

Subjective well-being and exercise in the second half of life: a critical review of theoretical approaches

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Abstract Research has shown repeatedly that the “feeling better” effect of exercise is far more moderate than generally claimed. Examinations of subgroups in secondary analyses also indicate that numerous further variables influence this relationship. One reason for inconsistencies in this research field is the lack of adequate theoretical analyses. Well-being output variables frequently possess no construct definition, and little attention is paid to moderating and mediating variables. This article integrates the main models in an overview and analyzes how secondary analyses define well-being and which areas of the construct they focus on. It then applies a moderator and/or mediator framework to examine which person and environmental variables can be found in the existing explanatory approaches in sport science and how they specify the influence of these moderating and mediating variables. Results show that the broad understanding of well-being in many secondary analyses makes findings difficult to interpret. Moreover, physiological explanatory approaches focus more on affective changes in well-being, whereas psychological approaches also include cognitive changes. The approaches focus mostly on either physical or psychological person variables and rarely combine the two, as in, for example, the dual-mode model. Whereas environmental variables specifying the treatment more closely (e.g., its intensity) are comparatively frequent, only the social support model formulates variables such as the framework in which exercise is presented. The majority

of explanatory approaches use simple moderator and/or mediator models such as the basic mediated (e.g., distraction hypothesis) or multiple mediated (e.g., monoamine hypotheses) model. The discussion draws conclusions for future research.

Keywords Well-being · Exercise · Mediation · Moderation · Explanatory approaches

Everyday assumptions about the effects of exercise on well-being are unanimously positive—as numerous *popular science* books confirm with promising titles such as *The aerobics programs for total well-being* [1] or *Life skills: 225 ready-to-use health activities for success and well-being* [2]. Even in the early years of *scientific* research in this field, few would have disagreed with the statement that “the ‘feeling better’ sensation that accompanies regular physical activity is so obvious that it is one of the few universally accepted benefits of exercise” ([3], p. 306). Nonetheless, a host of primary studies carried out between 1960 and the mid-1990s delivered no unequivocal confirmation of this hypothesis. As a result, studies since the 1990s have increasingly been integrated and compared in both narrative (e.g., [4, 5]) and meta-analytic reviews (e.g., [6, 7]).

In contrast to popular science claims, quantitative secondary analyses reveal that the overall effects on (subjective) well-being (SWB)¹ are not only small but also show a great deal of variation. For example, McAuley and Rudolph ([8], p. 68) have written: “Although many studies extol the almost intuitive psychological benefits of exercise, just as many fail to find any association.” It is only additional moderator analyses that reveal what are, in part, very special subgroups in which more reliable estimates of the true

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¹ Well-being and subjective well-being are taken to be synonymous here. The “subjective” is retained to emphasize that these are individual appraisals.

relationship can be made. However, secondary analyses differ in their findings on which moderators influence the relation between exercise and SWB in which way. Schlicht's [6] meta-analysis, for example, found a stronger relation for women than men ($r_{\text{women}} = .33$ vs. $r_{\text{men}} = .08$), whereas Netz et al. [7] found no impact of gender on effect sizes but an effect of age instead: Those aged 54–64 years profited more ($d = 0.33$) than those aged 65–74 years ($d = 0.20$), and these, in turn, more than the over-74s ($d = 0.11$). Nonetheless, both authors show more agreement over the type of exercise: Schlicht [6] reported the largest effect sizes for endurance sports ($r = 0.22$), and Netz et al. [7] found comparatively high effect sizes for aerobic exercise ($d = 0.29$).

The heterogeneity of findings in primary studies and the inconsistencies in meta-analyses hardly permit any clear statements on which forms of exercise promote well-being. As Ekkekakis and Backhouse [9] have shown for exemplary secondary analyses, a comparative inspection of the same literature can even lead to contradictory conclusions. Several authors consider that one essential step toward overcoming this unsatisfactory state of research would be a stronger theoretical reflection on the relation between exercise and SWB (e.g., [5, 10, 11]). When it comes to generating *evidence-based* recommendations for exercise that will promote well-being, the aggregation of empirical research findings seems to have run up against its limits. This becomes even clearer when it is considered that secondary analyses frequently integrate a multitude of different concepts of mental health, well-being, and quality of life. In this context, Rejeski and Mihalko ([5], p. 24) have suggested that “there is little hope of ever integrating extant research, because quality of life [or SWB] has no consistent meaning across studies.”

Against this background, the present study aims to present a critical reflection on existing theoretical approaches to the complicated relation between exercise and SWB. This should contribute to a further systematization of knowledge in the field. The basic concern is to analyze the influence of the independent variable exercise on the dependent variable SWB (see Fig. 1). Hence, theoretical reflections can start by examining how both variables are conceived. Starting with the independent variable, the literature reveals various concepts such as physical activity, exercise, and sport. *Physical activity* describes the most comprehensive category encompassing every movement of the body initiated by the skeletal muscles. *Exercise*, in contrast, is “planned, structured, and repetitive bodily movement” ([12], p. 127). It is generally associated with the goal of improving fitness (e.g., bicycle ergometer). Sport covers activities that take a structured course are equipped with a body of rules and possess a system of competitions (e.g., soccer [13]). This article will focus on physical exercise, although it will also include the category sport or sport activities (see also [14]). However, it

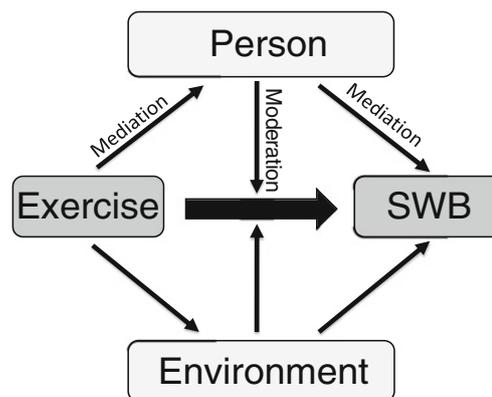


Fig. 1 Framing concept for the influence of exercise on SWB

excludes all physical activities outside the framework of leisure-time pursuits (domestic chores, employment activity, travel to work, etc.). Moreover, the analysis has to include various person characteristics (e.g., gender or age as mentioned above) and environmental features (e.g., exercising in groups, supervised exercise) (see Fig. 1).

As mentioned above, meta-analyses have shown the relevance of subgroups for the way SWB is influenced by exercise. Basically, person characteristics and environmental features can mediate or moderate this relation. Mediating variables explain *why* exercise impacts SWB and over which processes. Moderator effects, in contrast, indicate that other intervening variables are influencing the *strength* or *the direction* of the relation between exercise and SWB. In recent years, various authors have pointed out that a detailed examination of moderators and mediators shows promising potential for systematizing knowledge and thereby bringing about theoretical progress (e.g., [15, 16]). Based on this sketch of the problem, this article focuses on two central questions: (1) *What* is meant by SWB in sport science research? and (2) *How* does exercise influence SWB?

What is meant by SWB in sport science research?

