the most frequently measured dimension was "enjoyment." Still, there were also "remembered pleasure," "revitalization," "positive engagement," "vigor," "activation," and "excitement." Accordingly, there were various scales for measuring emotional states, for example, "the physical activity enjoyment scale (PACES)," "the PE enjoyment scale (PEES)," "visual analog scale (VAS) of enjoyment/remembered pleasure," "the interest/enjoyment subscale of intrinsic motivation inventory (IMI)," "single-item enjoyment scale (SES)," "exercise-induced feeling inventory (EFI)," "semantic differential scale of affective attitude (SD)," "profile of mood states (POMS)" and "mood survey scale (MSS)."

3.4 Characteristics of PA

In general, there were two broad categories of PA measurements: objective and subjective. **Appendix 2-4** and **Table 2-3** shows that objective and subjective measures were about equally divided. The primary four objective measurements were the recording list (equipment usage log/ attendance list), pedometer, accelerometer, and heart monitor. In contrast, subjective measures of PA were diverse. For example, 7-day physical activity recall (7DPAR), 3-day physical activity recall (3DPAR), the short-form of the international physical activity questionnaire (IPAQ), physical activity time-consuming questionnaire (PATCQ), the children's leisure activities study survey (CLASS), 6-point exercise frequency scale (EFS). The PA variables measured by the studies were also highly diverse, for example, moderate to vigorous physical activity (MVPA), leisure-time physical activity (LTPA), the metabolic equivalent of task (MET),

exercise adherence, equipment usage, %Max HR.

3.5 Moderating Effect of Methodological and Demographics Variables on PAVs and PA

Meta-analytic moderation results of the 37 studies can be found in **Table 2-3**. We first reported the moderating effects of demographic and methodological factors on PAVs. Experimental manipulations of PAVs had an overall effect size g = 0.28 (95% CI = 0.14 to 0.41) on PAVs (see **Appendix 2-6**). The examination of publication bias for the 37 studies was significant (Egger's intercept t = 1.65 (35), p = 0.02) (see **Figure 2-2**), and in cases such as this with small samples and large heterogeneity, caution should be exercised (Carter et al., 2019). Using the n = 35 criterion proposed by Coyne et al. (2010), small-sample bias was a significant moderator in the PAV (Q =6.64; p = 0.01) context, with larger effect size (g = 0.32, 95% CI = 0.08 to 0.57) reported for small sample sizes. Age was also a significant moderator to the findings (Q = 12.73, $p < 0.05$), mean age interval located between 36 and 50 years reported the largest effect size (g = 0.48, 95% CI = 0.12 to 0.84). There was also a significant moderating effect of gender on PAVs, with the largest effect size for mixed-gender studies (g = 0.30, 95% CI = 0.12 to 0.48). Similarly, there was a significant moderating effect of intervention duration on PAVs, with the largest effect size for intervention duration between three hours and two months (g = 0.69, 95% CI = 0.07 to 1.31). The theory was also a significant moderator in PAVs intervention, with SDT having the largest effect size (g = 0.80, 95% CI = 0.33 to 1.27). However, neither the intervention setting (Q = 5.83, p = 0.21) nor the baseline level of PA (Q = 6.54, p = 0.09) were significant moderators in our PAVs investigation.

Table 2-3. Demography and methodology effects of experimental effects on PAVs and PA

	PAVs							PA						
	k	g	SE	95% CI		Q	p	k	g	SE	95% CI		Q	p
Point estimate	37	0.28	0.07	0.14	0.41	202.89	0	37	0.30	0.10	0.11	0.48	412.08	0
Age						12.73	<0.05						19.23	<0.01
<18	15	0.14	0.11	-0.09	0.36			15	0.36	0.17	0.03	0.69		
18-35	13	0.31	0.10	0.11	0.51			13	0.44	0.27	-0.10	0.97		
36-50	7	0.48	0.18	0.12	0.84			7	0.37	0.09	0.18	0.55		
Gender						14.33	<0.01						11.53	<0.01
female	11	0.07	0.06	-0.05	0.19			11	-0.08	0.15	-0.39	0.22		
mixed	25	0.30	0.09	0.12	0.48			25	0.46	0.12	0.23	0.70		
Sample size						6.64	0.01						0.01	0.91
<35	17	0.32	0.12	0.08	0.57			17	0.31	0.16	-0.01	0.62		
⩾35	20	0.21	0.08	0.05	0.37			20	0.28	0.12	0.05	0.51		
Intervention duration						8.24	0.03						2.59	0.46
⩽3 hours	6	0.38	0.14	0.09	0.66			6	0.89	0.71	-0.50	2.27		
3 hours - 2 months	11	0.69	0.32	0.07	1.31			11	0.29	0.12	0.05	0.53		
2- 6 months (including 2 months)	12	0.13	0.08	-0.04	0.29			12	0.00	0.19	-0.37	0.37		
>6 months	8	0.09	0.07	-0.05	0.22			8	0.24	0.08	0.08	0.40		
Number of intervention methods used						6.40	0.04						3.99	0.14
1-3 methods used	3	0.19	0.12	-0.05	0.43			3	0.12	0.17	-0.21	0.44		
4-10 methods used	17	0.49	0.14	0.22	0.75			17	0.55	0.18	0.20	0.90		
>10 methods used	17	0.11	0.06	-0.02	0.23			17	0.16	0.11	-0.06	0.38		
Setting						5.83	0.21						3.21	0.36

School	12	0.08	0.08	-0.06	0.23			12	0.09	0.07	-0.05	0.24		
University	4	0.44	0.30	-0.14	1.03			4	-0.89	0.91	-2.68	0.90		
Lab	4	0.18	0.18	-0.17	0.53			4	0.38	0.16	0.07	0.69		
Community	5	0.49	0.19	0.11	0.87			5	0.53	0.08	0.38	0.68		
Other	12	0.33	0.16	0.02	0.64			12	0.40	0.22	-0.03	0.84		
Physical activity at baseline						6.54	0.09						4.00	0.26
Not meeting guideline	17	0.11	0.07	-0.03	0.26			17	0.23	0.08	0.08	0.38		
Meeting guideline	3	0.69	0.28	0.14	1.24			3	0.62	0.35	-0.07	1.32		
Mixed	9	0.45	0.17	0.11	0.78			9	0.62	0.32	-0.01	1.25		
Unreported	8	0.22	0.15	-0.08	0.52			8	-0.01	0.21	-0.43	0.40		
Positive affective variables measure						0.25	0.88						2.84	0.24
Affect	6	0.25	0.06	0.13	0.37			6	0.23	0.14	-0.05	0.50		
Emotional state	24	0.22	0.09	0.05	0.38			24	0.15	0.10	-0.05	0.34		
Affect & emotional state	7	0.34	0.25	-0.16	0.83			7	0.94	0.47	0.02	1.85		
Physical activity measure						9.11	0.10						5.44	0.36
MVPA (subjective)	9	0.16	0.09	-0.02	0.34			9	0.05	0.19	-0.31	0.42		
Steps	4	0.21	0.09	0.04	0.38			4	0.42	0.23	-0.02	0.86		
Frequency	6	0.84	0.44	-0.03	1.71			6	1.14	0.68	-0.19	2.46		
Intensity	6	0.20	0.13	-0.05	0.45			6	0.18	0.14	-0.09	0.45		
Multiple	10	0.16	0.11	-0.06	0.37			10	0.04	0.08	-0.12	0.20		
Theory						10.32	0.01						14.80	0.02
No framework explicitly mentioned	4	0.39	0.22	-0.04	0.82			4	0.25	0.16	-0.07	0.56		

Social Cognitive Theory	3	0.01	0.19	-0.37	0.39			3	0.16	0.12	-0.08	0.41		
The Transtheoretical Model	3	0.27	0.11	0.07	0.48			3	0.38	0.14	0.12	0.65		
Theory of Planned Behavior	3	0.53	0.45	-0.36	1.41			3	0.27	0.27	-0.26	0.81		
Self-Determination Theory	3	0.80	0.24	0.33	1.27			3	0.57	0.12	0.33	0.81		
Multiple	16	0.08	0.07	-0.06	0.22			16	0.01	0.12	-0.23	0.25		
Others	5	0.44	0.26	-0.08	0.95			5	1.03	0.43	0.18	1.88		
Study design						0.58	0.45						0.68	0.41
Randomized controlled trial	13	0.38	0.19	0.01	0.75			13	0.42	0.16	0.10	0.74		
Quasi-experimental study	24	0.23	0.07	0.09	0.36			24	0.25	0.11	0.03	0.47		
Study quality						0.57	0.75						4.08	0.13
low(1-2)	7	0.17	0.20	-0.22	0.57			7	0.02	0.12	-0.22	0.26		
medium(3-4)	24	0.26	0.08	0.11	0.41			24	0.34	0.13	0.09	0.58		
high(5-6)	6	0.38	0.20	0.00	0.77			6	0.39	0.21	-0.03	0.80		

Note: k indicates the number of intervention groups adopting/not adopting a particular technique. They are calculated using all comparisons (Two arms, Control vs. A, Control vs. B, Control vs. C) with a total of 49 data sets. Moderator analysis was only done on moderators present in >3 intervention groups.

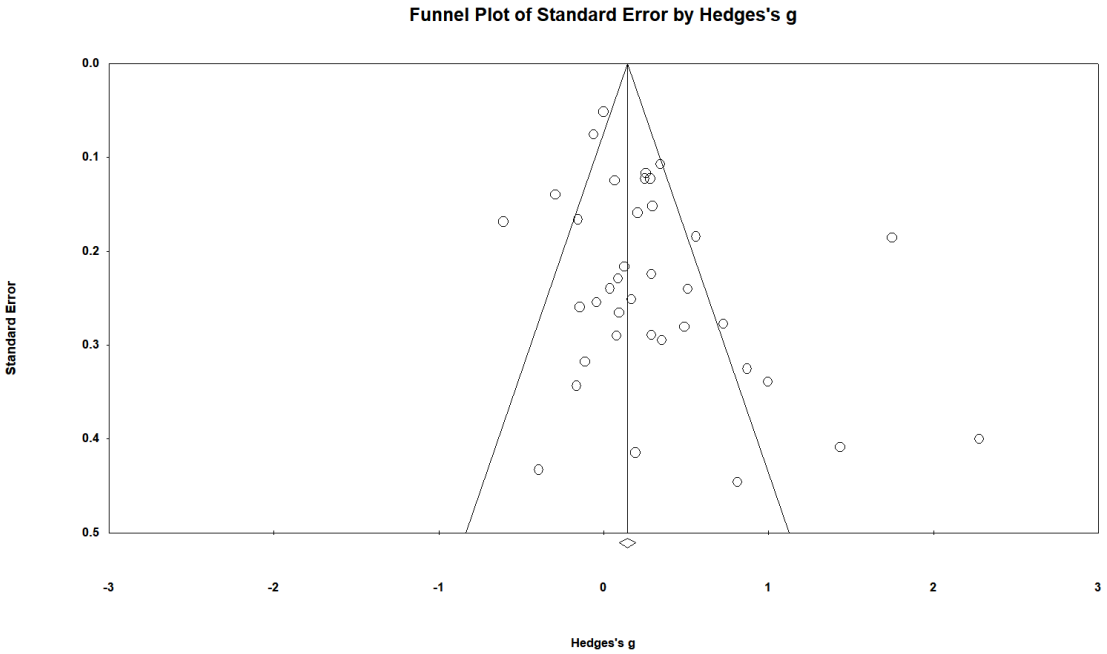

Figure 2-2. Funnel plot of positive affective variables in this review

Next, we would report the moderating effects of demographic and methodological factors on PA. The overall effect size of interventions on PA was g = 0.30 (95% CI = 0.10 to 0.48) (see **Appendix 2-7**). However, the Egger regression intercept for the PA data was not significant (t = 1.84 (35), p =0.07) (see **Figure 2-3**). The results of meta-analytic moderation analyses showed that small sample bias was not a significant moderator of PA outcomes (Q = 0.01, p = 0.91). Age was a significant moderator of PA outcomes (Q = 19.23, p < 0.01), with a maximum effect size reported for the mean age between 18 and 35 years (g = 0.44, 95% CI = -0.10 to 0.97). Gender was also a significant moderating variable (Q = 11.53, p < 0.01), with the mixed gender sample reporting larger effect size (g = 0.46, 95% CI = 0.23 to 0.70). In addition, theory was also a significant moderator of PA outcomes (Q = 14.80, p = 0.02), with the lagest effect sizes of "others" (g = 1.03, 95% CI = 0.18 to 1.88).

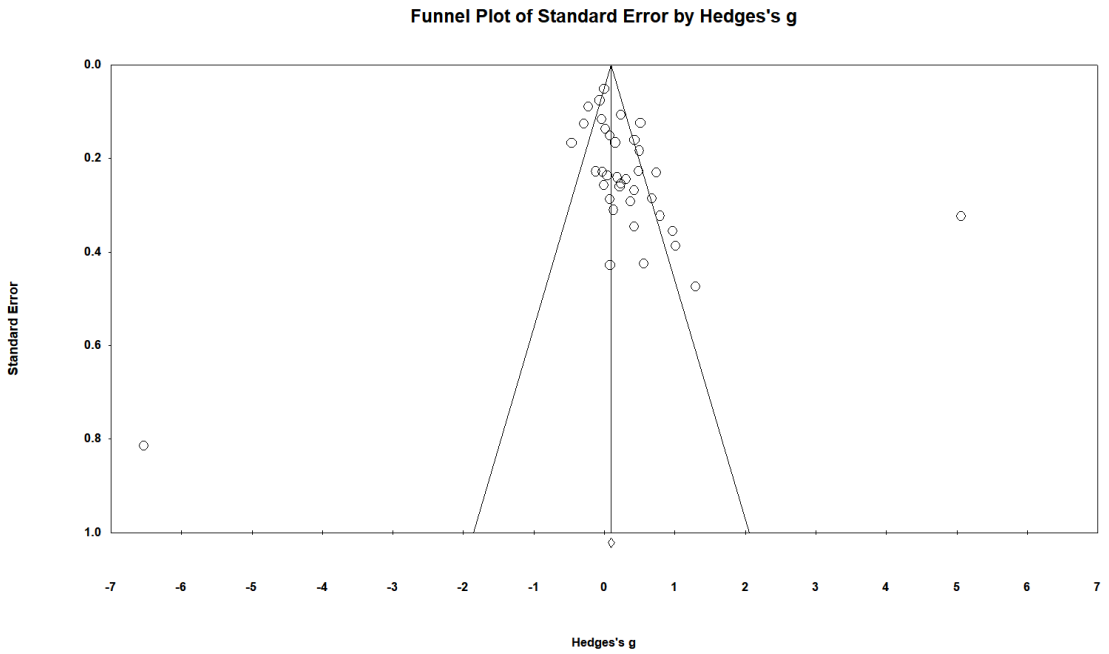

Figure 2-3. Funnel plot of physical activity in this review

3.6 Moderating Effect of Contents Applied in the Intervention on PAVs and PA

We performed 29 meta-analytic moderation analyses based on a refined taxonomy of intervention techniques (Michie et al., 2011; see **Table 2-1**). It was not sensible to perform moderating analyses for the remaining 11 techniques because fewer than three intervention groups utilized them. Refer to **Appendix 2-5** for details of the intervention techniques used in each intervention group.

The presence of two intervention techniques increased the variations in PAVs. They were "teach to use prompts/cues" (present g = 0.73; absent g = 0.26, p = 0.02) and "facilitate social comparison" (present g = 0.98; absent g = 0.26, p = 0.01). However, the application of two other intervention techniques could reduce the outcomes of PAVs. They were "barrier identification/ problem solving" (present g = 0.09; absent g = 0.45, p = 0.01) and "plan social support/ social change" (present g = 0.19, absent g = 0.45, p =0.04). None of the other 25 techniques included in the moderator analysis differed significantly in their effect size estimates between the two study groups, irrelevant of whether they included a specified technique or not (see **Table 2-4**).

