Development and validation of the physical effort scale (PES)

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Abstract

Objectives: Previous literature has primarily viewed physical effort as an aversive experience. However, recent research suggests that effort can also be valued positively. These differences in approach and avoidance tendencies toward physical effort may play a key role in the self-regulation of physical activity behaviors. The aim of this study was to develop a scale that measures these tendencies and contributes to a better understanding of physical effort and how it affects behavior.

Methods: The Physical Effort Scale (PES) was developed in Study 1 based on expert evaluations ($n = 9$) and cognitive interviews ($n = 10$). In Study 2 ($n = 680$, 69% female), content validity and dimensional structure were examined using principal component analysis and confirmatory factor analysis. Item reduction was conducted using item response theory. Preliminary construct validity was explored using regression. Study 3 ($n = 297$, 71% female) was used to validate dimensional structure, internal consistency, and construct validity, and to assess test-retest reliability.

Results: In Study 1, 44 items were rated for content validity, of which 18 were selected and refined based on cognitive interviews. Analyses from Study 2 allowed reducing the scale to 8 items with a two-dimension structure: Tendency to approach ($n = 4$) and to avoid physical effort ($n = 4$). The two subscales showed high internal consistency ($\alpha = 0.897$ for the approach dimension and 0.913 for the avoidance dimension) and explained usual levels of physical activity, providing preliminary evidence of construct validity. Study 3 confirmed the two-dimension structure with high internal consistency ($\alpha = 0.907$ and 0.916 for the approach and avoidance dimension, respectively) and revealed acceptable test-retest reliability (intraclass correlation > 0.66). Patterns of associations with other constructs showed expected relationships, confirming the concurrent, convergent, and discriminant validity of the scale.

Conclusions: The PES is a valid and reliable measure of individual differences in the valuation of physical effort. This scale can assess the propensity to engage in physically demanding tasks in non-clinical populations. The PES and its manual are available in the Supplementary Material.

Keywords: Exercise, Investigative Techniques, Motivation, Personality, Physical Exertion, Sports, Validation Study

Development and Validation of the Physical Effort Scale (PES)

Perception of physical effort can be defined as the conscious sensation experienced during the performance of a physical activity (Kent, 2006; Marcora, 2009). This perception is influenced not only by the task demands, the capacity to meet these demands, and actual physical effort (Steele, 2020), but also by previous experience of similar efforts, motivation, awareness, and affects (Abbiss et al., 2015; Cheval & Boisgontier, 2021). Effort minimization is a process that aims to achieve the most cost-effective behavior based on this perception (Cheval & Boisgontier, 2021; Cheval & Boisgontier, 2023). A compelling conceptual and empirical literature attests to the human tendency toward the principle of least effort (Zipf, 1949). This literature asserts that individuals are inclined to conserve energy and avoid unnecessary physical exertion (Bieleke et al., 2023; Brehm & Self, 1989; Gendolla et al., 2012; Silvestrini & Gendolla, 2013). The current study is grounded in a theory that aligns with this literature, the Theory of Effort Minimization in Physical Activity (TEMPA) (Cheval & Boisgontier, 2021; Cheval & Boisgontier, 2023). TEMPA proposes that individuals have a general tendency toward the minimization of physical effort, but also expects individual differences in this tendency, as has been observed for cognitive effort (Cacioppo et al., 1996).

Physical effort has been studied extensively in many fields, including exercise science, psychology, biomechanics, ethology, and neuroscience. Most of these studies suggest that, ceteris paribus, humans favor lower rather than higher effort (Bernacer et al., 2019; Klein-Flügge et al., 2016; Prévost et al., 2010; Skvortsova et al., 2014). Consistent with this suggestion, results robustly demonstrated that humans process physical effort as a cost in decision-making tasks and minimize the physical effort required to obtain a given reward (Bernacer et al., 2019; Klein-Flügge et al., 2016; Prévost et al., 2010; Skvortsova et al., 2014). Moreover, when exposed to visual stimuli associated with different levels of effort, they experience greater difficulty avoiding or not responding to stimuli associated with lower effort

(Cheval et al., 2020; Cheval, Cabral, et al., 2021; Cheval et al., 2018; Parma et al., 2023), supporting the idea that individuals are generally attracted toward effort minimization.

The perception of physical effort has been associated with specific brain regions, including the striatum, amygdala, supplementary motor area, and cingulate cortex (Bernacer et al., 2019; Prévost et al., 2010; Zénon et al., 2015). For example, dopamine function in the striatum and ventromedial prefrontal cortex has been shown to correlate with the willingness to exert greater effort for greater rewards (Treadway et al., 2012). Further, studies have identified differences in brain activation associated with the processing of physical effort that may underlie clinical conditions, such as behavioral apathy (Bonnelle et al., 2016; Pessiglione et al., 2018). Another study suggests that higher connectivity between the amygdala and the anterior cingulate cortex are associated with a greater ability to overcome the cost of physical effort (Bernacer et al., 2019). Collectively, this literature suggests that effort is an aversive experience, which explains the tendency to avoid unnecessary physical effort. An effort can be evaluated as unnecessary if it does not serve the pursuit of a goal, is excessive, or could be replaced by a more efficient or convenient alternative.