As McAuley and Rudolph ([8], p. 69) have pointed out so aptly in their overview, SWB is frequently “whatever an investigator has identified as being the psychological dependent measure in his/her investigation.” Rejeski and Mihalko ([5], p. 24) have added that “if quality of life [or SWB, etc.] is intended to be a psychological construct yet is used as an umbrella term for multiple outcomes, then there is no hope of developing theory or of ever understanding what causes variability or change in quality of life.” Whereas, for example, Netz et al. [7] examined effects on *psychological well-being*, and Schlicht [6] summarized the influence on *psychological health*. However, these are not merely different terms; it is far more the case that they are associated with

different understandings of the construct. This article will start by compiling an overview of what each secondary analysis understands as SWB. This will first define SWB on the basis of existing concepts and then analyze how far secondary analyses actually do refer to core elements of SWB or how far they, in part, go far beyond this.

How does exercise influence SWB?

Biddle and Mutrie ([11], p. 197) have noted that “researchers looking at the psychological outcomes of physical activity are strongly advised to attempt to refine our understanding of mechanisms.” Biddle and Ekkekakis ([10], p. 150) have also pointed out that “establishing one or more plausible mechanisms could help to show that the relationship between physical activity and well-being goes beyond statistical association, providing evidence that physical activity can, in fact, *cause* positive changes in well-being.” Indeed, secondary analyses often reveal a series of explanatory approaches in sport science that are mostly just listed (at the end of a article) or at best related post hoc to the moderator effects found (for positive exceptions, see, e.g., [17, 18]). This article will go beyond the perspective of statistical moderation and analyze explanatory approaches in sport science to see which person characteristics and environmental features are included in which way in their theoretical assumptions. It will draw on current mediator–moderator frameworks (e.g., [15]) to consider statements on the interplay between exercise, SWB, person characteristics, and environmental features. The analysis will concentrate on examining the *theoretical* moderation and mediation of the exercise–SWB relation *in terms of its content*.

One specific focus will be on the role of age. It can be assumed that the questions pursued in this article will reveal different findings as a function of this variable. For example, Netz et al. [7] have already found different effect sizes for different age groups. This could indicate that the processes with a dominant effect at one age will not be the same as those at other ages. Moreover, it is also known that adolescents have a different understanding of SWB than individuals in mid-adulthood (e.g., [19]), who, in turn, have a different understanding than the aged who base their judgments increasingly on objective benchmarks (e.g., [5]). In addition to this, several studies have also indicated that the way the aged perceive SWB might encompass further dimensions (e.g., developmental well-being [20]). Hence, to gain a sufficiently precise analysis of the field, this article will concentrate on middle and late adulthood. This focuses attention on an age segment in which there is an increasing need for research in light of the changes in population structure to be found in many modern societies.

An attempt to disentangle SWB

In their overview entitled *Subjective well-being: three decades of progress*, Diener, Suh, Lucas, and Smith ([21], p. 277) have pointed out succinctly that “we define SWB as a general area of scientific interest rather than a single specific construct.” Correspondingly, the various attempts to classify well-being in the scientific literature reveal no standard definition. One way to achieve systematization is to differentiate between the content-related, structural aspects, and the dynamic aspects of SWB.

Content-related structure of SWB

Various categorizations can be found that refer to not only different content domains but also differences in the number of domains considered to be relevant. The first is the standard work of Diener ([22], pp. 543–544) that points to three hallmarks: First, well-being always possesses a subjective character. Second, it does not just contain negative aspects but also positive ones. Third, there is also a global measure of well-being that encompasses all aspects of an individual’s life. These fundamental characteristics and features of well-being are integrated into the underlying concept of the construct used in this article insofar as (a) the model addresses *subjective* well-being (SWB), (b) it includes positive aspects of well-being, and (c) the model shows a hierarchic structure peaking in one global measure that integrates all subsidiary well-being measures.

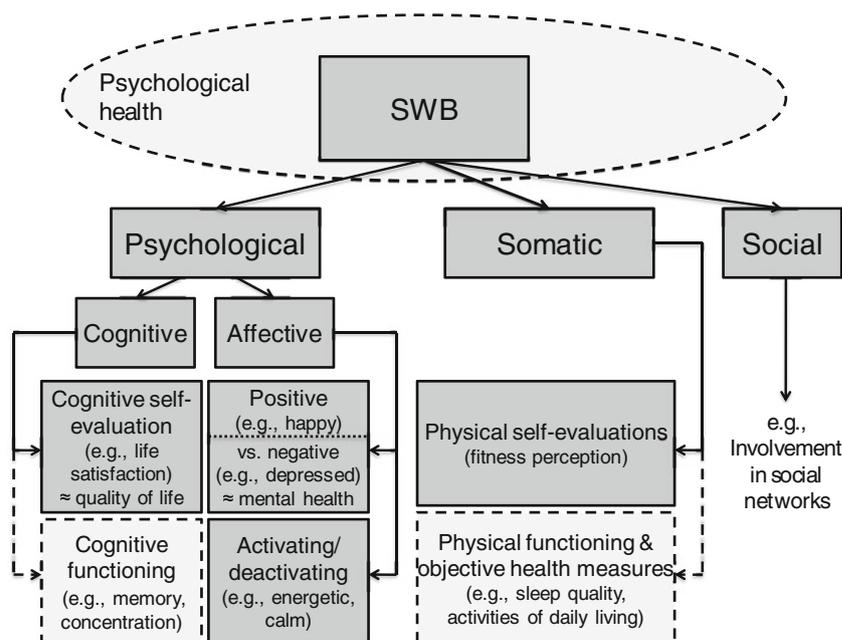
Figure 2 illustrates the understanding of SWB favored here by highlighting the decisive contents in gray-shaded boxes. The figure also integrates related constructs (e.g., physical functioning) or broader concepts (psychological health) because these have sometimes been used as outcome variables in secondary analyses. The following four sections will explain the classification of well-being components by drawing on existing definitions and demarcations of SWB.

WHO definition Back in 1946, the World Health Organization [23] already defined SWB as the subjective perspective on health and distinguished between three domains: somatic, psychological, and social SWB (first level of differentiation in Fig. 2).

Cognitive and affective SWB One fundamental distinction in the proposed model is also based on the standard work of Diener ([22], p. 547) who distinguished between three well-being components: life satisfaction (cognitive self-evaluation), positive affect, and negative affect.

Looking at cognitive SWB, the North American literature particularly uses the term *quality of life* (QoL) in order to emphasize that this is addressing a “conscious cognitive judgment of one’s life in which the criteria for judgment are up to

Fig. 2 Summary of understanding of SWB to be found in the literature



the person” ([24], p. 164). Ekkekakis and Backhouse ([9], p. 268) have additionally emphasized that these judgments are embedded “within the context of the surrounding culture and value systems and in relation to the individual’s goals, expectations, standards, and concerns.” Moreover, the subjectivity of the construct is also emphasized strongly in order to underline the contrast to earlier definitions in which QoL was described as a function taken from morbidity and mortality indices [25]. Hence, the definition emphasizes the cognitive focus, which is why QoL is partially equated with life satisfaction (see Fig. 2). One reason for the strongly cognitive approach to SWB in North America is that most operationalizations use instruments assessing life satisfaction (as a key component of SWB). Nonetheless, the level to which life satisfaction should be assigned in the hierarchy of an SWB model remains unclear. Spirduso, Francis, and MacRae ([26], p. 248), for example, have pointed to the problem that “global well-being is highly related to life satisfaction, and both concepts have resisted research attempts at separation.”