The presence of three intervention techniques increased the variations in PA. They were "provide information on consequences of behavior in general" (present g = 0.54; absent g = 0.26, p = 0.04), "teach to use prompts/cues" (present g = 1.33; absent g = 0.25, p <0.01) and "facilitate social comparison" (present g = 0.97; absent g = 0.3, p = 0.02). However, the application of another intervention technique could reduce the outcomes of PA. It was "barrier identification/ problem solving" (present g = 0.19;

absent g = 0.46, p <0.05). None of the other 25 techniques included in the moderator analysis differed significantly in their effect size estimates between the two study groups, irrelevant of whether they included a specified technique or not (see **Table 2-4**).

Table 2-4. Comparison between PAVs and PA, according to whether a specific technique is present or absent in the intervention

	Technique (moderator)	PAVs								PA							
		Present			Absent			Q	*p*	Present			Absent			Q	*p*
		k	g	SE	k	g	SE			k	g	SE	k	g	SE		
1	Provide information on consequences of behavior in general	15	0.29	0.11	34	0.32	0.08	0.05	0.83	15	0.54	0.13	34	0.26	0.09	3.45	0.04
3	Provide information about others' approval	9	0.26	0.15	40	0.32	0.07	0.02	0.73	9	0.18	0.16	40	0.39	0.08	1.35	0.25
4	Provide normative information about others' behavior	5	0.43	0.23	44	0.30	0.07	0.28	0.60	5	0.40	0.26	44	0.35	0.08	0.05	0.83
5	Goal setting (behavior)	19	0.29	0.10	30	0.33	0.08	0.12	0.73	19	0.39	0.11	30	0.32	0.10	0.25	0.61
6	Goal setting (outcome)	6	0.24	0.19	43	0.32	0.07	0.15	0.70	6	0.39	0.22	43	0.35	0.08	0.04	0.84
7	Action planning	28	0.20	0.08	21	0.38	0.10	2.21	0.14	28	0.33	0.09	21	0.38	0.12	0.10	0.75
8	Barrier identification/ problem solving	18	0.09	0.10	31	0.45	0.08	7.79	0.01	18	0.19	0.11	31	0.46	0.09	3.43	<0.05

9	Set graded tasks	10	0.16	0.13	39	0.36	0.07	1.87	0.17	10	0.35	0.15	39	0.35	0.08	0.00	0.98
10	Prompt review of behavioral goals	13	0.34	0.12	36	0.30	0.07	0.08	0.78	13	0.65	0.14	36	0.25	0.08	5.67	0.06
11	Prompt review of outcome goals	3	0.43	0.23	46	0.30	0.07	0.28	0.60	3	0.40	0.26	46	0.35	0.08	0.05	0.83
16	Prompt self-monitoring of behavior	24	0.24	0.09	25	0.37	0.09	1.12	0.29	24	0.28	0.11	25	0.42	0.10	0.88	0.35
17	Prompt self-monitoring of behavioral outcome	4	0.15	0.20	45	0.33	0.07	0.75	0.39	4	0.36	0.24	45	0.35	0.08	0.00	0.96
19	Provide feedback on performance	20	0.23	0.10	29	0.37	0.08	1.08	0.30	20	0.27	0.11	29	0.41	0.09	0.86	0.35
20	Provide instruction on when and where to perform the behavior	40	0.31	0.07	9	0.31	0.16	0.03	0.99	40	0.34	0.08	9	0.42	0.18	0.15	0.70
21	Provide instruction on how to perform the behavior	41	0.32	0.07	8	0.27	0.18	0.06	0.80	41	0.36	0.08	8	0.32	0.21	0.04	0.84

22	Model/demonstrate the behavior	28	0.28	0.08	21	0.36	0.10	0.29	0.60	28	0.43	0.09	21	0.23	0.12	1.75	0.19
23	Teach to use prompts/cues	6	0.73	0.20	43	0.26	0.06	5.09	0.02	6	1.33	0.23	43	0.25	0.07	19.80	<0.01
24	Environmental restructuring	15	0.29	0.11	34	0.32	0.08	0.04	0.85	15	0.21	0.12	34	0.42	0.09	1.94	0.16
26	Prompt practice	7	0.26	0.16	42	0.32	0.07	0.13	0.72	7	0.18	0.19	42	0.38	0.08	1.02	0.31
27	Use of follow-up prompts	3	0.19	0.29	46	0.32	0.06	0.19	0.66	3	0.46	0.32	46	0.34	0.07	0.12	0.73
28	Facilitate social comparison	4	0.98	0.25	45	0.26	0.06	7.95	0.01	4	0.97	0.28	45	0.30	0.07	5.45	0.02
29	Plan social support/ social change	25	0.19	0.08	24	0.45	0.09	4.11	0.04	25	0.41	0.10	24	0.28	0.11	0.86	0.35
33	Prompt self-talk	4	0.04	0.23	45	0.33	0.07	1.53	0.22	4	0.22	0.26	45	0.36	0.08	0.26	0.61
34	Prompt use of imagery	9	0.35	0.17	40	0.31	0.07	0.05	0.82	9	0.10	0.18	40	0.40	0.08	2.27	0.13

35	Relapse prevention/ coping planning	3	0.23	0.23	46	0.32	0.07	0.12	0.73	3	0.52	0.27	46	0.33	0.07	0.47	0.49
36	Stress management/ emotional training	24	0.26	0.09	25	0.36	0.09	0.66	0.42	24	0.32	0.10	25	0.39	0.10	0.23	0.63
37	Motivational interviewing	6	0.10	0.19	43	0.34	0.07	1.38	0.24	6	0.33	0.22	43	0.36	0.08	0.02	0.90
38	Time management	4	-0.16	0.25	45	0.34	0.07	3.62	0.06	4	0.08	0.27	45	0.37	0.08	1.08	0.30
39	General communication skills training	5	0.05	0.18	44	0.35	0.07	2.54	0.11	5	0.13	0.20	44	0.38	0.08	1.39	0.24

Note: k indicates the number of intervention groups adopting/not adopting a particular technique. They are calculated using all comparisons (Two arms, Control vs. A, Control vs. B, Control vs. C) with a total of 49 data sets. Moderator analysis was only done on moderators present in >3 intervention groups.

4 Discussion

This paper intended to provide a nuanced summary of the characteristics of current research methodologies for PAVs and PA interventions, identify intervention techniques that have been used sparingly, and determine the most compelling theories and techniques in recent researches. Therefore, this investigation had two series of objectives. First, summarize experimental studies targeting PAVs in order to change PA and their characteristics (study characteristics, BCT characteristics, PAV characteristics, PA characteristics); second, investigate the moderating effects of methodology, demographics, and BCTs.

4.1 The Characteristics of Demographics and Methodologies

The retrieved studies suggest that 83.78% of the included studies were of moderate or low quality, only about a third were RCTs, and approximately half were small sample studies. Besides, the majority of the retrieved studies were set in schools or universities, and only one study setting was the worksite. Approximately 70% of the studies did not specify subject genders; nearly 30% of the interventions targeted females only, with only one study exclusively targeting male subjects. Approximately 45% of the studies did not report on the subjects' PA level at baseline ("not meeting guideline" or "meeting guideline"), and the role of PAVs for different initial exercise conditions remained to be explored. Besides, PAVs were measured in various formats and dimensions, but no studies explained the differences and commonalities between those different formats and dimensions. Generally, PA consists of three elements: exercise intensity, exercise duration, and exercise frequency. However, only six of the 37 studies used accelerometers, and the others measured only one or two of the three elements of PA (subject's steps, heart rate, instrument usage, or possible time of exercise). Hence, in future studies, the accuracy of PA measurements could be improved further. Finally, eleven of 40 intervention techniques were utilized by less than three intervention groups, and their effectiveness should be explored better in relevant studies.

4.2 Moderating Effect of Methodological and Demographic Variables on PAVs and PA

The differences of effects between intervention and control conditions on both PAVs ($g = 0.29$; 95% CI = 0.15 to 0.43) and PA ($g = 0.30$; 95% CI = 0.11 to 0.49) were significant. Due to the studies' non-negligible heterogeneity, these considerable effect sizes should be interpreted with caution. Furthermore, our survey identified the underlying publication bias (Egger's intercept $t = 1.65$ (35), $p = 0.02$) in PAVs context. Given the significant publication bias in PAV, we further detected a larger effect size

for small studies. Borenstein et al. (2009) noted that this pattern of larger effect size for small studies might because we retrieved a biased sample of small studies, but it is also possible that the effect size for small studies is larger for entirely unrelated reasons. That is, the presence of a small-study effect (Sterne et al., 2001) in PAVs may contribute to its publication bias. Under these circumstances, we recommend focusing on high-power studies and reducing studies with small samples to obtain more reliable estimates in future meta-analyses. Overall, no significant variations were found across the number of intervention methods used, PA at baseline, measurement employed, study design, or study quality assessment. However, age, gender, intervention duration, and theoretical framework significantly moderated the finding of PA. These findings were briefly discussed below.

a) *Age moderated PAV and PA.* Studies at the age interval between 36 and 50 years reported the maximum effect size (g = 0.48) in the PAV context, and subjects age between 18 and 35 reported the maximum effect size (g = 0.44) in the PA context. These results were consistent with those described by Lundqvist et al. (2013) and Vieillard and Gilet (2013): on the one hand, aging was associated with the maintenance of positive affect and the reduction of negative affect; on the other hand, a stimulus rating task showed that older adults had a considerably smaller range of responses to emotional stimuli than youngers. Besides, Kang et al. (2009) showed that separating interventions for different age groups was significantly more effective than not separating. Maybe one appropriate intervention strategy for one age group may not be appropriate for another age group. Therefore, we recommend selecting samples of approximately similar ages in a single study and administering higher intensity emotional stimulation to the young population in such interventions.
b) *Gender moderated PA.* Mixed samples (g = 0.30) reported larger changes than female samples (g = 0.07) in the PAV context, and mixed samples (g = 0.46) also reported larger changes than female samples (g = -0.08) in the PA context. These findings are difficult to interpret because there are not enough male-only samples to compare to mixed samples. Future studies where participant gender is used as an ex post facto variable within the same design are needed to shed light on this finding.
c) *Intervention duration moderated PAV.* The results suggested that interventions shorter than two months showed the most significant effect size (g = 0.69). Based on this result, we take a long-term perspective and recommend that exercise intervention strategies should not be monotonous and constant over time but should be adjusted about once every two months in order to facilitate PAV growth.
d) *Theory moderated PAV and PA*. Interventions with SDT (g = 0.80) had the most significant impact on PAV outcomes, while interventions without a theoretical basis (g = 1.03) had the most significant impact on PA. SDT posits that there are two main types of motivation - intrinsic and extrinsic - and that both are powerful forces shaping who we are and how we act. When individuals are motivated by intrinsic motivation, they may feel self-directed and autonomous (Ryan and Deci, 2000). This result is understandable due to the numerous conceptual and content similarities between intrinsic motivation and PAVs (Wienke and Jekauc, 2016). Parallel to the aforementioned, the interventions without theory presented the most

significant impact on PA, which may reveal the limited predictive power of current theoretical frameworks. These findings highlighted the importance of developing theory underpinnings of PA prediction and intervention.

4.3 Moderating Effect of contents applied in the intervention on PAVs and PA

We found "teach to use prompts/cues" and "facilitate social comparison" were related to conceivable positive changes in PAV, and "teach to use prompts/cues," "facilitate social comparison," and "provides information on consequences of behavior in general" were related to positive changes in PA. These findings were briefly discussed below:

a) "*Teach to use prompts/cues*" *positively moderated PAV and PA.* The concept of "teach to use prompts/cues" is to instruct people to recognize environmental prompts (e.g., mobile phone reminders) that can be used to remind them to enact an intended behavior. This technique is desired as a planned, systematic delivery of cues to prompt people to do cognitive or metacognitive work on emotional arousal and PA to help people establish task-specific routines, automatic responses, or habits in their daily lives that internalize motivational factors and thus contribute to PA levels (Hayamizu, 1997). The TTM researchers note that teaching to use prompts/cues of PA behavior can facilitate individuals' transition from pre-contemplation stage to contemplation stage or even action stage. However, in explaining why this technique works, this theory only emphasizes consciousness-raising and ignoring PAVs' changes. Therefore, future TTM-based PA intervention studies could additionally consider the role of PAVs.

b) "*Facilitate social comparison*" *moderated PAV and PA.* It is not surprising that this technique enhanced both PAVs and PA, as the technique in line with a critical construct of SDT. The SDT assigns a central role to intrinsic motivation, a construct that is typically operationalized by assessing the degree of enjoyment associated with behavioral preferences (Deci and Ryan, 2008). The concept of "facilitate social comparison" is to draw attention to the performance of others to elicit comparisons. According to SDT, individuals have three necessary psychological needs for intrinsic motivation to adopt and adhere to behaviors: the need for competence, the need for relatedness, and autonomy. We speculate that social comparisons enhance the subjects' sense of competition and the likelihood of perceiving their competence (Kwasnicka et al., 2016).

c) "*Provide information on consequences of behavior in general*" *positively moderated PA.* Its purpose is to provide information on the relationship between PA and its possible consequences in general cases, based on epidemiological data. One possible explanation for the positive effect is that the epidemiological data may have facilitated the valuation of PA as healthy, but this could also be a statistical fluke of the results of multiple comparisons, so further research on this topic is recommended.

In contrast, “barrier identification/ problem solving” was negatively associated with PAVs and PA change, and “plan social support/social change” was related to an adverse change in PAVs. These findings were briefly discussed below:

a) “*Barrier identification/ problem solving*” *negatively moderated PAV and PA.* Both Koole and Rothermund (2011) and Gyurak et al. (2011) pointed out the difference between explicit (requires conscious and cognitive effort to initiate and monitor) and implicit (operates without the need for conscious supervision) emotion regulation. Gyurak et al. (2011) also noted that although, by definition, implicit emotion regulation is not intentional (i.e., it is not instigated or guided by explicit intentions), some research emphasizes the goal-directed nature of implicit emotion regulation. This aspect of non-intentionality distinguishes the studies of implicit emotion regulation from most studies of explicit emotion regulation because implicit emotion regulation does not require such explicit instruction, so it is more spontaneous than explicit emotional regulation (Koole and Rothermund, 2011). Given that “barrier identification & problem solving” was defined as prompting the person to think about underlying obstacles and identifying methods to overcome them (Michie et al., 2011), we considered it to be a cognitive variable. In other words, we thought this cognitive variable to be an explicit rather than implicit process, which might have hindered PAVs and subsequent PA growth. In addition, as a common intervention technique based on SCT, we might have to consider its impact on environmental modification and also on affective variables. However, it was also possible that barrier identification was not necessarily ineffective, but instead that the technique was ineffective due to an incorrect implementation method.

b) “*Plan social support/ social change*” *negatively moderated PAV.* Although relatively little research has been done on the relationship between this variable and PAVs, the outcome is understandable. Because planning is an activity that requires the activation of an individual’s cognitive resources, we consider this variable also to be an explicit rather than implicit process of emotion regulation. Based on the interaction between cognition and emotion (Liu et al., 2009), we speculate that complex cognition hinders the growth of PAVs. In general, social change is also a common intervention or environmental modification technique based on SCT. Future PA intervention studies using social support/social change need to address the impact on PAVs. However, this could also be a statistical fluke of multiple comparisons, and further research on this is recommended.

At present, new theoretical models of PA change have been developed based on the automatic affective valuation option, such as affective–reflective theory (ART; Brand and Ekkekakis, 2018) and the PA adoption and maintenance model (PAAM model; Strobach et al., 2020). However, they have not yet explored which specific BCTs would be helpful for enhancing positive affective evaluations (PAVs) in the healthy population, and this paper might be considered as a preliminary attempt.