While physical effort has primarily been viewed as an aversive experience, some studies show that effort can also be positively valued in humans and other species (Eisenberger, 1992; Friedrich & Zentall, 2004; Gunderson et al., 2013; Inzlicht et al., 2018; Leonard et al., 2017; Lin et al., 2021; Lydall et al., 2010; Norton et al., 2012). For example, recent evidence suggests that humans can learn to value cognitive effort positively (Clay et al., 2022; Lin et al., 2021). Moreover, large individual differences have been observed in the overall tendency to avoid unnecessary physical exertion (Strasser et al., 2020; Treadway et al., 2012). Notably, while these individual differences have mostly been treated as random error variance in laboratory tasks, they may in fact be critical in explaining the self-regulation of effort-based behaviors, of which physical activity is the archetype (Maltagliati et al., 2022). For example, people with a strong tendency to approach physical effort may find it easier to follow through on their intentions to be physically active than people with a strong tendency to avoid physical effort. While previous studies showed large individual differences in the processing of physical effort, no scale has been developed to capture these differences.

The present research

Despite its importance, research on the influence of individual differences in the valuation of physical effort on physical activity self-regulation is currently limited. This limitation is mainly due to the lack of an available instrument to measure these differences. Thus, the development of a short and easy-to-use scale that captures individual differences in the general tendencies to approach and avoid physical effort is warranted. The objective of the present study was to design, develop, and validate such a scale.

The present research included two phases and three studies: Scale development (Study 1) and scale validation (Study 2 and 3). The scale development phase included the following steps: Domain identification, comparison with existing scales, content validity of the developed items, and cognitive interviews to refine the items. The scale validation phase included the following steps: Structural validity, internal validity, concurrent validity, convergent validity, discriminant validity, and test-retest reliability. The studies were approved by the Ethics Committee of the Canton of Geneva, Switzerland (CCER2019-00065) and the Research Ethics Board of the University of Ottawa, Canada (H-07-22-8284).

Study 1: Item and Scale Development

The first study was designed to develop and select an initial pool of items targeting the domain of interest through expert evaluation and cognitive interviews.

Methods

Consistent with previous recommendations (Boateng et al., 2018), we first conducted a literature review to delineate the construct of interest and confirmed that there were no existing scales that adequately captured this construct. Next, we developed an initial item pool under the supervision of a psychometric expert (DSC). A panel of four experts in exercise sciences and in the psychology, physiology, or neuroscience of exercise, who are the authors of this article, reviewed the items. To assess content validity, defined as “the adequacy with which a measure assesses the domain of interest” (Hinkin, 1995), each item was evaluated by nine additional experts who were not authors of the study. These nine external experts rated the relevance, clarity, and essentiality of the items. To rate item relevance, the experts used the following scale: 1 = not relevant; 2 = somewhat relevant; 3 = very relevant. To assess wording clarity, they used the following scale: 1 = not clear; 2 = item needs some revision; 3 = very clear. To assess essentiality (i.e., how necessary the question is), the experts used the following scale: 1 = not essential; 2 = useful but not essential; 3 = essential. Finally, for each item, the experts could add any recommendations for improvement.

After this phase, cognitive interviews were conducted with 10 participants from the target population who were fluent in English (7 females and 3 males, 5 graduate students and 1 professor at the University of Ottawa, 1 senior researcher at the Ottawa Bruyère Research Institute, and 3 adults working outside academia). During these cognitive interviews, respondents first completed the questionnaire (approximately 5 minutes). During the completion of the questionnaire, the experimenter was quiet and discreetly checked if some items took longer to answer than others, which was not the case. The experimenter then asked the respondent to rate whether each item was clear and easy to answer, and if they had any recommendations for improvement. Each item was then carefully reviewed by a third experimenter and, if necessary, modified according to the respondents’ suggestions.

Results

Domain identification

Based on the existing literature and two online meetings between the authors, we formally defined the concept of "perception of physical effort", which we aimed to capture as the conscious sensation experienced during the performance of a physically active behavior. We then concluded that we wanted to develop a scale that would capture individual differences in the tendencies to approach and avoid physical effort, i.e., a propensity to perceive physical effort as aversive and thus tend to avoid situations evaluated as physically effortful, or a propensity to perceive physical effort as positive and thus to tend to approach these situations.