When it comes to affective SWB, the separate distinction between positive and negative affect indicates that these two dimensions are relatively independent (e.g., [27]). The term *mental health* is applied here only to outcome variables that can be classified to negative affect (e.g., depression, anxiety; see Fig. 2). It takes a clinical psychology perspective and classifies persons with a low negative mental state as “mentally healthy.” However, the exact cutoff is not given subjectively but is determined *objectively* by clinicians or researchers. Alongside its valence, affect is frequently viewed in terms of its potential activating/arousal-raising (energy, vigor, tension, and distress) or deactivating/arousal-sinking (calmness, relaxation, fatigue, and boredom)

functions. Regardless of which facet of affect is addressed, one can also differentiate according to intensity or frequency aspects. Life satisfaction can either be assessed globally or broken down into domain-specific evaluations. This differentiation is based on the observation that individuals sometimes show a strong variation in their evaluations across different life domains (work, family, health, leisure time, etc.) [28].

Psychological health In a North American work, psychological health describes a broader construct than SWB (see Fig. 2). Sallis and Owen [29], for example, subsume not only affective, anxiety, and sleep disorders under psychological health but also QoL. Evidently, there is a meaningful link between clinically relevant *and* clinically nonrelevant criteria. Accordingly, a high QoL is not a sufficient condition for psychological health [30]. As a result, SWB can be viewed as a constitutive feature of psychological health, but it cannot be equated with it. It is far more the case that psychological health subsumes further domains such as locus of control, self-esteem, and meaningfulness of life ([6], p. 26).

Objective functioning and subjective well-being One popular classification of SWB comes from Stewart and King [31]. Specially developed for the aged, it emphasizes the importance of a framework “that integrates both the quality-of-life and health status concepts, because health is an important element of life quality for people in older age groups” ([31], p. 110). The authors started off by differentiating two domains: (objective) functioning and (subjective) well-being. Functioning covers the domains of cognitive functioning, physical functioning, and social

functioning (participation in social activities). In line with the concepts favored here, SWB covers both physical (bodily) and emotional well-being. Stewart and King have emphasized that the perception of comfort or discomfort is a particularly decisive element for a classification to the category of physical well-being. As a result, it corresponds most closely to the category of physical self-evaluations in Fig. 2. Emotional well-being covers both positive and negative feeling states. Global appraisals of well-being such as overall quality of life or subjective appraisals of health are also subsumed under this category. The authors also assign the self-concept to the SWB, thereby distinguishing between self-esteem and sense of control. However, in the concept favored here, these aspects are assigned preferably to psychological health in the broadest sense and not to the conceptual core of SWB. According to Rejeski and Mihalko [5], Stewart and King's [31] classification exhibits strong similarities to the concept specifications of health-related quality of life (HRQL). HRQL is frequently analyzed in medically and behaviorally oriented studies (mostly of older adults). Although the central feature in both conceptions is a "compromise" between objective functioning parameters and subjective well-being indices, HRQL is nearly always assessed with the SF-36 [5]. However, because this instrument was developed in the medical context to assess the state of health, studies using HRQL tend to treat the areas of *subjective well-being* rather inadequately as an outcome variable. Although the objective part of HRQL contradicts the subjective character of SWB proposed here, it is integrated into Fig. 2 in the two boxes cognitive functioning and physical functioning and objective health measures.²

Moreover, it is questionable whether specific domains become less important with increasing age while others gain in significance, and it would also be interesting to know whether the dimensions that are relevant for young people and the aged are in any way the same. In one interesting qualitative study, Stathi et al. [20] asked 28 already active men and women aged 62–81 years what they understood by SWB and how they thought it could be influenced by exercise. The majority of dimensions they reported (along with their subcategories) could be classified within the framework proposed here. Only two dimensions describe further aspects: One is material well-being, but the respondents considered that this could not be influenced by exercise, making it only a subordinate aspect in the present field. The second dimension, developmental well-being, encompasses the categories of personal development (e.g., goal pursuit), independence (e.g., the ability to do things without

assistance), and maintenance (e.g., the need to lead an active life) and seemed to play an important role in relation to exercise for the respondents.

Dynamic aspects of SWB

Essentially, two aspects of intraindividual variation can be distinguished here: the stability (or instability) of SWB and its degree of variability (see Fig. 3).

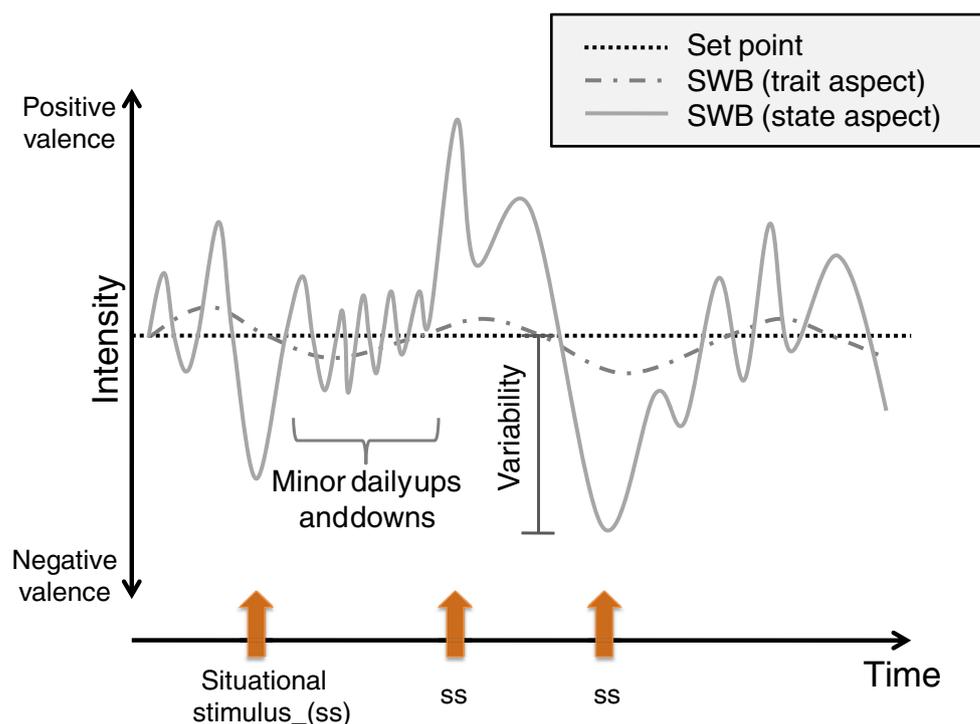
Stability A person's SWB varies around an individual set point. This set point describes a relatively stable intensity level and contains a strong genetic component (e.g., [33]). At times, the state aspect of SWB varies strongly around this individual set point as an outcome of interactions between situational stimuli (e.g., exercise) and personality (e.g., extraversion). The trait aspect of SWB, in contrast, is more stable and varies less strongly (i.e., in longer cycles) and at a smaller amplitude around the individual set point. In addition, trait SWB is determined to a greater extent by stable personality characteristics (e.g., extraversion, see [34]) and reveals a markedly higher temporal and situational consistency. Although these two aspects are differentiated clearly on a theoretical level, there are no concrete indications regarding how far one can talk about a "right now" (or state) SWB and specify when this changes into a "longer time period" (or trait) SWB.