5 Limitations and Future Research Directions

Although this review followed the Cochrane handbook for systematic reviews of interventions (Higgins et al., 2019b) as normatively as possible, several limitations still exist. First, the included studies were limited by search terms and language, and it was not possible to include all relevant studies. Future studies should consider including more languages to explore whether there are differences in manipulating positive affect variables and PA across countries or cultural contexts (e.g., Eastern and Western cultural contexts). Second, this study did not include unpublished data. However, given Bellefontaine and Lee (2014) explored the impact of including grey literature and found no significant differences in effect size and methodological quality with or without the inclusion of unpublished studies, we also considered this to be a minor limitation. Third, since it was not possible to split positive and negative affective variables into two, we only excluded negative affective variables. Fourth, due to data limitation, we could not analyze all 40 behavior change techniques listed in Michie et al. (2011), and only 29 BCTs were analyzed. Therefore, rigorous experimental testing using a factorial design that isolates and combines unique techniques is needed. Fifth, this paper focused on exploring the effectiveness of different BCTs, but not the effectiveness of affective change techniques, so more work needs to be done to gain insight into them. Sixth, given the broad age spectrum of the current study population, we expect future studies to narrow their age spectrum to explore age-specific intervention techniques. Seventh, the results might be inflated due to potential unit-of-analysis errors that might exist by using the current analytical methods. According to Cheung (2019) and Higgins et al. (2019a), multi-level meta-analysis and network meta-analysis are probably the best to deal with meta-analysis studies which include several effects from one study. Future studies should consider using them to achieve rigorous estimations.

6 Conclusion

Overall, the primary objective was to summarize the demographic, methodological, and BCTs of each study to review gaps in past experimental designs. Descriptive statistics showed that: at least 11 behavior change techniques were rarely used in included studies; the measurements of PAV dimensions and methods were highly inconsistent across studies; accelerometers were still not widely used in PA measurement. Inferential statistics yielded that: age, gender, intervention duration, and theoretical basis had significant moderating effects on PAV or PA outcomes; the utilization of “teach to use prompts/cues,” “facilitate social comparison,” and “provide information on consequences of behavior in general” had positive effects on PA or PAV outcomes; the utilization of “barrier identification/ problem solving” and “plan social support/ social change” negatively affected on PA or PAV outcomes. However, there was considerable heterogeneity in the findings, and the moderator analyses suggested that these effects may be exaggerated by publication and small sample bias. Nonetheless, this paper has considerable implications for future relative intervention

studies, and these findings will serve as a base for future such intervention studies.

- **Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
- **Author Contributions:** DJ and CC contributed to the study's conception and design, and DJ supervised the entire process. CC organized the database, performed the statistical analysis, wrote the manuscript. EF and AK supported CC in data extraction and data analysis phases; DJ, EF, and CC contributed to manuscript revision. All authors read and approved the submitted version.
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Chapter 4

Study 3: A Short Version of the Physical Activity Enjoyment Scale: Development and Psychometric Properties

1 Introduction

The scientific evidence allows the conclusion that physical activity (PA) during adolescence contributes to developing a healthier lifestyle in later life, reducing the prevalence of non-communicable diseases and improving psychological well-being(Hallal et al., 2006; Mason et al., 2016; Moreno et al., 2008; Ussher et al., 2007). According to the WHO recommendations on the health benefits of PA, adolescents should accumulate at least 60 min of moderate to vigorous PA per day (Organization, 2010). However, only a minority of adolescents report engaging in PA at a level compatible with the health guidelines (Burchartz et al., 2021; Irwin, 2007; D. R. Silva et al., 2018). Moreover, while many adolescents start PA programs to improve their health and lose weight, the rate of dropouts is high (Crane & Temple, 2015). Specifically, regarding the maintenance of PA, researchers emphasize the role of affective processes (Jekauc, Reimers, et al., 2013; Kwan et al., 2017; Weyland et al., 2020). Notably, there is a large volume of studies describing the critical role of enjoyment in PA (C. Chen et al., 2020; H. Chen et al., 2017; Dishman, Motl, Saunders, et al., 2005; Ghorbani et al., 2020; Jekauc, 2015; Schneider & Cooper, 2011; Yli-Piipari et al., 2013). Despite extensive research demonstrating the importance of PA enjoyment, to date, however, there has been little consensus on what PA enjoyment actually is (Kimiecik & Harris, 1996).

In general, enjoyment can be regarded as an emotion. There has been a long debate about how emotion might be defined. One study has collected a long list of definitions of emotion, none of which have been able to gain general acceptance (Kleinginna & Kleinginna, 1981). One well-known study stated that a distinction should be made between an automatic affect and a full-blown emotion (Baumeister et al., 2007). While automatic affect represents a simple and rapid appraisal that something is good or bad, positive or negative, emotions are more deliberate, slow, and involve cognitive processes. Although there is currently no universal definition of emotion, most scientists agree that emotions always represent a valenced state of relatively short duration and are related to an object, person, or activity (Mulligan & Scherer, 2012). Based on the component process model (Scherer, 1987), five emotion components can be distinguished: cognitive appraisal, physiological responses, action tendencies, motor expressions, and feelings (also called subjective experience). The components are re-cursively influenced by appraisal processes, contributing to their consistency and synchronization (Scherer, 1987, 2001). All these changes are then

integrated and centrally represented as feelings (Scherer, 2001), which are then further categorized and labeled as emotional terms (e.g., enjoyment). That is, the feeling component is considered the most central component of emotion, which differentiates it from other psychological states (Scherer, 2005). Based on these theoretical considerations, we define PA enjoyment as a positively valenced emotion directed towards PA associated with feelings such as pleasure, joy, and fun (Jekauc et al., 2020).

In measuring PA enjoyment, the physical activity enjoyment scale (PACES) is the most prominent instrument. While the original version was developed by Kendzierski and DeCarlo (1991), several alternative forms have been developed (see **Table 3-1** for a comparison). In detail, the original unidimensional 18-item PACES (Kendzierski & DeCarlo, 1991) was validated for its validity and reliability ($\alpha = 0.93$) in college students (aged between 18–24 years). However, a factor analysis of the PACES in the youth sports population (aged between 10–17 years) showed that the scale was not unidimensional (P. R. E. Crocker et al., 1995). After evaluating by a focus group, two items were removed (Motl et al., 2001), one of which ("I was very absorbed in the activity") was removed because it was considered to be irrelevant to PA enjoyment, the other ("It is very invigorating") was removed because it was considered redundant. However, the study also reported that the 16-item PACES fitted a unidimensional model with methodologic effects behind positively worded items (Motl et al., 2001). Given this, Dishman et al. (2005) eliminated the positively worded items reducing the scale items to seven and identified sufficient construct validity of the seven-item scale in a sample of US adolescents. However, one study argued that many scale shortening studies do not start from a conceptual point of view but place excessive credit on statistical techniques (Coste et al., 1997). Then PA enjoyment was defined as a positive response to the movement experience or an optimal psychological state that leads to performing PA (Raedeke, 2007). Raedeke noted that the 18-item PACES appears to tap not only into PA enjoyment (i.e., PA enjoyment reflects feelings about exercise and is a psychological state directly connected to an eliciting stimulus—the exercise experience) itself but also the potential antecedents and consequences of PA enjoyment. Therefore, content analysis with four experts was implemented to shorten the 18-item PACES, and ten items were removed because they were considered not to be the generalized state of enjoying PA or the experience itself. However, the inclusion of an item, "I was very absorbed in the activity," conflicts with Motl et al. (2001)'s results ("I was very absorbed in the activity" was removed because the content was considered not relevant to enjoyment). Furthermore, Raedeke (2007) only reported the item-total correlation and did not attempt to identify other psychometric properties (e.g., construct validity, test–retest reliability, and concurrent validity). In summary, various forms of PACES have been developed for which different limitations have been identified (e.g., the inadequate conceptualization of the PA enjoyment, the methodological effect of positively and negatively worded items). It can be assumed that the methodologic effect is based on an inadequate conceptualization of the construct enjoyment and that the items of PACES might contain contents of further similar constructs (Jekauc et al., 2020). To address these limitations, we argued that it might be helpful to use the definition mentioned above of PA enjoyment as a starting

point to develop a new, shortened scale based on the long versions of PACES.

Table 3-1. Characteristics of different versions of PACES and reasons for item deletions

Author (Year)	Kendzierski & DeCarlo (1991); P. R. E. Crocker et al., (1995)	Raedeke (2007)	Motl et al. (2001)	Dishman, Motl, Sallis, et al. (2005)
Version	18-item PACES	8-item PACES	16-item PACES	7-item PACES
Factor	1 factor	1 factor	1 factor	1 factor
Point	7 points	7 points	5 points	5 points
Subject	College students/ youth sports population	Young female adults/ old adults	Adolescents	Children
Items				
Item 1	I enjoy it; I hate it	I enjoy it	I enjoy it (positive)	
Item 2	I feel bored; I feel interested	I feel interested	I feel bored (negative)	I feel bored (negative)
Item 3	I dislike it; I like it	I liked it	I dislike it (negative)	I dislike it (negative)
Item 4	I find it pleasurable; I find it unpleasurable	I found it pleasurable	I find it pleasurable (positive)	
Item 5	I am very absorbed in this activity; I am not at all absorbed in this activity	I was very absorbed in the activity		
Item 6	It is not fun at all; it is a lot fun	It was a lot fun	It is no fun at all (negative)	It is no fun at all (negative)
Item 7	I find it energizing; I find it tiring		It gives me energy (positive)	
Item 8	It make me depressed; it makes me happy		It makes me sad (negative)	It makes me sad (negative)
Item 9	It is very pleasant; it is very unpleasant	It was very pleasant	It is very pleasant (positive)	
Item 10	I feel good physically while doing it; I feel bad physically while doing it		My body feels good (positive)	
Item 11	It is very invigorating; it is not at all invigorating			
Item 12	I am very frustrated by it; I am not at all frustrated by it		I get something out of it (positive)	

Item 13	It is very gratifying; it is not at all gratifying		It is very exciting (positive)	
Item 14	It is very exhilarating; it is not at all exhilarating		It frustrates me (negative)	It frustrates me (negative)
Item 15	It is not at all stimulation; it is very stimulating		It is not at all interesting (negative)	It is not at all interesting (negative)
Item 16	It gives me a strong sense of accomplishment; it does not give me any sense of accomplishment	I felt as though there was nothing else, I would rather be doing	It gives me a strong feeling of success (positive)	
Item 17	It is very refreshing; it is not at all refreshing		It feels good (positive)	
Item 18	I felt as though I would rather be doing something else; I felt as though there was nothing else		I feel as though I would rather be doing something else (negative)	I feel as though I would rather be doing something else (negative)
Reasons for item deletions	The original scale without deletion	Items seem to tap enjoyment of the activity as well as potential antecedents and consequences of enjoyment	Item 5: the content was not relevant to enjoyment; Item 11: redundant.	Due to the methodological effects behind the positively worded items of the 16-item scale, all positively worded items were deleted.

The purpose of this article was to provide a new form of PACES, using those items that are in line with the definition of PA enjoyment as "PA enjoyment as a positively valenced emotion directed toward the PA associated with feelings such as pleasure, joy, and fun." This implies a reduction of items since we are only interested in those items that truly reflect the subjective experience of PA enjoyment. We believe it could be further beneficial because it can reduce the burden on participants and be more easily used in large-scale studies (Haig, 2018; Ziegler et al., 2014). Hence, the first aim of this paper was to use content analysis to preliminary develop a new short scale. Based on the results of this procedure, the second aim was to measure the psychometric properties of the shortened scale. These include (a) construct validity, (b) internal consistency, (c) test–retest reliability, and (d) concurrent validity. To achieve these aims, first, experts were asked to evaluate the content validity of the individual items of PACES based on the definition of the provided PA enjoyment. Subsequently, the data collected in two studies (Jekauc, Wagner, et al., 2013; Mauz et al., 2020) (the

original authors and project director were contacted to obtain the original PA and PA enjoyment measurement data) were used to determine the psychometric properties of the new PACES.

2 Phase 1: Content Analysis

2.1 Method

According to Lynn (1986), at least five experts were required to provide sufficient control over the chance agreement. Therefore, six experts were selected. Four of these six experts held doctoral degrees in sports science, three of which hold professorships in sports psychology (based in Germany or Switzerland), and one held a research fellowship in sports management in Germany. The other two experts were a Ph.D. student in sports psychology and a master student in sports science in Germany, respectively. To determine the content validity index, the definition of PA enjoyment (i.e., PA enjoyment is a positively valenced emotion directed toward PA associated with feelings such as pleasure, joy, and fun) was provided based on the component process model (Scherer, 1987). Experts were explicitly asked to consider whether negatively worded items (e.g., it is not fun at all) could also measure PA enjoyment. A modified four-point Likert scale (1 = "does not match the definition"; 2 = "matches the definition somewhat well"; 3 = "matches the definition quite well"; 4 = "matches the definition very well") (Davis, 1992) was used to assess the content validity of each of the 16 items (Jekauc, Voelkle, et al., 2013; Motl et al., 2001). By calculating the results of the experts' evaluation, a new short version of the German PACES would then be preliminary developed, subsequently referred to as PACES-S.

2.2 Data Analysis: Content Validity (Item Selection)

The statistical analyses of content validity were performed in Microsoft Excel (Triola, 2010) using the formulas below.

A four-point Likert scale, clearly labeled with the definition of PA enjoyment and the content of each item, was sent to each expert separately. They were invited to rate the relevance of each item according to the definition of PA enjoyment independently. Based on the experts' evaluation results, ratings of 1 or 2 for each item were considered unacceptable, and 3 or 4 were considered acceptable (Lynn, 1986). Two types of content validity indices were used to assess and delete items: (a) item-level content validity index (I-CVI; i.e., the number of experts assigned Grade 3 or 4, divided by the total number of experts) (Davis, 1992); (b) the scale-level content validity index calculated by the average method (S-CVI/ Ave; i.e., the average proportion of items assigned either Grade 3 or 4 across judges) (Polit & Beck, 2006).

When N experts evaluated one item, of which n1 experts assigned it a rating of 1 or 2 and n2 assigned it a rating of 3 or 4 (N = n1 + n2), the I-CVI could be computed as:

$$\text{I–CVI} = \frac{n_2}{N}$$

However, the results derived from the above equations ignored the chance agreement. Therefore, Polit & Beck (2006) and Wynd et al. (2003) advocated adjusting I-CVI calculation and using k* to denote the adjusted I-CVI results. To compute k*, the probability of chance agreement (Pc) was calculated first. The formula was as follows:

$$P_c = \left[\frac{N!}{n_2!\,(N-n_2)!}\right].5^N$$

Next, k* was computed using the I-CVI and P_c:

$$k^* = \frac{\text{I–CVI} - P_C}{1 - P_c}$$

Then, if a scale had n items and the data value was I-CVIi (i = 1, 2, …, n), then we had:

$$\text{S–CVI/Ave} = \frac{1}{n}\sum_{i=1}^{n}(\text{I–CVI}_i)$$

Finally, k* and S-CVI/Ave were employed to evaluate the acceptability of the scale in item level and overall level, respectively. With six experts, the evaluation criteria for k* were as follows: below 0.40 indicated "poor" validity, 0.40 to 0.59 indicated "fair" validity, 0.60 to 0.74 indicated "good" validity, and greater than 0.74 represented "excellent" validity (Cicchetti & Sparrow, 1981; Fleiss et al., 1981). Polit and Beck (2006) recommended that a scale should be composed of items with k* of 0.74 or higher and S-CVI/Ave of 0.90 or higher.

2.3 Result

Based on the content validity evaluated by six experts, four out of sixteen items have been selected. All these four items showed k^* higher than 0.74, and the S-CVI/Ave of the PACES-S was 0.96 (see **Table 3-2**). The items included in the PACES-S were: "I enjoy it", "I find it pleasurable", "It is very pleasant", and "It feels good".

Table 3-2. Experts' rating of item relevance, item-level content validity index (I-CVI), and the Kappa designating agreement of relevance (k*) of the 16-item PACES.