In addition, the set point is known to remain stable throughout life, even though a number of losses generally also have to be accepted. In the literature, this is also known as the paradox of well-being (e.g., [35]). However, studies have shown different gain and loss trajectories in line with the multidimensionality of SWB. For example, Kunzmann et al. [36] used cross-sectional and longitudinal analyses of the two emotional components positive and negative affect to show that only negative affect fails to correlate with the age variable, whereas losses in positive affect have to be accepted with increasing age. Further analyses by these authors revealed that it is not age per se that is responsible for changes in SWB but health constraints. After controlling for these health constraints, the authors even found a positive correlation between age and positive affect as well as a negative correlation between age and negative affect.

Variability The amount of variability is the second dynamic aspect of SWB. In recent years, this has attracted increasing interest within research on differential psychology. Although two individuals may display the same set point or a similar average habitual SWB, one may react to situational events with more intensive changes of current SWB, whereas the other may react to similar events with much less variation. Like Diener et al. [21] beforehand, Nesselrode ([37], p. 189) has pointed out that the extent of intraindividual variability can, in

² For example, Rejeski, Brawley, and Schumaker [28] used HRQOL as the outcome variable in their secondary analysis, whereas Ekkekakis and Backhouse [9] analyzed HRQOL as just one of several outcome variables.

Fig. 3 Dynamic differentiations of SWB (adapted from Schlicht [32])



turn, also be a stable “trait-like” construct and vary interindividually. The extent of these fluctuations evidently depends on various personality characteristics such as neuroticism [38].

It can be seen repeatedly that different relations are assumed between content-related and dynamic aspects of SWB. In general, affective SWB is associated with both trait aspects (in the sense of a long-term basic mood) and state aspects (in the sense of a current mood), whereas the cognitive aspect of life satisfaction tends to be associated with a trait perspective. Some researchers even relate the set-point approach explicitly to life satisfaction [39].

Use of SWB in exercise-related secondary analyses

The present selection of secondary analyses contains quantitative and qualitative studies published between 1995 and 2009. With one exception [6],³ they all stem from the North American and English-speaking world. Six of these 19 works are meta-analyses; the remaining 13 are narrative reviews. Seven of them focus particularly on the aged and generally apply a minimum age (or mean minimum age) of 65 years as their criterion for inclusion. The remaining secondary analyses were not only, strictly speaking, age-specific but also contained studies of younger persons. The present approach draws on Netz [40], who deliberately set no age limits for his narrative review. Instead, he included

³ However, the majority of primary studies integrated in Schlicht’s [6] meta-analysis also come from the North American or English-speaking world.

studies addressing the relation between exercise and well-being in young versus aged persons. This places the aging process at the center of attention, while pointing to the particular features of this process. Reviews were included only when they applied SWB in the sense of the above-mentioned definitions or used related concepts such as psychological health (see Fig. 2). Reviews were not included when they concentrated *exclusively* on clinically relevant features of well-being (e.g., depression) or when they addressed single cognitive functioning parameters or purely physical parameters (e.g., [41]).

The analyses of the different uses of terms in secondary analyses predominantly addressed content-related, structural differentiations of well-being. Most studies did not explicitly state the understanding of the dynamics of SWB on which they based their research. However, most of them implicitly assumed at least a mid-term stability of the dependent variables.⁴ Table 1 reports which domains were taken into account in the secondary analyses.

The following points should be mentioned with regard to this analysis: (a) There was a tendency to take only certain components of well-being into account. Review articles concentrated mostly on affective (17 out of 19) and cognitive (12 out of 19) well-being. They less frequently addressed somatic (eight out of 19) and social SWB (three out of 19). (b) Both Fox [4] and Sallis and Owen [29] mostly discussed the negatively defined mental health

⁴ Exceptions are the secondary analyses of Reed and Ones [17] and Reed and Buck [18] that studied the influence of exercise on exclusively state aspects of well-being (the “right now” effect).

Table 1 SWB domains in the secondary analyses

	Global	Psychological				Somatic		Social
		Cognitive		Affective		Physical functioning/ Objective health measures	Physical self-evaluations	
		Cognitive functioning	Cognitive self-evaluations	Positive	Negative			
Meta-analytic reviews								
Arent et al. [42] ^a								
Gillison et al. [43]			Psychological well-being		Physical health		Social relationships	
Netz et al. [7] ^a								
Reed & Buck [17]								
Reed & Ones [18]								
Schlicht [6]								
Narrative reviews								
Arent et al. [44]					Depression, anxiety			
Biddle [45]								
Biddle & Mutrie [11]			Self-esteem, self-perception			Sleep quality		
Ekkekakis & Backhouse [9]		Fluid & crystallized abilities	Self-esteem		Anxiety, depression			
Fox [4]			Self-esteem, self-perception		Depression, anxiety	Sleep quality		
Fox [46]			Self-esteem, self-perception					
McAuley & Rudolph [8] ^a			E.g., positive affect, self-efficacy		E.g., depression, anxiety			
			Life satisfaction	Generalized mood				
Netz [40] ^a			Self-perception					
Rejeski et al. [47]								
Rejeski & Mihalko [5] ^a			Life satisfaction					
Sallis & Owen [29]					Depression, anxiety			
Spiriduso & Cronin [48] ^a								
Spiriduso et al. [26] ^a	Global well-being/ Life satisfaction		Self-concept, self-esteem, self-efficacy		Depression, anxiety, stress	Bodily well-being		
							Body consciousness	

Specifications of table categories are given in the cells. ¹ Reviews of studies with the aged

^a Reviews of studies with the aged

concept of well-being. Other authors, in contrast, concentrated on positive aspects of well-being [8] or even exclusively on positive affect [17, 18]. (c) Whereas some authors limited themselves exclusively to single or only a few demarcated areas of SWB (e.g., [17, 18, 42, 45, 46]), others covered all or the majority of categories addressed here (e.g., [7, 9, 47]). (d) Especially in meta-analyses, the use of a very broad understanding of SWB runs the risk of producing very heterogeneous findings. Despite the advantage of a broader study base, this reduces the clarity. There is a corresponding tendency for more recent reviews to focus on specific outcomes. (e) In wide-ranging narrative reviews, researchers need to be careful about generalizing effects across different domains of well-being. Otherwise, they run the risk of making sweeping statements particularly when evaluating the findings from secondary analyses by other authors.

How does exercise influence SWB?

After having systematized the use of SWB as a dependent variable in secondary analyses, it is now necessary to explain *how* the outcome variables are influenced by exercise. Secondary analyses discuss a series of moderator variables that reveal different effects depending on the characteristics of the corresponding grouping variables (see, e.g., [7, 11, 18, 42, 46]). Figure 4 tries to classify these in line with the basic presentation in Fig. 1.

The variables discussed are, on the one hand, person characteristics and environmental features; on the other hand, features that specify the exercise treatment. In general, secondary analyses rarely explain a priori why they have

chosen one specific set of moderator variables. A further problem is that meta-analyses conceive the moderator concept only in statistical terms. As a result, it is not just differentiations of components of well-being that are treated as (statistical) moderator variables; mediating factors (e.g., fitness increase) are subsumed under the moderator label as well. Hence, in order to address the content-related theoretical moderation and mediation of the exercise–SWB relation, it is necessary to have a sound moderator and/or mediator framework that will provide a foundation for a systematization of the explanatory approaches in sports science.

Moderator and/or mediator framework

Figure 5 presents an overview of potential moderator and mediating effects that take into account the later analysis of the explanatory approaches. These are ranked from top to bottom according to successively increasing complexity (see [49, 50]).

Figure 5a depicts a classic mediator effect, that is, it explicates which mediating variable (M) mediates the influence of exercise on SWB (e.g., exercise raises self-efficacy; self efficacy, in turn, is the reason for a change in SWB). Alongside such simple mediation models, one can find *multiple mediator models* in which the outcome variable SWB is influenced by several variables (sequential or contemporaneous, see Fig. 5c and d; [15]). In moderator effects, in contrast, moderator variables influence the strength and/or the direction of the relation between exercise and SWB (see Fig. 5b; e.g., the effect of exercise on SWB is higher in mid-adulthood than in late adulthood). The presence of moderator variables (Z) indicates the generalizability of the

Fig. 4 Moderator variables in exercise-related secondary studies

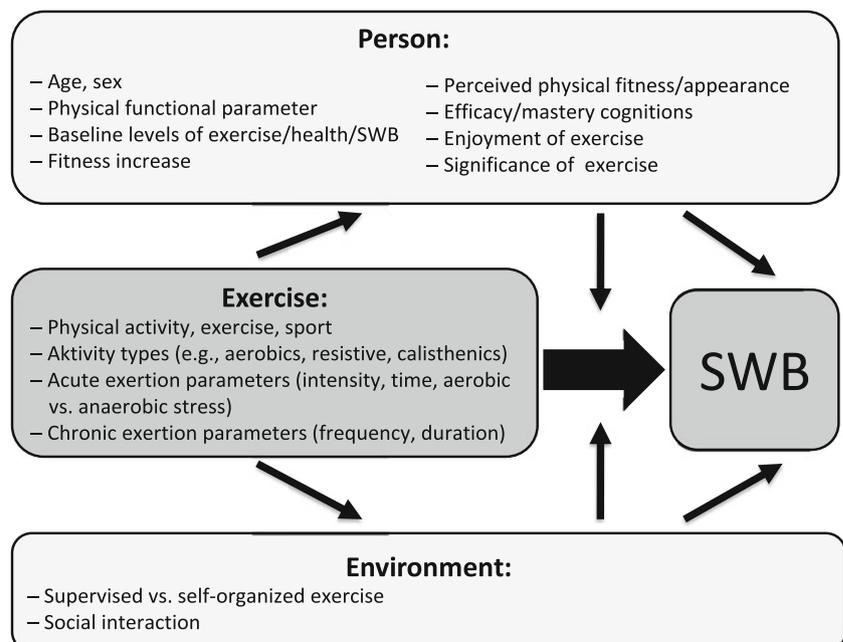


Table 2 Explanatory approaches in sport science

	Increase in well-being through...	Further reading
Neurophysiological explanations		
Cardiovascular fitness	improved physical fitness	Biddle and Ekkekakis [10]
Thermogenic hypothesis	raised body temperature	Koltyn [52]
Improvement in cerebral blood flow	increased cerebral blood flow leading to increased oxygen transport	Rogers, Meyer, and Mortel [53]
Endorphin hypothesis	increased release of endorphins	Hoffmann [54]
Endocannabinoid hypothesis	increased endocannabinoid release	Sparling et al. [55]
Monoamine hypotheses	a change in the specific neurotransmitter systems	Chaouloff [56]
Central serotonin		Dishman [57]
Catecholamines (esp. noradrenaline)		
Transient hypofrontality hypothesis	reduced neural activity in the prefrontal cortex (thereby reducing conscious cognitive processes)	Dietrich [58]
Cross-stressor adaptation hypothesis	repeated and sufficiently intensive and long-lasting stressors that lead to nonspecific adaptations of the stress reaction; the reduction in stress reactivity can be transferred to other non-exercise-related stressors	Sothmann [59]
(Social) psychological explanations		
Distraction hypothesis (“time out”)	distraction from problems and stress	Bahrke and Morgan [60]
Self-efficacy theory/Mastery hypothesis	the acquisition of subjective ability appraisals	Bandura [61]
Meditative consciousness states (flow experience)	the fit between skill and challenge level	Csikszentmihalyi [62]
“Exercise and self-esteem” model	increased self-esteem ^a through changes in physical self-efficacy that exert a positive influence on the two components of self-esteem “physical competence” and “physical acceptance” on a more global level	Sonstroem and Morgan [63]
Social support	experiencing social support and an accompanying increase in self-efficacy	Fox [4]
Mixed approaches		
“Dual-mode” model	the existence of two mechanisms (cognitive processes and the perception of interoceptive information due to physiological changes); depending on the intensity of exercise, these two mechanisms vary in the strength of their (positive or negative) influence	Ekkekakis [64]
Two-dimensional activation model	an intensive increase in the energetic arousal level accompanied by a simultaneous decline in emotion-related tension arousal	Thayer [65]

^a It is assumed here that the gain in self-esteem through exercise triggers a general “feel better” effect, thereby leading to improved well-being [9]

relation between the independent variable exercise and the outcome variable SWB by “illustrating the context(s) under which the relation holds” ([15], p. 54).

Moreover, mediating and moderator effects can occur simultaneously and can then be labeled as *conditional indirect effects* [49]. These authors defined a conditional indirect effect “as the magnitude of an indirect effect at a particular value of a moderator” ([49], p. 186; see Fig. 5e–h).

Analysis of explanatory approaches in sport science

This section presents those explanatory approaches that contain SWB or specific domains such as stress (negative affect) as a dependent variable. Basically, they can be split into neurophysiological and (social) psychological approaches together with models containing a mixture of

the two (see Table 2). It is conspicuous that there have hardly been any further notable developments—particularly in the (social) psychological approaches. A look at Biddle and Mutrie’s list from 1991 [51] reveals almost the same explanatory approaches as those to be found in more recent overviews (e.g., [40]).

The analysis of the explanatory approaches based on the moderator and/or mediator framework presented here addresses the naming of the person and environmental variables, the specification of exercise variables (treatment), and the understanding of well-being insofar as this is explicated (see Table 3). This procedure can be illustrated for the “cardiovascular fitness” approach: An aerobic exercise stimulus (specification of the treatment variable) influences current SWB (dependent variable) indirectly (basic mediated model) over an increase (in specific parameters) of cardiovascular fitness (person variable).