	Items	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Experts in agreement	I-CVI	P_C	k*	Evaluation
1	I enjoy it	Y	Y	Y	Y	Y	Y	6	1.00	0.02	1.00	Excellent
2	I feel bored					Y	Y	2	0.33	0.23	0.13	Poor
3	I dislike it	Y	Y				Y	3	0.50	0.31	0.27	Poor
4	I find it pleasurable	Y	Y	Y	Y	Y	Y	6	1.00	0.02	1.00	Excellent
5	It is no fun at all	Y	Y		Y	Y		4	0.67	0.23	0.56	Fair
6	It gives me energy							0	0.00	0.02	−0.02	Poor
7	It makes me depressed							0	0.00	0.02	−0.02	Poor
8	It is very pleasant	Y	Y	Y	Y	Y		5	0.83	0.09	0.82	Excellent
9	My body feels good							0	0.00	0.02	−0.02	Poor
10	I get something out of it							0	0.00	0.02	−0.02	Poor
11	It is very exciting		Y		Y			2	0.33	0.23	0.13	Poor
12	It frustrates me						Y	1	0.17	0.09	0.08	Poor
13	It is not at all interesting		Y					1	0.17	0.09	0.08	Poor
14	It gives me a strong feeling of success							0	0.00	0.02	−0.02	Poor
15	It feels good	Y	Y	Y	Y	Y	Y	6	1.00	0.02	1.00	Excellent
16	I feel as though I would rather be doing something else							0	0.00	0.02	−0.02	Poor

3 Phase 2: Psychometric Properties

3.1 Method

The data of two cohort studies (Jekauc, Wagner, et al., 2013; Mauz et al., 2020)

were used to determine internal consistency, test–retest reliability, construct validity, and concurrent validity of the PACES-S developed in Phase 1. The subjects' PA enjoyment and PA data were measured in Study 1 (Measure 1, Measure 2) and Study 2, respectively.

Study 1

Participants

A total of 182 students (male, n = 103, female, n = 79) aged between 11–17 years were recruited for this study. All students came from a comprehensive secondary school in a German city, with all three types of the traditional German tripartite secondary school system: Hauptschule, Realschule, and Gymnasium. After the teachers had agreed, and according to the Helsinki Declaration, informed written consent was obtained from the participants and their parents or guardians before entering the study (Williams, 2008). The study was approved by the ethics committee of the Charité Universitätsmedizin Berlin. Detailed information on the data collection techniques and quality of the sample are presented elsewhere (Jekauc, Wagner, et al., 2013).

Procedure

Participants provided their personal information (e.g., age, gender, school type). They also completed the MoMo physical activity questionnaire (MoMo-PAQ) and the PACES-S twice (Measure 1, Measure 2; Measure 1 and Measure 2 correspond to the PACES-S administered before and after seven days, respectively) at school, with a 7-day interval between the completions. During these seven days, participants wore accelerometers and completed Previous Day Physical Activity Recall (PDPAR; Williams, 2008) daily. This study was performed between April and July 2009.

Measurement

Physical activity enjoyment. The 16-item PACES was used in this study (Jekauc, Voelkle, et al., 2013; Motl et al., 2001). However, based on the results of the content analysis described above, we only included the four items of PACES-S (i.e., Item 1: I enjoy it; Item 2: I find it pleasurable; Item 3: It is very pleasant; Item 4: It feels good) (Jekauc, Voelkle, et al., 2013). The items were answered using a five-point Likert scale ranging from 1 = "strongly disagree" to 5 = "strongly agree".

PA questionnaire. Habitual PA was measured by MoMo-PAQ (Jekauc, Wagner, et al., 2013). This questionnaire contained 28 items and measured PA in four distinct settings: daily PA, school PA, PA in and outside organized sports clubs. For each setting, the frequency, duration, intensity, and types of PA were measured. MoMo-PAQ has been shown to be a validated instrument with acceptable reliability (test–retest

reliability = 0.68) and significant correlations with accelerometer-recorded data (r = 0.29) (Jekauc, Wagner, et al., 2013).

PA diary. The PDPAR (Weston et al., 1997) is a self-reporting and time-based recall instrument designed to capture adolescents' previous day's PA. In the present study, certain hours of a day were divided into one-hour metric blocks. Participants were instructed to note their specific activities (38 activities were listed for participants to select from, which could be grouped into six main clusters: eating, sleep/bathing, transportation, work/school, spare time, PA) and the intensity of activity for each time block (light, moderate, vigorous, very vigorous). Finally, the metabolic equivalent (MET) levels were computed to determine each participant's PA. The instrument has proven to be valid and reliable in measuring PA (Booth et al., 2002; Weston et al., 1997).

Accelerometer. The Actigraph GT1M accelerometer (Pensacola, FL, USA) was also used to measure PA. It is a two-axis accelerometer with a solid-state sensor and micro-electro-mechanical system with a dynamic range of 0.05–2.5 G and frequency range of 0.25–2.5 Hz. The filtered acceleration signal was digitized, rectified, integrated (calculating the 'activity count'), stored, and reset at user-specified intervals (10 s for the present study). Ultimately, we evaluated the participants' daily PA based on the duration and intensity of PA (light < 3 METs, moderate 3–6 METs, vigorous 6–9 METs, very vigorous > 9 METs) measured and calculated by accelerometers. In particular, the duration of moderate, vigorous, and extreme vigorous PA per day was combined into a single variable as "accelerometer-recorded MVPA". The accelerometers were worn around the participants' waists via elastic waistbands. Participants were requested to wear the devices for seven consecutive days of waking hours (except for swimming and bathing). Measuring PA with the Actigraph GT1M has been proven valid and reliable for adolescents (P. Silva et al., 2010; Vries et al., 2006). Eligible accelerometer data should meet the criteria that: (1) participants wore the accelerometer for at least 10 h per day over a minimum of 5 days, and (2) non-wearing was defined as at least 60 consecutive minutes of zero activity intensity (1–2 min of counts between 0 and 100 were allowed).

3.1.1 Study 2

To replicate the reliability and validity analyses of the PACES-S in Study 1, psychometric properties of the measure were also assessed using data from Study 2 (Mauz et al., 2020).

Participants

The German Health Interview and Examination Survey for Children and Adolescents (KiGGS) is part of the Federal Health Monitoring System conducted by the Robert Koch Institute (RKI) and consists of regularly conducted nationwide surveys among children, adolescents, and young adults aged 0 to 29 years and living in Germany. KiGGS Wave 2 was conducted between 2014 and 2017. The Motorik-Modul Study

(MoMo) is a submodule of the KiGGS study and aims to assess physical fitness, PA, as well as determinants of PA in children and adolescents (Woll et al., 2021). The whole study sample was drawn from the German resident population aged 4 to 17 years (only subjects aged between 11 and 17 years were selected for this study) using a two-stage cluster sampling approach. Informed consent to participate in the study was obtained from the participants and their parents or guardians. In addition, participants from the baseline study (2003–2006) and Wave 1 (2009–2012) were reinvited. A detailed description of the study design and sampling procedure can be found elsewhere (Burchartz et al., 2020; Choi et al., 2011; Mauz et al., 2020). KiGGS and MoMo provide nationally representative data of PA and sedentary behavior of children, adolescents, and young adults living in Germany (Choi et al., 2011). A favorable vote of the ethics committee of Karlsruhe Institute of Technology of 23 September 2014, is available for the study. A total of 3219 participants (male, n = 1538, female, n = 1681) aged between 11–17 years were recruited for this study.

Procedure

Participants provided their personal information (e.g., age, gender, school type) and completed the PACES-S after physical fitness tests (Wagner et al., 2014). After completing the scales, participants were assigned to wear accelerometers for eight days to record their PA data (data measured on the first day were discarded. This study was performed between 2014 and 2017.

Measurement

Enjoyment. Enjoyment was measured using the PACES-S described in Study 1.

Accelerometer. PA was measured using the Actigraph GT3X, the successor accelerometer model described in Study 1. The technical and methodological details of the accelerometer measurement of Study 2 can be found elsewhere (Choi et al., 2011). In short, placement of the device was on the hip, sampling frequency was 30 Hz, the same filter as in Study 1 was used, epoch lengths was 1s with the possibility to convert into 5 s, 10 s, 15 s, 30 s, and 60 s, non-wear time definition was the algorithm by Choi et al. (2011), and the valid datasets needed eight hours of recordings on four weekdays and one further weekend day when wearing the device for seven days. Sedentary and physical activity intensity classification used algorithms by Evenson et al. (2008) and Romanzini et al. (2014). In addition, the number of days that each participant met the WHO physical activity recommendation level (i.e., Daily MVPA greater than 60 min; Organization, 2010) over seven days was combined into a new variable, “PA compliance days”.

3.2 Data Analysis (Study 1 and 2)

For psychometric properties, we evaluated the internal consistency, test–retest

reliability, construct, and concurrent validity of the PACES-S.

Internal consistency. The PACES-S data from Study 1 (Measure 1, Measure 2) and Study 2 were used to analyze internal consistency in SPSS 25(Howitt & Cramer, 2017). The internal consistency was assessed by examining Cronbach's alpha coefficient (Cronbach, 1951). An acceptable alpha value would be in the range of 0.70 to 0.90 (Streiner, 2003; Tavakol & Dennick, 2011).

Test–retest reliability. The PACES-S scores measured twice a week apart in Study 1 were used to calculate Pearson correlation coefficients in SPSS 25. A 5% cut-off was taken for significance, whereby a value greater than 0.70 was deemed to be acceptable (L. Crocker & Algina, 1986).

Construct validity. Factor analyses were conducted to assess construct validity based on the results of the PACES-S from Study 1 (Measure 2) and Study 2. Data from Study 1 (Measure 2) were used for an exploratory factor analysis (EFA) to explore the underlying structure of the PACES-S in SPSS 25 (Fabrigar et al., 1999). Then, data from Study 2 were used for a confirmatory factor analysis (CFA) to validate the identified factor structure in AMOS 25 (Finch et al., 2016; Jöreskog, 1969). Firstly, the factors were extracted in EFA using the principal component method with varimax rotation. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were employed to test the appropriateness of the factor analysis (Kaiser, 1974). Missing data ranged between 0.5–2.7% for the PACES items. Further, the specific evaluation criteria were as follows: (1) the factor loading of an item was not less than 0.6 (Ogden et al., 1997); (2) the number of factors was determined using a scree plot (Cattell, 1966) and the following criteria: eigenvalue greater than 1 (Cliff, 1988; Guttman, 1954), an individual factor accounting for no less than 10% of the total variance, and a composite of the extracted factors accounting for no less than 70% of the total variance (O'Rourke et al., 2013). Secondly, CFA was used to validate the structure obtained in EFA using full-information maximum likelihood estimation. This method yields less biased estimates than classical missing data procedures, such as list-/pairwise deletion or means imputation (Jekauc et al., 2012). Missing data ranged between 1.9–2.5% for the PACES items. Given the high sensitivity of Chi-square statistics in large samples (Martin-Löf, 1974), the following fit indices and criteria were used to examine the goodness of fit of the model (it was considered good if the following criteria were satisfied): root mean square error of approximation (RMSEA) between 0 and 0.08 (Browne et al., 1993); comparative fit index (CFI), normed fit index (NFI), relative fit index (RFI) and Tucker-Lewis Index (TLI) between 0.95 and 1, and incremental fit index (IFI) over 0.90 (Bentler, 1990; Bentler & Bonett, 1980; Hu & Bentler, 1999).

Concurrent validity. The concurrent validities for PACES-S were derived by computing Pearson correlation coefficients between PACES-S scores (Measure 2) and criterion scores for MoMo-PAQ (Jekauc, Wagner, et al., 2013), PDPAR (Weston et al., 1997), and accelerometer ("accelerometer-recorded MVPA") in Study 1. Simultaneously, the correlations between results on accelerometers ("accelerometer-recorded MVPA" and "PA compliance days") and PACES-S provided the estimate of concurrent validity in Study 2. A 5% cut-off was used for significance, with four levels

of interpretation for correlation-based effect sizes: very small ($r < 0.1$), small ($0.10 \leq r \leq 0.30$), moderate ($0.30 \leq r < 0.50$), large ($0.50 \leq r$) (Cohen, 1988).

3.3 Results

3.3.1 Study 1

Descriptive Statistics

Of the 182 participants, 103 (56.6%) were males, and 79 (43.4%) were females. Regarding age distribution, 111 (61.0%) were between 11 and 13 years old, 71 (39.0%) were between 14 and 17 years old. Different types of schools accounted for the following percentages of participants: Hauptschule (14.8%), Realschule (30.8%), and Gymnasium (54.4%). As can be seen in **Table 3-3**, the overall data of 174 PACES-S data and participants were valid (missing or invalid data: PACES-S (time 1), n = 8, PACES-S (time 2), n = 8, accelerometer, n = 2; PA questionnaire, n = 0, PA diary, n =0). Concerning males only, 100 (97.1%, missing or invalid data, n = 3) and 98 (95.1%, missing or invalid data, n = 5) participants' PACES-S data were valid for time 1 and time 2, respectively. All (n = 103, 100%) male participants' accelerometer, PA questionnaire, and diary data were valid, 101 (98.1%) male participants' accelerometer data were valid (missing or invalid data, n = 2). For females only, 74 (93.7%, missing or invalid data, n = 5) and 76 (96.2%, missing or invalid data, n = 3) participants' PACES-S data were valid for time 1 and time 2, respectively. All (n = 79, 100%) female participants' accelerometer, PA questionnaire, and diary data were valid.

Table 3-3. Descriptive Statistics and Reliability of the PACES in Study 1

	N	*M* (*SD*)	Minimum Score	Maximum Score	α
Measure 1					
Overall	174	15.75 (3.39)	6	20	0.83
Male	100	15.85 (3.35)	7	20	0.82
Female	74	15.61 (3.46)	6	20	0.85
Measure 2					
Overall	174	15.69 (3.44)	4	20	0.86
Male	98	16.00 (3.54)	4	20	0.87
Female	76	15.29 (3.29)	8	20	0.83

Internal Consistency

As seen in **Table 3-3**, for Measure 1 of Study 1, the overall Cronbach's alpha for the PACES-S was 0.83, for male participants, the Cronbach's alpha for the PACES-S was 0.82, and the Cronbach's alpha for the PACES-S for female participants was 0.85.

For Measure 2 of Study 1, the overall Cronbach's alpha for the PACES-S was 0.86, for male participants, the Cronbach's alpha for the PACES-S was 0.87, and the Cronbach's alpha for the PACES-S for female participants was 0.83.

Test–Retest Reliability

The stability coefficient of the PACES-S for a one-week interval was found to be significant and sufficiently high ($r = 0.76$, $t = 15.14$, $df = 165$, $p < 0.01$).

Construct Validity

In EFA, the results of Study 1 (Measure 2) showed KMO=0.80, Bartlett's test of sphericity $\chi 2 = 313.18$, $df = 6$, $p < 0.001$, indicating that the data were suitable for the factor analysis. Following the principle of eigenvalues greater than 1 and the scree plot to assess the results of the principal component analysis, we identified one factor (eigenvalue = 2.82), which explained 70.38% of the total variance. The factor loadings for the items ranged from 0.79 to 0.86 (see **Table 3-4**).

Table 3-4. Factor loadings from exploratory factor analysis of each item in PACES-S

	Item	Factor Loading
1	I enjoy it	0.86
2	I find it pleasurable	0.85
3	It is very pleasant	0.86
4	It feels good	0.79

Concurrent Validity

We found a moderate correlation between scores on the PACES-S and the MoMo-PAQ, $r = 0.36$, $t = 4.98$, $df = 173$, $p < 0.001$; a moderate correlation between the PACES total score and PDPAR (MVPA minutes) results, $r = 0.44$, $t = 6.34$, $df = 173$, $p < 0.001$; and a moderate correlation between the PACES-S scores and the accelerometer criterion (accelerometer-recorded MVPA), $r = 0.32$, $t = 3.48$, $df = 109$, $p < 0.001$.