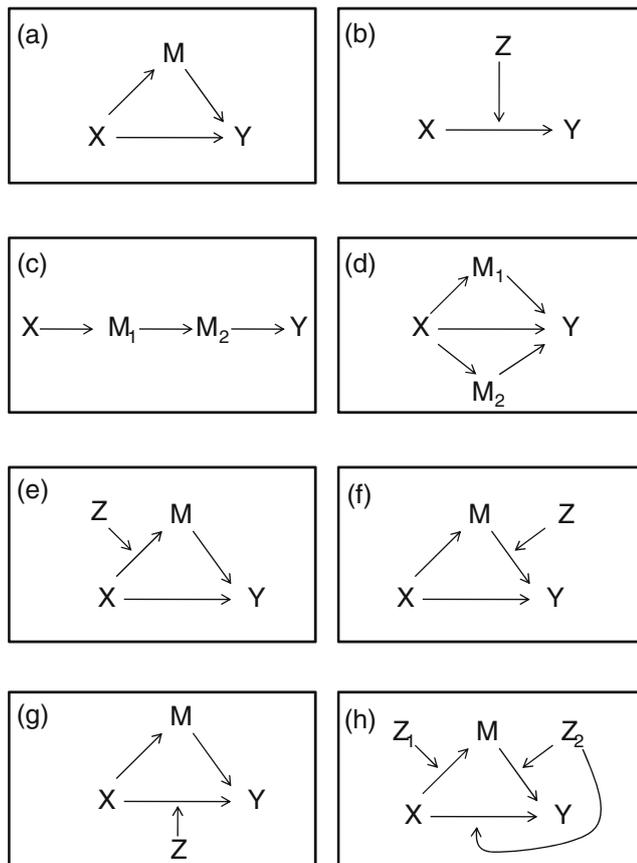


Fig. 5 **a** Basic mediated model, **b** basic moderated model. Multiple mediator models: **c** sequential and **d** contemporaneous. Different conditional indirect effects: **e** first stage moderation model, **f** second stage moderation model, **g** direct effect moderation model. **h** Combinations of multiple mediator models (adapted from [49, 50])

The following sections draw conclusions for each of the features and characteristics analyzed.

Person variables The explanatory approaches focus on one (or in individual cases, several) person variable(s). This often provides the label for the approach (e.g., endorphin hypothesis). Attention focuses mostly on either physical (e.g., monoamine) or psychological person variables (e.g., self-efficacy). The dual-mode approach, in contrast, focuses on a combination of physical and psychological person variables. It assigns a central role to various interoceptive cues (e.g., ventilation, acidosis, core temperature) alongside cognitive processes (e.g., self-efficacy, goals, attributions). The stability of the person variables in the explanatory approaches varies greatly. Whereas most physical person variables tend to be unstable and effective for only a short time (e.g., endorphin), psychological person variables are generally more stable (e.g., perceived social support, self-efficacy).

Environmental variables Only one explanatory approach differentiates an environmental variable. The social support

model focuses on the way in which exercise is embedded in social interaction. It proposes that the social interaction in the exercise group increases well-being.

Treatment A number of approaches specify treatment variables. These refer almost exclusively to acute exertion parameters (intensity, aerobic vs. anaerobic exertion). However, it remains mostly unclear whether these treatment variables address specifications of the exercise itself or a moderator and/or mediating variable. For example, the treatment variable aerobic exertion in the transient hypofrontality hypothesis represents a specification of the independent variable. According to this approach, aerobic exertion leads to enhanced neural activity in the brain that mediates the effect of exercise on SWB. With the exception of the endorphin hypothesis and meditative consciousness states, all treatment variables are viewed as a specification of exercise as the independent variable. A decisive concern in this classification has been whether the approaches address a variation of the variables concerned (e.g., higher intensity leading to the release of endorphin that results in increased well-being compared to a lower intensity leading to no release).

Subjective well-being Physiological explanatory approaches tend to model an influence on the affective components of SWB with a predominant focus on negative feelings or clinically relevant affective or anxiety disorders. In contrast, psychological explanatory approaches, which are frequently based on cognitive processes such as ability appraisals and evaluations, relate to cognitive components of SWB as well ([26], p. 250). Explanatory approaches also differ in terms of the “permanence” of the change in SWB. Most explanatory approaches view exercise as a situational stimulus for short-term changes to current SWB. Hence, exercise can trigger internal responses that either are more physiological in nature (e.g., changes in the hormone or neurotransmitter balance or in core temperature) or elicit psychological changes (e.g., distraction). However, some psychological explanatory approaches (e.g., the “exercise and self-esteem” model or the mastery hypothesis) should also explain habitual changes in well-being (e.g., increase in self-efficacy or physical acceptance).

Mediator and/or moderator framework The majority of models are basic mediated (e.g., distraction hypothesis) or multiple mediated (e.g., monoamine hypotheses). As a result, most explanatory approaches reveal the following structure: Exercise (in general or of a specific type) influences a certain person variable that, in turn, influences (basic mediation) the SWB (in general or a specific component thereof), or, in contrast, several mediators mediate (sequentially) between exercise and SWB (multiple mediation). Such multiple mediated models are particularly frequent in

Table 3 Analysis of explanatory approaches in sport science

	Person variables	Environmental variables	Treatment	SWB	Mediator–moderator framework
Neurophysiological explanations					
Cardiovascular fitness	e.g., cardiorespiratory endurance		More aerobic exertion	Unspecific	2
Thermogenic hypothesis	Core temperature increase			Affect	2
Improvement in cerebral blood flow	Cerebral blood flow, oxygen transport			Cognitive functioning parameters, affect	3
Endorphin hypothesis	Endorphin		Intensity	Positive affect	3
Endocannabinoid hypothesis	Endocannabinoid			Positive affect	3
Monoamine hypotheses	Monoamine			Negative affect	3
Central serotonin					
Catecholamines (esp. noradrenaline)					
Transient hypofrontality hypothesis	Neural activity in cortex		Aerobic exertion	Negative affect (depression, anxiety)	3
Cross-stressor adaptation hypothesis	Stress hormones, physiological parameters		Repeated, intensive, and persistent exertion	Negative affect (stress)	3
(Social) psychological explanations					
Distraction hypothesis (“time out”)	Distraction			Negative affect (stress)	2
Self-efficacy theory/Mastery hypothesis	Self-efficacy, age			Cognitive self-evaluations	4
Meditative consciousness states	Skills, flow experience		challenge imposed by exercise	Positive affect	4
“Exercise and self-esteem” model	Physical self-efficacy, physical acceptance, physical competence			Cognitive self-evaluations (self-esteem)	3
Social support	Self-efficacy, perception of social support	Social interaction		Unspecific	3
Mixed approaches					
“Dual-mode” model	Cognitive processes (appraisals of meaning of exercise, goals, different self-perceptions), interoceptive cues		Intensity	Affect	4
Two-dimensional activation model	Energetic and emotion-related arousal		Intensity	Negative affect	3

1 basic moderated model, 2 basic mediated model, 3 multiple mediator model, 4 conditional indirect effect

neurophysiological explanatory approaches, with the effect generally proceeding over various physiological (state-like) person variables. For example, there are indications that the release of endogenous opioids in the central nervous system is brought about by continuous stimulation of ergoreceptors [54]. In addition, there are a few approaches with moderator and mediator effects occurring at the same time (conditional indirect effects). For example, the mastery hypothesis applies a first-stage moderation model in which the influence of the moderator variables is found on the path between the independent variable and the mediator. It is also argued that the increase in self-efficacy (mediator) through exercise depends on age (moderator). For older persons whose self-efficacy is lower due to lower functional abilities, exercise offers (more strongly than among younger persons) an opportunity for a mastery experience that leads

to an increase in self-efficacy and thus, indirectly, to a stronger increase in SWB ([40], p. 501). The dual-mode model uses a combination of multiple mediator models in which the effect of the mediators (cognitive factors, interoceptive cues) on the outcome variable (affect) varies (first stage in Fig. 5e) depending on the level of the moderator variable intensity. Similarly, the explanation through meditative consciousness states is based on a more complex pattern of effects. Exercise leads to an enhanced state when it elicits an experience of flow (basic mediated model). However, flow can be experienced only when there is a fit between skill and challenge level. The combination of these two moderators determines the level of the mediator variable (flow experience), which is why this approach also reveals a combination of multiple mediator models.