Study 2

Descriptive Statistics

Of the 3219 participants, 1538 (47.8%) were males, and 1681 (52.2%) were females. In terms of age distribution, 1343 (41.7%) were between 11 and 13 years old, and 1876 (58.3%) were between 14 and 17 years old. Different types of schools accounted for the following percentages of participants: Grundschule (1.8%), Hauptschule (3.5%), Realschule (22.2%), Gymnasium (50.7%), Gesamtschule (9.1%), Förderschule (0.7%), and other types of schools or missing data (11.87%). As shown in **Table 3-5**, the overall data of 3118 PACES-S data were valid (missing or invalid data: PACES-S, n = 101, accelerometer, n = 1318). Concerning males only, 1493 (97.1%) participants' PACES-S data were valid (45 missing or invalid data), 885 (57.5%) participants' accelerometer data were valid (653 missing or invalid data). For females only, 1625 (96.9%) participants' PACES-S data were valid (56 missing or invalid data), 1016 (60.4%) participants' accelerometer data were valid (665 missing or invalid data).

Table 3-5. Descriptive Statistics and Reliability of the PACES in Study 2

	N	***M* (*SD*)**	**Minimum Score**	**Maximum Score**	**α**
Overall	3118	15.99 (3.10)	4	20	0.87
Male	1493	16.25 (3.06)	4	20	0.88
Female	1625	15.75 (3.12)	4	20	0.87

Internal Consistency

As seen in **Table 3-5**, for Study 2, the overall Cronbach's alpha for the PACES-S was 0.87, for male participants, the Cronbach's alpha for the PACES-S was 0.88, and the Cronbach's alpha for the PACES-S for female participants was 0.87.

Construct Validity

We further used data from Study 2 to test the one-factor model (identified through EFA in Study 1) fit of the PACES-S in AMOS and the overall results indicated a good model fit ($\chi 2 = 53.62$, df = 2, $p < 0.001$; RMSEA = 0.073; CFI = 0.99; RFI = 0.96; NFI = 0.99; TLI = 0.96; IFI = 0.99).

Concurrent Validity

We found a small correlation between scores of PACES-S and the accelerometer-recorded MVPA, r (1840) = 0.21, t = 9.19, $p < 0.001$; and a small correlation between the PACES-S scores and the accelerometer criterion PA compliance days, r (1840) = 0.20, t = 8.78, $p < 0.001$.

4 Discussion

This study aimed to develop a new short, theory-based version of PACES, as there was no reliable version for German adolescents. To this end, first content validity was used to select items that matched the definition of PA enjoyment" PA enjoyment as a positively valenced emotion directed toward the PA associated with feelings such as pleasure, joy, and fun." Subsequently, psychometric properties of the new measures were assessed (i.e., construct validity, internal consistency, test–retest reliability, concurrent validity). Based on the internal consistency and test–retest reliability, the results indicate the good reliability of the new measure. Moreover, both exploratory and confirmatory factor analyses showed a good construct validity of the measure. Finally, regarding the concurrent validity, the results showed that PACES-S positively correlated with self-reported and device-based measures of physical activity.

4.1 Item Selection for Short-Version Scale (Content Validity)

Previous studies have pointed to the inappropriateness of the unidimensional factor and redundant items in the original 18-item PACES (Kendzierski & DeCarlo, 1991; Motl et al., 2001) and the methodological effect of negatively worded items in the 16-item PACES (Jekauc, Voelkle, et al., 2013; Motl et al., 2001). Thus, Dishman et al. (2005) and Raedeke (2007) shortened the scales and obtained a seven-item PACES and an eight-item PACES, respectively. However, the psychometric properties were not adequately validated for the 7-items PACES (Dishman, Motl, Saunders, et al., 2005; Fuentesal-García et al., 2019), and the theoretical conceptualization was missing for the 8-items PACES (Raedeke, 2007).

To solve the issue of inadequate conceptualization, we conceptualized PA enjoyment based on the Component Process Model (Scherer, 1987) and adopted the methodology of Davis and Polit and Beck (2006) to select items. The analytical results found that only 4 of the 16 items achieved the benchmark value for retention ($k^* \geq 0.74$), and the S-CVI/Ave for the shortened scale was 0.96, indicating that the PACES-S had excellent item-level and scale-level content validity indices. Although the experts were explicitly asked to consider that some items are negatively worded with a higher number indicating a low level of PA enjoyment, the procedure resulted in only positively worded items. Including only positively worded items showed similarity to Raedeke (2007)'s experts' assessment.

4.2 Internal Consistency and Test–Retest Reliability

The results indicated good reliability with Cronbach's alpha ranging from 0.82 to 0.88 and test–retest reliability of 0.76. These values were comparable to studies measuring the psychometric properties of other forms of PACES (Jekauc, Voelkle, et al., 2013; Motl et al., 2001). The values were a bit lower than Kendzierski & DeCarlo (1991; $\alpha = 0.96$). However, considering that Kendzierski & DeCarlo (1991)'s alpha value is greater than 0.9, as pointed out by Tavakol & Dennick (2011), this might imply the presence of redundant items in the scale. Compared to the results of Jekauc, Wagner,

et al. (2013), the internal consistency is similar to the long version of the PACES.

4.3 Construct Validity

The exploratory factor analysis showed that all items were on a single factor. The CFA was then conducted to verify the one-factor solution. Overall, the fit indices indicated that the one-factor model did represent an acceptable fit. Thus, it represented that PACES-S was not suffered from method effects similar to the long version of PACES.

4.4 Concurrent Validity

The PACES-S presented adequate concurrent validities with total MoMo-PAQ ($r = 0.36$), PDPAR ($r = 0.44$), accelerometer-recorded MVPA (Study 1: $r = 0.32$; Study 2: $r = 0.21$), and accelerometer-recorded PA compliance days ($r = 0.20$). Taken together, the PACES-S displayed small to moderate significant correlations with both self-reported PA and accelerometer-measured PA. Similarly, Jekauc, Wagner, et al., (2013) measured the predictive validity of the original German version of the 16-item PACES and showed that the scale significantly correlated with the MoMo-PAQ, PDPAR, and accelerometer-recorded MVPA results in German adolescents. Besides, the acceptable concurrent validity between PACES (16 items) and self-reported PA was also in line with the result ($r = 0.16$, $p < 0.01$) by Moore et al. (2009) concerning American children and adolescents. The results of this investigation were also consistent with other studies (Barr-Anderson et al., 2007; Yli-Piipari et al., 2009) that identified PA enjoyment as an important motivating factor for adolescent participants in PA.

5 Strengths and Limitations

Based on the component process model (Scherer, 1987), the study provided a theory-based definition of PA enjoyment to develop a new version of PACES. This study utilized a reasonably large sample (Study 2) and a smaller sample (Study 1) to investigate the psychometric properties of the PACES-S. This procedure resulted in a new shortened version of PACES that may be particularly useful to reduce the burden of participants in large-scale studies, where a wide range of variables are measured. However, there were still some limitations. First, we did not measure PA enjoyment by more objective indicators (e.g., face expression). However, it is crucial to consider that the objective measure of discrete emotions is highly debated within the scientific community(Lisa, 2006). Moreover, the current results are based on studies with German-speaking participants. Therefore, future studies should try to replicate the findings in other languages. Besides, the research did not include children under 11 years old. We presume that children could benefit from this short version with graphical illustration. Further research could be refined and implemented among them. Finally, the technical development is a normal process, but we think that it should be mentioned

in any case that Study 2 used the newer model of the accelerometer with three-dimensional accelerometer acquisition instead of one dimension in Study 1. On the other hand, Kaminsky and Ozemek (Kaminsky & Ozemek, 2012) compared both models used in this investigation and concluded that the data are comparable with each other, whereby the comparability with our data should remain given as well.

6 Conclusions

In conclusion, the four-item PACES-S offered a short and economical measure of PA enjoyment based on a comprehensive definition derived from the component process model. The investigations of the psychometric properties indicated good reliability and validity of the measure, which were comparable to the reliability and validity of the 16-item version of the PACES. The two studies showed that the method effect underlying the 16-item version of PACES could be eliminated. We hope that the use of PACES-S will contribute to a better understanding of the role of PA enjoyment in PA promotion and maintenance research.

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- **Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committees of the Charité Universitätsmedizin Berlin (Baseline Study), the University of Konstanz (Wave 1), and the Karlsruhe Institute of Technology (KIT) (Wave 2 and 3, a positive ethics vote was given from on 23 September 2014 by the ethics committee of the KIT).
- I**nformed Consent Statement:** Informed consent was obtained from all participants involved in the study.
- **Data Availability Statement:** The datasets generated and analyzed during the current study are not publicly available due to the strict ethical standards required

by the Federal Office for the Protection of Data with which study investigators are obliged to comply but are available from the corresponding author on reasonable request.

- **Conflicts of Interest:** The authors declare no conflict of interest.

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Chapter 5

General Discussion

This dissertation is a systematic investigation of the relationship between PAV and PA, and explores effective intervention mechanisms and strategies for improving PA and methods for accurately measuring PA enjoyment. Being inspired by affective heuristics and the Dual-Process Theory (System 1), this dissertation began by exploring the mediating effects of PAVs, and found that PAVs can partially mediate the relationship between interventions and PA (Study 1); it further identified several intervention strategies that may work for either PAVs or PA (Study 2); finally, developing a new PA enjoyment measurement scale (Study 3). We then integrated the findings and discussed the implications of these three studies in terms of their theoretical contributions and practical benefits.

1 Theoretical implications

Mediation analysis is widely used in many fields, because it allows the analysis of the processes and mechanisms of influence between variables. In statistics, the mediation model attempts to identify and explain the mechanism or process of the observed relationship between the independent and dependent variables by including a third hypothetical variable, the mediating variable. It can give more in-depth results between independent and dependent variables than a regression analysis. Although a mediation analysis cannot definitively state that it confirms what is going on, it can help us support a theory and exclude competing theories. The results of Study 1 indicated interventions can modestly increase individuals' PAVs, PAVs can moderately improve exercisers' PA, interventions can slightly increase individuals' PA, and PAVs partially mediate the relationship between intervention and PA. To some extent, the results are fundamentally consistent with the content of the Affect Heuristic and System 1 of the Dual Process Theory. Many new PA change theories have recognized the results of this meta-analysis. For example, the ART (Brand & Ekkekakis, 2018) posits that stimuli associated with PA trigger automatic associations and the automatic positive or negative affective responses associated with PA. The PAAMM (Strobach et al., 2020) assumes the implicit process may influence the explicit system depending on the strength of affective responses and the availability of self-regulatory capacity in PA decision making. Hagger and Chatzisarantis (2014) integrated hypotheses from social-cognitive, motivational, dual-process theories and posited an Integrated Behavior Change Model (IBCM) for PA, which stated that factors beyond consciousness and implicit processes (e.g., affective variables) can affect PA. Conroy and Berry (2017) pointed out that automatic affective evaluations of PA ('gut reactions') are different from reflective attitudes towards PA; more positive automatic affective evaluations are perhaps positively correlated with more physical activity. Overall, PAVs are modifiable and represent promising new targets for PA interventions. Meanwhile, researchers in the field could consider adding PAVs as mediating variables to theoretical models,

developing more refined and advanced theoretical models.

Meanwhile, the results of Study 2 demonstrated significant moderating effects of theoretical foundations (e.g., SDT) on PAVs outcomes, which also emphasized the importance of theoretical research in the context of PA intervention. It is well known that SDT postulates that motivation can be divided into two types - intrinsic and extrinsic - both of which contribute to powerful forces in forming who we are and how we act. When individuals are motivated by intrinsic motivation, they feel self-directed and autonomous (Ryan & Deci, 2000). In 2005, Vlachopoulos and Karageorghis examined the ways in which external regulation, introjected regulation, and recognition regulation interact with PA-related intrinsic motivation, and their relevance to PA enjoyment. The results showed that high levels of identified regulation coexisted with high levels of intrinsic motivation, corresponding to higher PA enjoyment degrees. Therefore, it is considered that this result also side-by-side and partially corroborated the reasonableness of Study 1. Also, we found that fewer than 3 included studies in Study 2 used the Dual-Process Model alone for the PA intervention, so we could not compare the moderating effects of SDT and Dual-Process Model on PAV and PA. Likewise, the validity or interpretability of the new proposed PAV and PA intervention theories (e.g., ART, PAAMM, IBCM) mentioned earlier also warrant exploration and comparison via a large volume of empirical studies.

2 Practical implications

Marcus et al. (2000) summarized and analyzed previous studies that raised many issues in PA change (initiation and maintenance) research and offered some research directions and recommendations. Those directions and recommendations include: a) examine predictors, mediators, and correlates of maintenance of PA in different populations; b) explore the role of various theory-based intervention models in conceptualizing and maintaining PA change; c) evaluate intervention techniques to promote adoption and maintenance of PA and examine behavioral and cognitive strategies to promote long-term adherence to PA; d) validate existing PA-related concepts' measures and develop new ones. Similarly, Rebar et al. (2016) suggested it is essential to not only know the mechanisms and theories of PA interventions but also how to conduct PA interventions based on theories and how to refine the critical concepts and measures in the theories. These papers and recommendations have greatly inspired our work.

In Study 1, we validated the plausibility of a PA intervention model with PAV as a mediating variable. However, how would this simple model work? We argue that this involves two main aspects: regarding intervention implementers, who should not only focus on skill learning, PA intervention intensity, duration, and physiological benefits during PA interventions, but also on designing, scheduling, and observing intervention strategies and their effectiveness with PAVs as fundamental requirements of subjects (e.g., to enhance the recreational atmosphere of group activities); concerning individual subjects, it may be pivotal to observe and understand the effects of different PA types and different PA partner choices on their PAV before attempting to start and maintain

PA. We consider that the results of this meta-analysis further highlighted that the focus of PA interventions perhaps should shift from cognitivism to hedonism.

In Study 2, we sought to evaluate different intervention techniques to promote PA (Marcus et al., 2000) or to answer the question of how to conduct PA interventions (Rebar et al., 2016). Through this study, we found that: at least 11 BCTs have been rarely used in past PA change researches; the use of 'teach to use prompts/cues,' 'facilitate social comparison' and 'provide information on consequences of behavior in general' had positive impacts on PA or PAV outcomes; the use of 'barrier identification/problem solving and 'planning social support/social change' had adverse effects. Besides, the study also found that intervention strategies with a theoretical basis in SDT had the most significant effect on PAV outcomes, while intervention strategies without a theoretical basis had the most significant effect on PA. From our perspective, the results of this study have three main practical contributions:

a) Future intervention studies can refer to this study's results for an experimental intervention design;
b) Given the heterogeneity of the results and the fact that at least 11 of the 40 intervention techniques were not adopted by any of the included intervention studies, rigorous experimental testing using isolation and factorial designs incorporating unique techniques are needed to accurately explore the effectiveness of each intervention technique;
c) In general, 'teach to use prompts/cues,' 'facilitate social comparison' and 'provide information on consequences of behavior in general' are not methods of direct stimulation of PAVs but are intervention techniques commonly referred to in cognitivist theories. In detail, the main methods of direct stimulation of PAVs are picture stimuli (Sousa et al., 2010), film clips (Weiss et al., 2019), surprise boxes (Scambler et al., 2007) and so on. While 'facilitate social comparison' is commonly applied in SDT-based intervention studies, 'teach to use prompts/cues' is commonly applied in TPB-based intervention studies, and 'provide information on consequences of behavior in general' is usually applied in SCT-based intervention studies. It is clear that intervention techniques that work directly on PAV are rarely used in PA intervention studies, and therefore future research should strengthen such studies. We recommend that future research could address these issues: first, a detailed classification of intervention techniques for direct stimulation of PAVs (PAV-change technique taxonomy) ought to be made; second, exploring the effectiveness of different PAV-change techniques in PA interventions; third, comparing the effectiveness between BCTs and PAV-change techniques in PA interventions.

Developing appropriate measurements is crucial to the progression of psychology as a science. Without the ability to adequately measure the expected constructs, scientists would find it difficult to conduct experiments, develop theories, or improve interventions. The results of Study 3 showed that the 4-item PACES-S provided a brief, economic, comparable measure of PA enjoyment to the 16-item PACES, which has a good reliability and validity. The PACES-S can serve as an effective measure of PA enjoyment for future intervention studies, survey studies, and

theoretical studies.

3 Limitation and prospects

The population studied in this series was non-clinical. Therefore, the mediating role of PAV, which intervention techniques can be significantly effective, and how reliable and valid the PACES-S among clinical populations is are unknown. Therefore, future research should broaden the research population for such studies. Similarly, Study 3 only validated the psychometric properties of the PACES-S for 11 to 17-year-old German adolescents. Thus, future studies should explore the reliability and validity of the PACES-S in other countries and different age groups. In addition, we considered that children could benefit from PACES-S with graphic illustrations so that future researchers could release a graphic edition.

Although this dissertation has systematically explored intervention mechanisms and intervention strategies for PA, we have not conducted intervention experiments and validated the results of Study 1 and Study 2. Therefore, appropriate intervention studies are recommended in order to validate and extend these findings.

In Studies 1 and 2, we did not ruinously distinguish between "automatic affective evaluations of PA" and "reflective attitudes toward PA" (e.g., affective attitudes). However, differentiating them in empirical studies ultimately is very difficult. Conroy and Berry (2017) stated that automatic affective evaluations of PA reflect the affective experiences that arise quickly and spontaneously when the PA concept is activated in one's mind. They are based on associations learned and experienced over time. They reflect a direct affective appraisal of a target - here PA - and can be derived from the direct or indirect experience of that target (e.g., an affective evaluation of that target while performing PA or observing others' PA). Distinct from reflective affective associations, automatic affective evaluations occur quickly and effortlessly; they do not require conscious processing or elaboration (Kiviniemi et al., 2007). They can influence both automatic motivations (e.g., motivating people to pursue goals without conscious awareness) and reflective affective processes (e.g., anticipated affects or affective attitudes). These processes are considered to be upstream determinants of affective motivation for PA. We, therefore, appeal for more PA and affective variables related studies that can rigorously distinguish between "automatic affective evaluations of PA" and "reflective attitudes toward PA" and explore in depth their distinct roles in the initiation and maintenance of PA.

4 Conclusion

By reflecting on cognitivist theories, this investigation focused its research beyond cognitivism, i.e., hedonism and the Dual-Process Theory (System 1). A series of essential explorations have ensued. In Study 1, we determined the mediating role of PAV in PA interventions. In Study 2, we identified several intervention techniques that had positive or negative effects on PAV or PA, and through observation, we further

realized that they were not direct PAV-change techniques (e.g., picture stimuli, film clips, surprise box), but rather standard cognitivist intervention techniques. In Study 3, we developed and validated a new PA enjoyment measure, the PACES-S. Overall, as a systematic investigation of PAVs and PA, this dissertation step-by-step explored a mechanism of PA intervention, strategies to improve PA, and how to measure PA enjoyment accurately. We hope that these groundworks, findings, and prospects could provide some evidence and ideas to support and inspire future PA surveys, interventions, and theory research.

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Appendices

Appendix 1-1

General Study Characteristics

	Study		Participants in Intervention Group				Intervention		Affective dimensions		PA	
	Primary Author & Year	Setting	PA Level	N	Female %	M_{age} (SD)	Theory	Length	Type	Measure	Type	Measure
1	Berg et al., 2020	Internet	Unreported	226	96.02	27±6.68	SDT, DMP	4 weeks	Positive affects	PANAS-X	PA engagement	PA time-consuming questionnaire
2	Faro et al., 2019	University	Not meeting guideline	34	100	27.3±4.5	DMM	4 weeks	Enjoyment	PACES, FS	RPE, HR	RPES, HRM
3	Gråstén et al., 2019	School	Mixed	661	52.60	12.12±0.33	AGT, SEM	2 years	Enjoyment	PEES	MVPA	HBSC, Accelerometer
4	Invernizzi et al., 2019	School	mixed	62	46.77	10.5±0.5	CPT	12 weeks	Enjoyment	PACES	PA	PAQ-C

5	Keeney et al., 2019	University	Unreported	36	15.1	34±13.7	SDT, TCMM	16-17 weeks	Enjoyment	IMI	PA	Pedometer
6	Robbins et al., 2019	School & internet	Mixed	1519	100	12.05±1.01	HPM, SDT	17 weeks	Enjoyment	PACES	MVPA	Accelerometer
7	Rodríguez et al., 2019	School	Mixed	131	51.91	8.66±1.77	TGM	8 weeks	Affective valence	FS	PA	Pedometer
8	Vazou et al., 2019	School	Mixed	148	52%	10.39±0.98	ART	30 minutes	Enjoyment	S-PACES	PA	Accelerometer
9	Vitali et al., 2019	School	Mixed	80	48.75	10.45±0.23	Null	4 years	Enjoyment	PACES	PA	CLASS
10	Andruschko et al., 2018	School	Not meeting guideline	20	100	13.2±0.9	SCT	6 months	Enjoyment	Likert scale	PA, MVPA	Accelerometer
11	Hutchinson et al., 2018	Lab	Meeting Guideline	17	47.1	28.1±9.9	HT, DMM	48 hours	Remembered pleasure	VAS	HR	HRM

12	Miragall et al., 2018	Internet & university	Not meeting guideline	76	85.5	22.18±3.71	TTM	3 weeks	Enjoyment	PACES	PA	Pedometer
13	Rhodes et al., 2019	Family	Not meeting guideline	73	Unreported	11.5±1.3	TPB, SDT	13 weeks	Affective attitude	SD differentia	Equipment usage	Exercise log
14	Billing, 2017	Telephone	Not meeting guideline	40	90	39±12	DMM, HT, SCT	12 weeks	Enjoyment	PACES	MVPA	Accelerometer, 7DPAR
15	Niedermeier et al., 2017	Outdoor, lab	Mixed	42	48	32.00±11.90	DMM, CM	170 minutes	Mood state	MSS	HR, RPE	RPES
16	Noradechanunt et al., 2017	Community	Not meeting guideline	39	74.36	66.6±6.7	Null	12 weeks	Enjoyment	PACES	PA	PASE
17	Jekauc, 2015	Community	Unreported	41	87.8	46.12	SDT	8 weeks	Enjoyment	PACES	Exercise Adherence	Attendance lists
18	Kraft et al., 2015	University	Mixed	20	50	22.06±3.6	Null	15minutes*3	Enjoyment	VAS	HR, RPE, MET	HRM, RPES, Acceler

												ometer
19	Wang et al., 2015	School	Unreported	62	50	22.3±1.51	SDT, SNST	8 weeks	Enjoyment	IMI	PA	IPAQ
20	Mark et al., 2013	Family	Not meeting guideline	30 families	50.84	36.83±6.30	TPB	6 weeks	affective attitude	Likert scale	leisure-time PA	GLTEQ
21	Bergh et al., 2012	School	Unreported	215	60	11.±6.3	Null	20 months	Enjoyment	SD	PA	Accelerometer
22	Fitzsimons et al., 2012	Community	Not meeting guideline	79	88.73	49±9	TTM	48 weeks	Affect	PANAS	PA	Pedometer
23	Conner et al., 2011	University	Not meeting guideline	316	64.24	22	TPB	3 weeks	Affective attitude	SD	PA	GLTEQ
24	Schneider et al., 2011	School	Not meeting guideline	122	100	15.04±0.78	HT, SDT	9 months	Enjoyment	PACES	PA	3DPAR
25	Louise et al., 2010	School	Unreported	221	59.28	13.29±0.99	SMT	16 weeks	Enjoyment	PACES	LTPA	7DPAR
2	Sirriyeh et al.,	School	Unreport	31	70	17.3±0	TPB	14	enjoya	Unrepor	PA	IPAQ

6	2010		ed			.68		days	ble	ted		
27	Focht, 2009	Lab & Outdoor	Meeting guideline	35	100	22.14±1.73	TPB	10 minutes	Enjoyment	SES	PA, HR	LTEQ, HRM
28	Rhodes, Warburton, & Bredin, 2009	University	Meeting guideline	29	0	22.7±4.0	TPB	6 weeks	Affective attitude	SD	Adherence to exercise	Attendance list
29	Annesi et al., 2008	Community	Unreported	269	59	10.6±1.1	SET, SCT	1 year	Vigor	POMS	Voluntary Physical Activity	SSMVPA
30	Baker et al., 2008	Community	Not meeting guideline	79	79.75	49.2±8.9	TTM	12 weeks	Affect	PANAS	PA	Pedometer
31	Edmunds et al., 2008	University	Mixed	56	100	21.32±5.56	SDT	10 weeks	Affect	PANAS	Exercise Behavior	Attendance list

32	Duntion et al., 2007	School	Not meeting guideline	79	Unreported	10th or 11th students	SCT, SEM	3 years	Enjoyment	PACES	PA	3DPAR
33	Rose et al., 2007	Lab	Not meeting guideline	19	100	39.37± 10.29	DMM, SCT, SET	20 minutes	Affective valence	FS	RPE	RPES
34	Focht et al., 2007	Lab	Not meeting guideline	18	55.56	24.10± 3.40	SCT	8 weeks	Exercise-induced feelings	EFI	RPE	RPES
35	Robbins et al., 2006	School	Not meeting guideline	77	100	12.13± 0.91	HPM, TTM, SCT	12 weeks	Enjoyment	PACES	PA	CAAL
36	Dishman et al., 2005	School	Unreported	1049	100	13.6±0.6		1 year	Enjoyment	PACES	PA	3DPAR
37	Jamner et al., 2004	School	Not meeting guideline	58	100	14.94± 0.79	Null	4 months	Enjoyment	PACES	PA	2DPAR, SUPAS
38	Digelidis et al., 2003	School	Unreported	782	52.17	12.05± 0.73	TPB, GPT,	1 year	Enjoyment	IMI	Exercise	EFS

							TARGETM				behavior	
39	McAuley et al., 2003	Gymnasium	Not meeting guideline	174	71.84	65.5	SCT	6 months	Exercise affect	FS	Exercise frequency	Exercise log
40	Nichols et al., 2000	Worksite	Not meeting guideline	160	78.13	42.0±9.7	SCT, TTM	33 months	Enjoyment	PACES	PA	7DPAR

Note. PAQ-C = The physical activity questionnaire for children; CLASS = The children's leisure activities study survey; RPES = Ratings of perceived exertion scale; 7DPAR = 7-day physical activity recall; 3DPAR = 3-day physical Activity Recall; 2DPAR = 2-day physical activity recall; HRM = Heart rate monitor; HBSC = The health behavior in School-aged children research protocol; PASE = The physical activity scale for the elderly; IPAQ = The short-form of the international physical activity questionnaire; GLTEQ = A modified Godin leisure-time exercise questionnaire; LTEQ = Leisure-time exercise questionnaire; SSMVPA = A single-item scale to assess the moderate to vigorous physical activity over the previous week; CAAL = the child and adolescent activity log; SUPAS = the Stanford usual physical activity scale; EFS = 6-point exercise frequency scale; PACES = The physical activity enjoyment scale; S-PACES = Shorted physical activity enjoyment scale for children; FS = The feeling scale; PEES = The PE enjoyment scale; DMP = Dualistic Model of Passion; VAS = Visual analog scale; MSS = A mood survey scale; IMI = The intrinsic motivation inventory; EFI = The Exercise-induced Feeling Inventory; PANAS = The positive and negative affect schedule; PANAS-X = The positive and negative affect schedule-expanded form; TCMM = The trans-contextual model of motivation;SES = Single-item enjoyment scale; POMS = The tension and vigor scales of the profile of mood states-short Form; CPT = Challenge point theory; DMM = The dual-mode model; HPM = the health promotion model; SMT = Self-management theory; PMT = Protection motivation theory; SDT = Self-determination Theory; TGM = Tactical games model; ART = Affective reflective theory; AGT = Achievement goal theory; SEM = Social ecological model; SCT = Social cognitive theory; TTM = The transtheoretical model; TPB = Theory of planned behavior; HT = The hedonic theory; CM = The circumplex model; SNST = Social network site theory; SMT = Social marketing theory; SET = Self-efficacy theory; GPT = Goal perspectives theory; TARGETM = The TARGET model

Appendix 1-2

Intervention techniques included in each study

	Study	Intervention techniques
1	Berg et al., 2020	16, 34, 37
2	Faro et al., 2019	16, 20, 21, 22
3	Gråstén et al., 2019	7, 8, 16, 19, 20, 21, 22, 24, 26, 29, 36, 39
4	Invernizzi et al., 2019	1, 5, 7, 8, 9, 16, 19, 20, 21, 22, 28, 29, 36
5	Keeney et al., 2019	6, 11, 17, 18, 19, 28, 29
6	Robbins et al., 2019	2, 8, 16, 19, 29, 36, 37
7	Rodríguez et al., 2019	10, 20, 21, 22, 26
8	Vazou et al., 2019	3, 7, 13, 16, 19, 20, 21, 22
9	Vitali et al., 2019	1, 5, 10, 20, 21, 22, 23, 29
10	Andruschko et al., 2018	5, 7, 8, 16, 19, 20, 21, 22, 29, 36, 37, 38
11	Hutchinson et al., 2018	10, 16, 20, 21, 24, 36
12	Miragall et al., 2018	1, 5, 6, 16, 19, 36
13	Rhodes et al., 2019	5, 7, 8, 10, 16, 20, 21, 24,29, 34
14	Billing, 2017	5, 6, 7, 10, 12, 16, 23, 27, 29, 34, 36
15	Niedermeier et al., 2017	5, 9, 20, 21, 24, 29
16	Noradechanuntet al., 2017	7, 20, 21, 22, 27
17	Jekauc, 2015	7,10,11,18,19,20,21, 22, 28,36
18	Kraft et al., 2015	7,10,11,18,19,20,21, 22, 28,36
19	Wang et al., 2015	1, 3, 4, 7, 20, 21, 22, 23, 25, 28, 29, 36
20	Mark et al., 2013	13, 16, 20, 21, 24, 34
21	Bergh et al., 2012	7, 12, 20, 21, 24, 29
22	Fitzsimons et al., 2012	7, 8, 9, 10, 16, 17, 19, 21, 22, 29, 35, 36, 37
23	Conner et al., 2011	1, 34, 36
24	Schneider et al., 2011	1, 3, 5, 7, 8, 16, 19, 20, 21, 22, 29, 36
25	Louise et al., 2010	1, 8, 10, 19, 20, 21, 22, 24, 29, 36, 39
26	Sirriyeh et al., 2010	1, 36
27	Focht, 2009	20, 24
28	Rhodes, Warburton, & Bredin, 2009	7, 16, 20, 21, 24, 34
29	Annesi et al., 2008	1, 4, 5, 6, 7, 10, 11, 19, 20, 21, 22, 26, 29, 33
30	Baker et al., 2008	7, 8, 9, 10, 16, 17, 19, 21, 22, 29, 35, 36, 37
31	Edmunds et al., 2008	4, 6, 7, 10, 11, 19, 20, 21, 22, 26, 29, 33
32	Dunton et al., 2007	7, 8, 14, 20, 21, 22, 29, 36, 38
33	Rose et al., 2007	5, 20, 21, 36
34	Focht et al., 2007	7, 20, 21
35	Robbins et al., 2006	1, 2, 3, 4, 7, 8, 19, 20, 21, 22, 24, 29, 36
36	Dishman et al., 2005	1, 7, 20, 21, 22, 24, 29
37	Jamner et al., 2004	1, 3, 5, 7, 8, 16, 19, 20, 21, 22, 29, 36
38	Digelidis et al., 2003	1, 5, 6, 7, 9, 17, 19, 20, 21, 22, 29, 33, 34, 36, 38, 39
39	McAuley et al., 2003	7, 9, 20, 21, 22
40	Nichols et al., 2000	1, 3, 5, 7, 8, 16, 18, 20, 21, 22, 23, 24, 26, 29, 33, 38, 39