Discussion

Proceeding from the inconsistent state of research on exercise and well-being, the introduction pointed to the need for stronger theoretical reflection. This article has tried to meet this need by analyzing the following two questions: (a) “*What is meant by SWB in sport science?*” and (b) “*How does exercise influence SWB?*”

It started off by trying to integrate the variety of understandings of well-being to be found into one summary presentation. This made it possible to compare the understandings of the term used in secondary analyses and gain answers to the first research question. For example, it could be shown that a comparatively large number of studies have been carried out on cognitive and affective (above all, negative) SWB, whereas there has been markedly less research on other components of well-being such as social but also positive affective SWB. This is surprising when it is considered that it is particularly positive affective SWB that seems to decline with growing age (see [36]). Hence, when considering this domain of SWB, it would be particularly worthwhile to study the potential of exercise to bring about change. Some researchers have already started to do this (see, e.g., [17, 18]). Moreover, with reference to age, it would be desirable to focus attention on changes in the meaning of various components of well-being across the life span. Correspondingly, it would seem less promising to just apply one and the same domain of well-being as outcome variables for both the young and the aged. Moreover, some studies have quantitatively summarized a broad spectrum of well-being components along with related constructs. A homogeneous set of findings cannot be anticipated for this reason alone. One basic recommendation for future research would be to specify which facet of SWB should be modified in advance during the study planning stage. The analysis also showed that authors have based their outcome variables on constructs that cannot be assessed within SWB according to the model proposed here. Instead, these are frequently intervening variables such as self-esteem or self-efficacy. This additionally indicates the need to analyze the explanatory approaches in order to “expose” what are really determinants being presented as outcome variables (e.g., the exercise and self-esteem model or self-efficacy theory).

To assess the second research question profitably, explanatory approaches in sport science were analyzed within a mediator and/or moderator framework. This analysis led to several conclusions.

Statistical moderation versus theoretical and content-related moderation and mediation

Most of the intervening variables in the theoretical approaches analyzed here were mediators. When moderators were included, it was in the form of moderated mediation. In contrast, the

quantitative secondary analyses treated intervening variables exclusively as moderators influencing the direction and the strength of the relationship. They did not test (statistically) any potential mediating effect of the variables. Even on the level of primary studies, there was frequently no consistent distinction between moderator and mediator effects. Indeed, insufficient attention was paid to the fact that the presence of moderators and/or mediators indicates that a different theoretical background is involved. In general, the adoption of mediating variables in a model is guided by a theory. Mediators offer an explanation for *why* an exercise program exerts an influence on SWB. The release of endorphins, for example, should bring about an increase in positive mood. In contrast, an application of moderator variables is often characterized by their empirical confirmation. Hence, either features of exercise variables, environmental variables, or particular characteristics of participants are identified that have a more or less confirmed effect on SWB. For example, it is assumed that exercise can bring about a stronger gain in self-efficacy with increasing age [66].

An insufficient differentiation between mediators and moderators is not just problematic on the theoretical level. In methodological terms, the fact that the choice of a specific model leads to different evaluation strategies is also just as crucial for primary studies. Whereas moderator effects are found typically in designs using analysis of variance, mediator effects require, for example, approaches using path analysis. In conclusion, the potential of moderator and mediator analyses could be exploited much more strongly in both primary and secondary research.

Degree of complexity in theoretical approaches

Basically, it can be seen that approaches differ greatly in terms of their complexity. For example, the “exercise and self-esteem” model or the “dual-mode” model make a series of differentiated statements in their core assumptions, and this is reflected in the number of differentiated features in these approaches. Accordingly, they are classified as complex mediator models. Other approaches such as the distraction hypothesis, consider only one further intervening variable, thereby revealing the structure of a basic mediated model.

Inclusion of environmental variables

Both the explanatory approaches and the secondary analyses studied here pay little attention to environmental variables. Only the social support approach uses the feature of social interaction to focus on the setting in which exercise occurs. Ekkekakis and Backhouse ([9], p. 268) have also criticized this underrepresentation of environmental features: “It is important to contextualize physical activity. Individuals do not partake in this behavior in a vacuum, so many moderating variables likely exist.”

Inclusion of person variables

The analysis shows that the explanatory approaches contain a range of different person variables. In neurophysiological approaches, these are mostly neurophysiological parameters that are assigned a mediating role. The (social) psychological approaches generally describe person-internal mediators and pay less attention to personal preconditions. However, it is particularly here that recent research is increasingly indicating the central significance of individuals' preferences for certain activities. This is clear to see when Biddle ([45], p. 82) states: "We will never resolve this issue since people will 'feel good' after exercise they prefer, and feel 'less good' after exercise that is not to their liking." Isolated studies have already shown different effects depending on intrinsic versus extrinsic exercise goals [67], activity- versus purpose-related incentives [68], intrinsic versus extrinsic motivation toward an activity [69], or choice of exercise mode [70, 71].

Dynamic aspects of SWB

A further aspect that has yet to be explained satisfactorily is the stability of intended changes to well-being. There are hardly any explicit reports on this. Implicitly, it is assumed that single bouts with effects over a short period of time address state SWB, whereas repeated, longer lasting, chronic exercise units tend to influence the stable part of SWB. Nonetheless, there is a need for ideas on how the relation between the state and trait aspect of SWB can be explained precisely in theoretical terms. A few single assumptions can be found such as the accumulation effect or the maintenance explanation, and these have been discussed particularly for affective reactions [17]. According to the former, an accumulation of repeated "daily uplifts" leads to an increase in current SWB. According to the maintenance explanation, in contrast, exercise does not have a lasting effect on SWB. The observable effects of regular exercise merely reflect a continuous regeneration of increases in current SWB through repeated single bouts. Current research findings do not support the accumulation effect. If such were to exist, it would have to be possible to measure higher well-being effects for regular exercise than for single bouts. The two meta-analyses performed by Reed and Ones [18] and Reed and Buck [17] took an almost identical approach (inclusion criteria for primary studies, coding, and computing of effect sizes) to study, in one case, the influence of acute and, in the other case, the influence of regular activity on affective well-being. However, they found comparable overall effect sizes for both. Although this seems to reject the assumption of a simple cumulation of effects, it does not automatically support a maintenance explanation. Other explanations are conceivable and need to be considered. In some circumstances, a critical frequency of exercise may prove to be necessary

before it will have an effect on habitual well-being. Before this threshold, current well-being will be deflected in the way described by the maintenance explanation (parabolic trajectory of SWB change). Alternatively, the effect on habitual SWB might decline the more frequently an individual engages in exercise. Then, one would have to assume a tolerance effect (hyperbolic trajectory). There are numerous potential explanations and assumptions. However, the fact is, as Reed and Buck ([17], p. 589) have concluded, that "more studies...are needed to gain a better understanding of the interaction between acute and regular aerobic exercise responses." Looking at the aging process, there is also a tendency for traits to become increasingly stable over the life course [72]. Such a stabilization decreases the probability that a specific stimuli such as engaging in exercise will lead to current changes in the aged.