Note. The symbolic coding corresponds to the following behavior change strategies: 1_Provide information on consequences of behavior in general; 2_Provide information

on consequences of behavior to individual; 3_Provide information about others' approval; 4_Provide normative information about others' behavior; 5_Goal setting (behavior); 6_Goal setting (outcome); 7_Action planning; 8_Barrier identification/problem solving; 9_Set graded tasks; 10_Prompt review of behavioral goals; 11_Prompt review of outcome goals; 12_Provide rewards contingent on effort or progress towards behavior; 13_Provide rewards contingent on successful behavior; 14_Shaping; 15_Prompt generalization of a target behavior; 16_Prompt self-monitoring of behavior; 17_Prompt self-monitoring of behavioral outcome; 18_Prompting focus on past success; 19_Provide feedback on performance; 20_Provide instruction on when and where to perform the behavior; 21_Provide instruction on how to perform the behavior; 22_Model/demonstrate the behavior; 23_Teach to use prompts/cues; 24_Environmental restructuring; 25_Agree behavioral contract; 26_Prompt practice; 27_Use of follow-up prompts; 28_Facilitate social comparison; 29_Plan social support/social change; 30_Prompt identification as a role model/position advocate; 31_Prompt anticipated regret; 32_Fear arousal; 33_Prompt self-talk; 34_Prompt use of imagery; 35_Relapse prevention/coping planning; 36_Stress management/ emotional training; 37_Motivational interviewing; 38_Time management; 39_General communication skills training; 40_Stimulate anticipation of future rewards

Appendix 1-3

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Appendix 2-1

Quality assessment scoring by study in meta-analytic analyses

	Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	QA score
1	Berg et al., 2020	0	0	1	1	0	0	2
2	Taylor, 2020	1	0	1	1	0	0	3
3	Invernizzi et al., 2019	0	1	1	1	1	0	4
4	Pearce et al., 2019	1	1	1	0	0	0	3
5	Rhodes et al., 2019	0	0	0	1	1	0	2
6	Robbins et al., 2019	1	0	1	1	1	0	4
7	Rodríguez et al., 2019	1	0	1	0	1	0	3
8	Vazou et al., 2019	0	0	1	1	1	0	3
9	Vitali, et al., 2019	1	0	1	1	0	0	3
10	Faro et al., 2019	1	1	1	1	0	0	4
11	Gråstén et al., 2019	0	0	1	1	1	0	3
12	Andruschko et al., 2018	0	0	1	0	0	0	1
13	Miragall et al., 2018	1	0	1	0	1	1	4
14	Hutchinson et al., 2018	1	0	1	1	1	0	4
15	Noradechanuntet al., 2017	1	1	1	1	1	0	5
16	Niedermeier et al., 2017	0	1	1	1	1	1	5
17	Billing, 2017	0	1	0	1	0	0	2
18	Wang et al., 2015	0	0	1	1	0	1	3
19	Kraft et al., 2015	1	0	1	0	0	1	3
20	Jekauc, 2015	0	0	0	1	1	0	2

21	Mark et al., 2013	1	1	1	1	1	1	6
22	Focht, 2013	1	0	1	1	1	0	4
23	Fitzsimons et al., 2012	0	0	1	1	1	1	4
24	Schneider et al., 2011	0	0	1	1	1	0	3
25	Louise et al., 2010	0	0	1	1	0	1	3
26	Rhodes, Warburton, & Bredin, 2009	1	1	1	1	0	1	5
27	Focht, 2009	0	0	1	1	1	0	3
28	Edmunds et al., 2008	0	0	0	1	1	0	2
29	Annesi et al., 2008	0	0	1	1	1	0	3
30	Baker et al., 2008	0	1	1	1	1	1	5
31	Focht et al., 2007	1	0	1	1	0	0	3
32	Rose et al., 2007	0	0	1	1	1	0	3
33	Robbins et al., 2006	0	0	1	1	0	1	3
34	Jamner et al., 2004	1	0	1	1	1	0	4
35	McAuley et al., 2003	1	0	0	0	1	1	3
36	Digelidis et al., 2003	0	0	0	1	0	0	1
37	Nichols et al., 2000	1	1	1	1	0	1	5

Note. Item 1 = Did the study describe the participant eligibility criteria?; Item 2 = Were the participants randomly selected (or for experimental studies, was the process of randomization clearly described and adequately carried out?); Item 3 = Did the study report the sources and details of physical activity assessment and did the instruments have acceptable reliability for the specific age group?; Item 4 = Did the study report the sources and details of assessment of potential correlates and did all of the methods have acceptable reliability?; Item 5 = Did the study report a power calculation and was the study adequately powered to detect hypothesized relationships?; Item 6 = Did the study report the numbers of individuals who completed each of the different measures and did participants complete at least 80% of physical activity measures?; QA = quality assessment; 1-2 = low, 3-4 = medium, 5-6 = high

Appendix 2-2

General Study Characteristics

	Study		Participants in Intervention Group				Intervention		Affective dimensions		PA	
	Primary Author & Year	Setting	PA Level	N	Female %	M_{age} (SD)	Theory	Length	Type	Measure	Type	Measure
1	Berg et al., 2020	Internet	Unreported	226	96.02	27±6.68	SDT, DMP	4 weeks	Positive affects	PANAS-X	PA	PATCQ
2	Taylor, 2020	Internet & university	Unreported	19	100	College freshman	SCT, SDT	9 weeks	Enjoyment	PACES	PA	IPAQ
3	Invernizzi et al., 2019	School	Mixed	62	46.77	10.5±0.5	CPT	12 weeks	Enjoyment	PACES	PA	PAQ-C
4	Pearce et al., 2019	School & home	Unreported	63	64	8 to 13	SMT, SCT, PMT, TTM, TPB	8 months	Enjoyment	PACES	MVPA	Accelerometer, PAQ-C

5	Rhodes et al., 2019	Family	Not meeting guideline	73	Null	11.5±1.3	TPB, SDT	13 weeks	Affective attitude	Semantic differentia	Equipment usage	Exercise log
6	Robbins et al., 2019	School & internet	Mixed	1519	100	12.05±1.01	HPM, SDT	17 weeks	Enjoyment	PACES	MVPA	Accelerometer
7	Rodríguez et al., 2019	School	Mixed	131	51.91	8.66±1.77	TGM	8 weeks	Affective valence	FS	PA	Pedometer
8	Vazou et al., 2019	School	Mixed	148	52%	10.39±0.98	ART	30 minutes	Enjoyment, affective valence	S-PACES, FS	PA	Accelerometer
9	Vitali, et al., 2019	School	Mixed	80	48.75	10.45±0.23	Null	4 years	Enjoyment	PACES	PA	CLASS
10	Faro et al., 2019	University	Not meeting guideline	34	100	27.3±4.5	DMM	4 weeks	Enjoyment, affect	PACES, FS	HR	HRM
1	Gråstén et al.,	School	Mixed	661	52.60	12.12±0	AGT,	2 years	Enjoyme	PEES	MVPA	HBS

1	2019					.33	SEM		nt			C, Actigraph
12	Andruschko et al., 2018	School	Not meeting guideline	20	100	13.2±0.9	SCT	6 months	Enjoyment	Likert scale	PA, MVPA	Accelerometer
13	Miragall et al., 2018	Internet & university	Not meeting guideline	76	85.5	22.18±3.71	TTM	3 weeks	Enjoyment	PACES	PA	Pedometer
14	Hutchinson et al., 2018	Lab	Meeting Guideline	17	47.1	28.1±9.9	HT, DMM	48 hours	Affective valence, Remembered pleasure	FS, VAS	HR	HRM
15	Noradechanunt et al., 2017	Community	Not meeting guideline	39	74.36	66.6±6.7	Null	12 weeks	Enjoyment	PACES	PA	PASE
16	Niedermeier et al., 2017	Outdoor, lab	Mixed	42	48	32.00±11.90	DMM, CM	170 minutes	Mood states	FS, MSS	HR	HRM

17	Billing, 2017	Telephone	Not meeting guideline	40	90	39±12	DMM, HT, SCT	12 weeks	Affect, enjoyment	FS, PACES	MVPA	Accelerometer, 7DPAR
18	Wang et al., 2015	School	Unreported	62	50	22.3±1.51	SDT, SNST	8 weeks	Enjoyment	IMI	PA	IPAQ
19	Kraft et al., 2015	University	Mixed	20	50	22.06±3.6	Null	15minutes*3	Enjoyment	VAS	HR, MET	HRM, Accelerometer
20	Jekauc, 2015	Community	Unreported	41	87.8	46.12	SDT	8 weeks	Enjoyment	PACES	Exercise Adherence	Attendance lists
21	Mark et al., 2013	Family	Not meeting guideline	30 families	50.84	36.83±6.30	TPB	6 weeks	affective attitude	Likert scale	leisure-time PA	GLTEQ
22	Focht, 2013	Lab	Not meeting	23	100	26.62±5.16	SCT, TPB	30mins/10mins	Affective valence,	FS, EFI	PA	LTEQ

			guideline						exercise-induced feeling			
23	Fitzsimons et al., 2012	Community	Not meeting guideline	79	88.73	49±9	TTM	48 weeks	Affect	PANAS	PA	Pedometer
24	Schneider et al., 2011	School	Not meeting guideline	122	100	15.04±0.78	SDT	9 months	Enjoyment	PACES	PA	3DPAR
25	Louise et al., 2010	School	Unreported	221	59.28	13.29±0.99	SMT	16 weeks	Enjoyment	PACES	LTPA	7DPAR
26	Rhodes, Warburton, & Bredin, 2009	University	Meeting guideline	29	0	22.7±4.0	TPB	6 weeks	Affective attitude	Semantic differential	Adherence to exercise	Attendance list

27	Focht, 2009	Lab & Outdoor	Meeting guideline	35	100	22.14±1.73	TPB	10 minutes	Affective valence, enjoyment, exercise-induced feelings	FS, EFI, SES	PA, HR	LTEQ, HRM
28	Edmunds et al., 2008	University	Mixed	56	100	21.32±5.56	SDT	10 weeks	Affect	PANAS	Exercise Behavior	Attendance list
29	Annesi et al., 2008	Community	Unreported	269	59	10.6±1.1	SET, SCT	1 year	Vigor	POMS	Voluntary Physical Activity	SSMVPA
30	Baker et al., 2008	Community	Not meeting guideline	79	79.75	49.2±8.9	TTM	12 weeks	Affect	PANAS	PA	Pedometer

31	Focht et al., 2007	Lab	Not meeting guideline	18	55.56	24.10±3.40	SCT	8 weeks	Affective valence, exercise-induced feelings	FS, EFI	-	-
32	Rose et al., 2007	Lab	Not meeting guideline	19	100	39.37±10.29	DMM, SCT, SET	20 minutes	Affective valence	FS	HR	HRM
33	Robbins et al., 2006	School	Not meeting guideline	77	100	12.13±0.91	HPM, TTM, SCT	12 weeks	Enjoyment	PACES	PA	CAAL
34	Jamner et al., 2004	School	Not meeting guideline	58	100	14.94±0.79	Null	4 months	Enjoyment	PACES	PA	2DPAR, SUPAS

35	McAuley et al., 2003	Gymnasium	Not meeting guideline	174	71.84	65.5	SCT	6 months	Exercise affect	FS	Exercise frequency	Exercise log
36	Digelidis et al., 2003	School	Unreported	782	52.17	12.05±0.73	TPB, GPT, TARGETM	1 year	Enjoyment	IMI	Exercise behavior	EFS
37	Nichols et al., 2000	Worksite	Not meeting guideline	160	78.13	42.0±9.7	SCT, TTM	33 months	Enjoyment	PACES	PA	7DPAR

Note. PATCQ = Physical activity time consuming questionnaire; PAQ-C = The physical activity questionnaire for children; CLASS = The children's leisure activities study survey; 7DPAR = 7-day physical activity recall; 3DPAR = 3-day physical Activity Recall; 2DPAR = 2-day physical activity recall; HRM = Heart rate monitor

Appendix 2-3

Constructs, dimensions, and measurements of positive affective variables in the included studies

Constructs	Measurement	Dimensions	Studies
Affect			
	FS	Affective valence	7, 8, 10, 14, 17, 22, 27, 31, 32, 35
	PANAS	Positive affect	1, 23, 28, 30
Emotional state			
Enjoyment	PACES	PAE	2, 3, 4, 8, 9, 10, 6, 13, 16, 17, 20, 24, 25, 33, 34, 37
	PEES	PEE	11
	VAS	Enjoyment	19
	IMI	Enjoyment	18, 36
	SES	Enjoyment	12, 27
Pleasure	VAS	Remembered pleasure	14
Exercise-induced feelings	EFI	Revitalization	22, 27, 31
		Positive engagement	22, 27, 31
Affective attitude	SD	Affective attitude	5, 26
	Likert scale	Affective attitude	21
Mood states	POMS	Vigor	29
	MSS	Activation	16
		Excitement	16

Note. Study content in Appendix 6; FS= Feeling scale; PANAS = Positive and negative

affect schedule; PEES = The PE enjoyment scale; SES = Single-item enjoyment scale; VAS = Visual analog scale; IMI = Intrinsic motivation inventory; PACES = The physical activity enjoyment scale; PAE = Physical activity enjoyment; PEE = The PE enjoyment; EFI = Exercise-induced feeling inventory; SD= Semantic differential items on seven-point scales; POMS = Profile of mood states; MSS = Mood survey scale

Appendix 2-4

Physical activity assessment methods and measurements in each study

Assessment methods	Variables	Measurements	Studies
Objective methods			
Pedometer	Steps	The Omron HJ-109E Step-O-Meter	23, 30
		Pedometer Fitbit One	13
		Yamax Digiwalker SW-650 (Yamax Corporation, Toyko, Japan)	7
Accelerometer	MVPA	ActiGraph(did not state the type, manufacturer, and place of origin)	17
		ActiGraph GT3X+ (ActiGraph, Ft. Walton Beach, FL, USA)	4, 6
	MVPA, PA	Actigraph Model 7164 (Fort Walton Beach, FL, USA)	12
	MET	ActiGraph GT3X+ (Pensacola, FL)	19
		The SenseWear Armband Monitor (BodyMedia, Pittsburgh PA)	8
Log or list	Equipment usage	Log	5, 35
	Exercise Adherence	Attendance lists	20, 26, 28
HR monitoring	HR or %Max HR or HR at VT	HR monitor	10, 14, 16, 19, 27, 32
Subjective methods			

Questionnaires	MVPA	7DPAR	12
		IPAQ	2, 18
		HBSC	11
		3DPAR	24
		PAQ-C	4
	LTPA	7DPAR	25
		LTEQ	22
	VPA	SSMVPA	29
	PA	7DPAR	37
		2DPAR	34
		PASE	15
		CAAL	33
		PAQ-C	3
		CLASS	9
		PATCQ	1
	LTPA	GLTEQ	21
	Lifestyle activity	SUPAS	34
	Exercise behavior	EFS	36

Note. Study content in Appendix 10; MVPA = Moderate to vigorous physical activity; PA = Physical activity; LTPA = Leisure-time physical activity; LTEQ = Leisure-time exercise questionnaire; GLTEQ = A modified Godin leisure-time exercise questionnaire; SSMVPA = A single-item scale to assess the moderate to vigorous physical activity over the previous week; VPA = Voluntary physical activity; HR = Heart rate; MET = The metabolic equivalent of task; 7DPAR = 7-day physical activity recall; 3DPAR = 3-day physical activity recall; 2DPAR = 2-day physical activity recall; IPAQ = The short-form of the international physical activity questionnaire; PATCQ = Physical activity time consuming questionnaire; HBSC = The health behavior in school-aged children; PASE = The physical activity scale for the elderly; CAAL = the child and adolescent activity log; PAQ-C = The physical activity questionnaire for older children; CLASS = The children's leisure activities study survey; SUPAS = The Stanford usual physical activity scale; EFS = 6-point exercise frequency scale