In addition, neither empirical research nor sport-specific explanatory approaches reveal any signs of work on the second dynamic aspect treated here, namely, variability. This is not surprising because it is a relatively new construct. However, the inclusion of variability not only makes it possible to explain systematic variance but also increases the power of smaller effects in those individuals who demonstrate only a slight variability in principle.

Age specificity

Despite an increasing number of empirical studies on the particular influence of exercise on SWB in the aged, there are hardly any age-specific explanatory approaches. Although it is not age-specific in a strict sense, the only (psychological) explanatory approach that at least considers how the postulated effect relates to age is self-efficacy theory (see [40]). Nonetheless, it can be assumed that further determinants are more important for older compared to younger persons. For example, the perception of physical competence (exercise and self-esteem model) or of social support through exercise might be far more important for the aged. Because of the frequent age-related decline in physical abilities or social contacts, exercise could possess a great potential here. The cross-stressor adaptation hypothesis also shows that other non-exercise-related stressors are more relevant for older than younger persons. Comparative studies are needed in order to examine whether specific explanatory mechanisms reveal age-specific adaptations.

Outlook

Inputs from differential gerontology

This section discusses theories designed to deliver explanations for the ways in which individuals age successfully.

The criteria for successful aging have generally been subjective parameters such as life satisfaction or well-being [73]. The interesting question in the present context is the role of exercise in theories of successful aging or how far determinants named in these theories can be modulated by exercise. For example, the results of the study of Stathi et al. [20] can also be explained through activity theory [74]. These authors found that successful “agers” are particularly those who manage to maintain their activities, to replace old roles through new ones, and to remain involved in society. In line with activity theory, the sample recruited by Stathi et al. [20] were aged people who were already active (in exercise) at the time of the study. More recent theories on successful aging have additionally shown that it is particularly stabilizing adaptive strategies that have a decisive impact on SWB in the aged [75]. Types of exercise that exert a positive influence on such stabilizing adaptive strategies are accordingly particularly effective for promoting SWB.

Kanning and Schlicht [76] have proposed an interesting approach that combines the issue addressed here with theories of successful aging. Their heuristic model is designed to explain how SWB can be influenced positively in order to age successfully. They combine their approach with Deci and Ryan’s [77] self-determination theory according to which setting and pursuing goals leads to increased well-being when this satisfies psychological needs (competence, autonomy, and relatedness). In this context, exercise could influence the satisfaction of psychological needs in two ways: First, positive physiological and psychological effects that emerge through exercise can lead to more vitality and mobility. As a consequence, more personally valued goals can be pursued. Second, psychological needs can also be satisfied directly through exercise (e.g., through social interaction and relatedness).

General and differential approaches

In all, the analysis of explanatory approaches reveals that neurophysiological approaches focus predominantly on (specifications of) treatment variables that are responsible for (short-term) reactions of certain person-internal variables (e.g., release of hormones, brain activity). In contrast, (social-) psychological approaches focus more on stable (trait) person characteristics. However, these less frequently deliver indications on how exactly the treatment should be shaped for the desired effect to occur. Only a few approaches (e.g., the dual-mode model) reveal an equally strong focus on person-internal and -external variables. The dominance of treatment variables in neurophysiological approaches and (stable) person variables in (social-) psychological approaches corresponds to a fundamental debate between general and differential psychology (see, on the antagonism between general and differential psychology [78]). Questions in *general psychology* focus on the uniformity of human behavior and

thereby general laws. Researchers are primarily interested in whether these laws can be ascertained in a representative sample with a certain probability of error. If they still have no success after considering all relevant person-external variables, they shift to limiting the extent of generalizability by introducing (personal) framing conditions. For example, a law may be valid only for women or only for persons of a certain age. They generally do not consider person variables to be systematically variable. In the best case, they are controlled or held constant. Researchers taking the *differential psychology* perspective, in contrast, focus primarily on interindividual differences in person variables, and classic research reveals a strong concentration on individuals with their stable personality characteristics or stable personality structure. Although the influence of further person-external variables is not denied, these are not the focus of interest and are typically conceived as an additional context condition that is not differentiated any further.

However, concentrating exclusively on interindividual differences in person variables (differential psychology) is just as unproductive as concentrating solely on nomothetic, universal laws (general psychology). With increasing interindividual differences, it either becomes harder to detect general psychological laws, or their scope becomes narrower. The only promising perspective is one that unites both general psychological *and* differential aspects. Diener et al. ([21], p. 295) have described this content in general for changes in SWB: “It is pointless to search for a single cause of happiness. Instead, they need to understand the complex interplay of culture, personality, cognitions, goals and resources, and the objective environment.”

If explanatory approaches were to pay attention to both person-internal *and* person-external mediators and moderators, they would do more justice to the complexity of the subject area. The present classification of the explanatory approaches in a mediator and/or moderator framework has shown that the majority of models are currently basic mediated and multiple mediated. An integrative general psychological and differential perspective in contrast would make it necessary to pay more attention to conditional indirect effects in the (further) development of explanatory approaches in the sport sciences and to apply adequate causal evaluation strategies when testing these empirically.

Combining approaches

Finally, with regard to research practice, it is necessary to clarify whether some approaches are “better” than others and should therefore be preferred. Models such as the dual-mode model, which possess a certain degree of complexity, have more explanatory power than simple descriptive approaches such as the distraction hypothesis. Nonetheless, the decision in favor of *one* correct explanation is just as

misleading as statements proclaiming the shared (but not specified more closely) influence of a host of explanations:

Possible explanations for why physical activity might influence mental health and well-being are likely to work in a synergistic way in which people may feel better, perceive an increased sense of control, notice less tension in muscles, sleep better, use less effort in daily tasks and have higher levels of circulating neurotransmitters. Perhaps it is this “gestalt” which provides the effect rather than one mechanism explaining one outcome. ([11], p. 197)

Although it can be assumed that using several approaches will increase the explanatory potential, this has no practical utility when they fail to specify in which persons under which framing conditions a specific component of well-being will be influenced. In this context, Ekkekakis and Backhouse ([9], p. 268) have pointed out that “the subjective nature of the self means that the mechanisms accounting for change are variable and will depend on the individual’s subjective experience of the activity and the setting in which it takes place.” This once again shows the importance of adopting a differential perspective as the precondition for a better understanding of individual experience. Particularly for planned changes to *habitual* well-being, this also means paying more attention to stable individual preconditions for action (e.g., extraversion). A further feature that has still received hardly any attention in research on well-being in sport science is the degree of intra-individual variability in well-being.

Researchers are faced with the difficult task of precisely analyzing which explanatory approaches they intend to use for their concrete research question before they go on to carry out a study. In addition, they need to have a clear idea on which domain of well-being the planned intervention should address against the background of the chosen theoretical framework. One can only hope for more homogeneous findings and their interpretation in the future as researchers increasingly engage in careful and prudent theoretical deliberations that flow into the planning of their interventions.

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