Appendix 2-5

Intervention techniques included in each intervention group in current review

Studies		Intervention techniques
1	Berg et al., 2020	16, 34, 37
2	Taylor, 2020	5, 8, 10, 16, 19, 20, 23, 29, 34, 36, 38
3	Invernizzi et al., 2019	1, 5, 7, 8, 9, 16, 19, 20, 21, 22, 28, 29, 36
4	Pearce et al., 2019	1, 5, 7, 8, 9, 20, 21, 22, 36
5	Rhodes et al., 2019	5, 7, 8, 10, 16, 20, 21, 24,29, 34
6	Rodríguez et al., 2019	10, 20, 21, 22, 26
7	Vazou et al., 2019	3, 7, 13, 16, 19, 20, 21, 22
8	Vitali, et al., 2019	1, 5, 10, 20, 21, 22, 23, 29
9	Faro et al., 2019	16, 20, 21, 22
10	Robbins et al., 2019	2, 8, 16, 19, 29, 36, 37
11	Gråstén et al., 2019	
	Group 1	7, 8, 16, 19, 20, 21, 22, 24, 26, 29, 36, 39
	Group 2	7, 8, 16, 19, 20, 21, 22, 24, 26, 29, 36, 39
12	Andruschko et al., 2018	5, 7, 8, 16, 19, 20, 21, 22, 29, 36, 37, 38
13	Miragall et al., 2018	
	Group 1	1, 5, 6, 16, 19, 36
	Group 2	1, 5, 6, 36
14	Hutchinson et al., 2018	10, 16, 20, 21, 24, 36
15	Noradechanuntet al., 2017	
	Group 1	7, 20, 21, 22, 27
	Group 2	7, 20, 21, 22, 27
16	Niedermeier et al., 2017	
	Group 1	5, 9, 20, 21, 24, 29
	Group 2	5, 9, 20, 21, 24, 29
17	Billing, 2017	5, 6, 7, 10, 12, 16, 23, 27, 29, 34, 36
18	Wang et al., 2015	
	Group 1	7, 20, 21, 22
	Group 2	1, 3, 4, 7, 20, 21, 22, 23, 25, 28, 29, 36
	Group 3	1, 3, 4, 8, 16, 21, 22, 23, 24, 25, 28, 29, 36
19	Kraft et al., 2015	
	Group 1	20, 21, 24, 34
	Group 2	20, 21, 24, 26, 34
20	Jekauc, 2015	7,10,11,18,19,20,21, 22, 28,36
21	Mark et al., 2013	3, 16, 20, 21, 24, 34
22	Focht, 2013	9, 20
23	Fitzsimons et al., 2012	
	Group 1	7, 8, 9, 10, 16, 17, 19, 21, 22, 29, 35, 36, 37

	Group 2	7, 8, 9, 10, 16, 17, 19, 21, 22, 29, 35, 36, 37
24	Schneider et al., 2011	
	Group 1	1, 3, 5, 7, 8, 16, 19, 20, 21, 22, 29, 36
	Group 2	1, 3, 5, 7, 8, 16, 19, 20, 21, 22, 29, 36
25	Louise et al., 2010	1, 8, 10, 19, 20, 21, 22, 24, 29, 36, 39
26	Rhodes, Warburton, & Bredin, 2009	7, 16, 20, 21, 24, 34
27	Focht, 2009	20, 24
28	Edmunds et al., 2008	4, 6, 7, 10, 11, 19, 20, 21, 22, 26, 29, 33
29	Annesi et al., 2008	1, 4, 5, 6, 7, 10, 11, 19, 20, 21, 22, 26, 29, 33
30	Baker et al., 2008	7, 8, 9, 10, 16, 17, 19, 21, 22, 29, 35, 36, 37
31	Focht et al., 2007	
	Group 1	7, 20, 21
	Group 2	7, 20, 21
32	Rose et al., 2007	
	Group 1	5, 20, 21, 36
	Group 2	5, 20, 21
	Group 3	5, 20, 21
33	Robbins et al., 2006	1, 2, 3, 4, 7, 8, 19, 20, 21, 22, 24, 29, 36
34	Jamner et al., 2004	1, 3, 5, 7, 8, 16, 19, 20, 21, 22, 29, 36
35	McAuley et al., 2003	7, 9, 20, 21, 22
36	Digelidis et al., 2003	1, 5, 6, 7, 9, 17, 19, 20, 21, 22, 29, 33, 34, 36, 38, 39
37	Nichols et al., 2000	1, 3, 5, 7, 8, 16, 18, 20, 21, 22, 23, 24, 26, 29, 33, 38, 39

Note. Intervention technique content in **Table 2-1**.

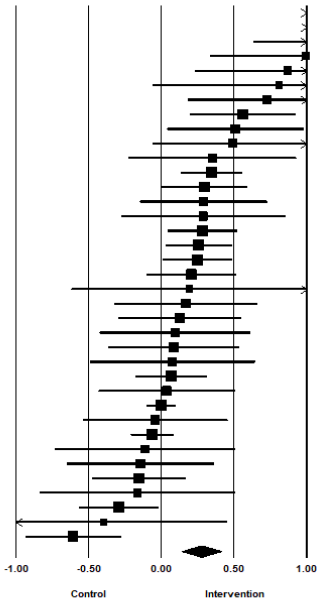
Appendix 2-6

Forest plot of positive affective variable in this review

Study name	Comparison	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Jekauc, 2015	Two arms	2.279	0.400	0.160	1.495	3.062	5.697	0.000
Vitali, 2019	Two arms	1.749	0.185	0.034	1.386	2.112	9.440	0.000
Rhodes, 2009	Two arms	1.434	0.409	0.167	0.632	2.235	3.507	0.000
Rose, 2007	Combined	0.996	0.339	0.115	0.332	1.661	2.938	0.003
Kraftet, 2015	Combined	0.869	0.325	0.106	0.231	1.507	2.671	0.008
Wang, 2015	Combined	0.810	0.446	0.199	-0.064	1.684	1.817	0.069
Mark, 2013	Two arms	0.726	0.277	0.077	0.182	1.269	2.616	0.009
Invernizzi, 2019	Two arms	0.560	0.184	0.034	0.199	0.921	3.040	0.002
Focht, 2009	Two arms	0.509	0.240	0.058	0.038	0.980	2.119	0.034
Miragall, 2018	Combined	0.490	0.280	0.079	-0.060	1.039	1.747	0.081
Hutchinson, 2018	Two arms	0.352	0.295	0.087	-0.225	0.929	1.195	0.232
Gr?stén, 2019	Combined	0.345	0.107	0.011	0.135	0.554	3.220	0.001
McAuley, 2003	Two arms	0.296	0.152	0.023	-0.001	0.594	1.951	0.051
Baker, 2008	Two arms	0.290	0.224	0.050	-0.149	0.729	1.296	0.195
Jamner, 2004	Two arms	0.289	0.289	0.084	-0.277	0.856	1.001	0.317
Annesi, 2008	Two arms	0.283	0.123	0.015	0.042	0.523	2.306	0.021
Vazou, 2019	Two arms	0.256	0.116	0.014	0.028	0.484	2.199	0.028
Berg et al., 2020	Two arms	0.249	0.123	0.015	0.008	0.489	2.027	0.043
Fitzsimons, 2012	Combined	0.206	0.159	0.025	-0.105	0.518	1.298	0.194
Noradechanuntet, 2018	Combined	0.193	0.415	0.172	-0.620	1.006	0.466	0.641
Billing, 2017	Two arms	0.167	0.251	0.063	-0.325	0.660	0.666	0.506
Niedermeier, 2017	Combined	0.126	0.217	0.047	-0.298	0.551	0.583	0.560
Edmunds, 2008	Two arms	0.094	0.265	0.070	-0.426	0.614	0.355	0.723
Robbins, 2006	Two arms	0.087	0.229	0.052	-0.362	0.536	0.379	0.704
Focht, 2013	Two arms	0.078	0.290	0.084	-0.491	0.646	0.268	0.789
Rodríguez, 2019	Two arms	0.068	0.125	0.016	-0.176	0.312	0.545	0.586
Faro, 2019	Two arms	0.038	0.240	0.057	-0.432	0.508	0.157	0.875
Robbins, 2019	Two arms	0.000	0.051	0.003	-0.101	0.101	0.000	1.000
Schneider, 2011	Combined	-0.042	0.254	0.065	-0.541	0.457	-0.165	0.869
Digelidis, 2003	Two arms	-0.062	0.076	0.006	-0.211	0.086	-0.821	0.412
Taylor, 2019	Two arms	-0.113	0.318	0.101	-0.736	0.510	-0.355	0.722
Nichols, 2000	Two arms	-0.144	0.260	0.067	-0.653	0.365	-0.555	0.579
Pearce, 2019	Two arms	-0.154	0.166	0.028	-0.480	0.171	-0.929	0.353
Focht, 2007	Combined	-0.165	0.343	0.118	-0.838	0.508	-0.479	0.632
Louise, 2010	Two arms	-0.293	0.139	0.019	-0.566	-0.019	-2.099	0.036
Andruschko, 2018	Two arms	-0.395	0.433	0.187	-1.243	0.454	-0.912	0.362
Rhodes, 2018	Two arms	-0.608	0.168	0.028	-0.938	-0.278	-3.607	0.000
		0.276	0.070	0.005	0.138	0.414	3.919	0.000

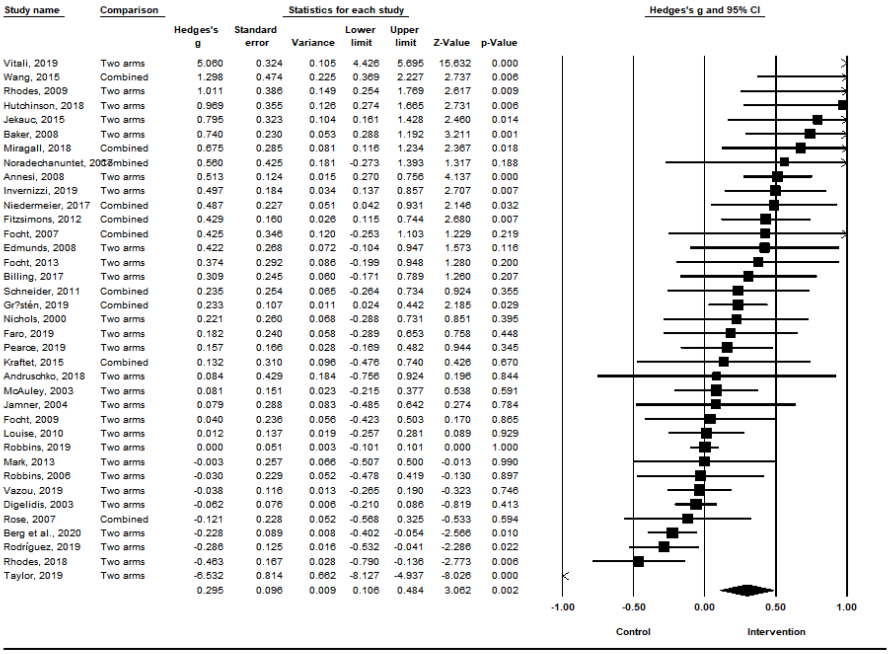
Statistics for each study

Hedges's g and 95% CI



Appendix 2-7

Forest plot of physical activity in this review



Study name	Comparison	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Vitali, 2019	Two arms	5.060	0.324	0.105	4.426	5.695	15.632	0.000
Wang, 2015	Combined	1.298	0.474	0.225	0.369	2.227	2.737	0.006
Rhodes, 2009	Two arms	1.011	0.386	0.149	0.254	1.769	2.617	0.009
Hutchinson, 2018	Two arms	0.969	0.355	0.126	0.274	1.665	2.731	0.006
Jeksuc, 2015	Two arms	0.795	0.323	0.104	0.161	1.428	2.460	0.014
Baker, 2008	Two arms	0.740	0.230	0.053	0.288	1.192	3.211	0.001
Miragall, 2018	Combined	0.675	0.285	0.081	0.116	1.234	2.367	0.018
Noradechanuntet, 2018	Combined	0.560	0.425	0.181	-0.273	1.393	1.317	0.188
Annesi, 2008	Two arms	0.513	0.124	0.015	0.270	0.756	4.137	0.000
Invernizzi, 2019	Two arms	0.497	0.184	0.034	0.137	0.857	2.707	0.007
Niedermeier, 2017	Combined	0.487	0.227	0.051	0.042	0.931	2.146	0.032
Fitzsimons, 2012	Combined	0.429	0.160	0.026	0.115	0.744	2.680	0.007
Focht, 2007	Combined	0.425	0.346	0.120	-0.253	1.103	1.229	0.219
Edmunds, 2008	Two arms	0.422	0.268	0.072	-0.104	0.947	1.573	0.116
Focht, 2013	Two arms	0.374	0.292	0.086	-0.199	0.948	1.280	0.200
Billing, 2017	Two arms	0.309	0.245	0.060	-0.171	0.789	1.260	0.207
Schneider, 2011	Combined	0.235	0.254	0.065	-0.264	0.734	0.924	0.355
Gr?stén, 2019	Combined	0.233	0.107	0.011	0.024	0.442	2.185	0.029
Nichols, 2000	Two arms	0.221	0.260	0.068	-0.288	0.731	0.851	0.395
Faro, 2019	Two arms	0.182	0.240	0.058	-0.289	0.653	0.758	0.448
Pearce, 2019	Two arms	0.157	0.166	0.028	-0.169	0.482	0.944	0.345
Kraftet, 2015	Combined	0.132	0.310	0.096	-0.476	0.740	0.426	0.670
Andruschko, 2018	Two arms	0.084	0.429	0.184	-0.756	0.924	0.196	0.844
McAuley, 2003	Two arms	0.081	0.151	0.023	-0.215	0.377	0.538	0.591
Jamner, 2004	Two arms	0.079	0.288	0.083	-0.485	0.642	0.274	0.784
Focht, 2009	Two arms	0.040	0.236	0.056	-0.423	0.503	0.170	0.865
Louise, 2010	Two arms	0.012	0.137	0.019	-0.257	0.281	0.089	0.929
Robbins, 2019	Two arms	0.000	0.051	0.003	-0.101	0.101	0.000	1.000
Mark, 2013	Two arms	-0.003	0.257	0.066	-0.507	0.500	-0.013	0.990
Robbins, 2006	Two arms	-0.030	0.229	0.052	-0.478	0.419	-0.130	0.897
Vazou, 2019	Two arms	-0.038	0.116	0.013	-0.265	0.190	-0.323	0.746
Digelidis, 2003	Two arms	-0.062	0.076	0.006	-0.210	0.086	-0.819	0.413
Rose, 2007	Combined	-0.121	0.228	0.052	-0.568	0.325	-0.533	0.594
Berg et al., 2020	Two arms	-0.228	0.089	0.008	-0.402	-0.054	-2.566	0.010
Rodríguez, 2019	Two arms	-0.286	0.125	0.016	-0.532	-0.041	-2.286	0.022
Rhodes, 2018	Two arms	-0.463	0.167	0.028	-0.790	-0.136	-2.773	0.006
Taylor, 2019	Two arms	-6.532	0.814	0.662	-8.127	-4.937	-8.026	0.000
		0.295	0.096	0.009	0.106	0.484	3.062	0.002

Appendix 2-8

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Abbreviations

Positive affective variables	PAVs
Physical activity	PA
Physical activity enjoyment	PA enjoyment
Social cognitive theory	SCT
The theory of planned behavior	TPB
The trans-theoretical model	TTM
Self-determination theory	SDT
Behavior change techniques	BCTs
The interest/enjoyment subscale of intrinsic motivation inventory	IMI
Visual analog scale of enjoyment/ remembered pleasure	VAS
the physical activity enjoyment scale	PACES
Physical Activity Enjoyment Scale-Short	PACES-S
Item-level content validity index	I-CVI
The scale-level content validity index calculated by the average method	S-CVI
The Affective-Reflective Theory	ART
The Physical Activity Adoption and Maintenance Model	PAAMM
The Integrated Behavior Change Model	IBCM

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