We identified several existing scales and questionnaires related to the measurement of approach and avoidance tendencies and to the processing of physical or cognitive effort. Specifically, we identified instruments that assess approach and avoidance tendencies in a general context [e.g., the Approach-Avoidance Temperament Questionnaire (ATQ) (Elliot & Thrash, 2010), the Behavioral Inhibition System / Behavioral Activation System (BIS/BAS) Scales (Carver & White, 1994), and the Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ) (Corr & Cooper, 2016)] and in specific contexts [e.g., the Approach and Avoidance of Alcohol Questionnaire (AAAG) (Levine et al., 2019), the Food Approach and Avoidance Questionnaire (FAAQ) (Rancourt et al., 2019)]. Regarding the measure of effort, we identified the Need for Cognition Scale (Cacioppo & Petty, 1982; Cacioppo et al., 1996), the Mental Effort Tolerance Questionnaire (METQ) (Dornic et al., 1991), and the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) (Ekkekakis et al., 2005), which are instruments capturing individual differences in the processing of physical or mental effort. Collectively, these scales and questionnaires confirm the relevance of capturing approach and avoidance tendencies as they reflect fundamental features of human behavioral regulation (Carver, 2006; Davidson, 1998), and suggest that individual differences in effort processing could explain the self-regulation of physically effortful behaviors (Cheval & Boisgontier, 2021; Inzlicht et al., 2018).

While we were conducting this study, two additional scales were developed to capture individual differences in the valuation of effort, namely the Meaningfulness of Effort Scale (MES) (Campbell et al., 2022) and the Value of Physical Effort scale (VoPE) (Bieleke et al., 2023), which are currently available as non-peer-reviewed preprinted manuscripts. Although related, the concepts addressed by these scales differ from those of the Physical Effort Scale (PES) presented in this article. The PES assesses the approach and avoidance dimensions of physical effort in general, whereas the MES is designed to capture the extent to which effort can be a source of meaning in a person's life (e.g., "Pushing myself helps me see the bigger picture") and the VoPE focuses on sport rather than movement-based behavior in general (e.g., "I prefer physically effortful sports activities to those that can be done without much effort"). Accordingly, the PES captures a unique mechanism related to the processing of physical effort. The recent development of these new scales further demonstrates the growing interest in effort perception.

Initial pool of items

Based on the domain identification procedure, we generated 57 items to measure the tendency to approach or avoid physical effort. The four experts who are the authors of this article reviewed the items and retained 44 of them. Then, after discussing the recommendations for improvement, we dropped 26 items that were not sufficiently clear, relevant, or essential according to the nine external experts, resulting in an initial questionnaire of 18 items (9 items for the approach dimension and 9 items for the avoidance dimension).

Cognitive interviews

Since the suggestions for improvement from the 10 interviewed respondents were minor and easily incorporated into the modified version of the items, the 18-item format of the questionnaire developed during the content validity phase was retained.

Interim discussion

In Study 1, after a domain identification procedure, item generation, and item reduction, we obtained an 18-item version of the scale that covered the tendency to approach physical effort and the tendency to avoid physical effort.

Study 2: Initial Scale Validation

The second study was designed to examine the structural validity, preliminary construct validity, and reliability of the scale. In terms of structural validity, and based on the domain identified in Study 1, we hypothesized that two dimensions would emerge: The tendency to approach physical effort and the tendency to avoid physical effort. In terms of preliminary construct validity, we hypothesized that participants' usual level of physical activity would be positively associated with the tendency to approach physical effort and negatively associated with the tendency to avoid physical effort.

Methods

Participants and procedure

Participants were recruited from the University of Ottawa's research participation pool of students who were offered partial course credit in exchange for their participation in the studies. Participants were screened on the platform to ensure that they reported sufficient English language proficiency. All participants followed the procedure online and were asked to complete the study on a computer in a quiet environment.

According to recommendations (Terwee et al., 2007), a study sample of at least 180 participants was required to examine the structure and reliability of a scale of 18 items (number of items × 10), which was the number of items retained after Study 1. Respondents were excluded if they were under 18 years of age or not fluent in English. Principal component analysis, exploratory factor analyses, item response theory, and confirmatory analyses were used to validate the structure of the scale. Internal consistency and preliminary construct validity were then estimated.

Measures

Participants completed the 18 items from Study 1 and a questionnaire measuring their usual level of physical activity.

Physical effort. Physical effort was assessed using the 18-item version of the PES. Participants were instructed to indicate their level of agreement with each item on a Likert scale anchored with (1) I completely disagree, (2) I disagree, (3) I neither agree nor disagree, (4) I agree, (5) I completely agree. The 18-item version of the PES takes approximately 5 minutes to complete.

Preliminary construct validity. To assess the preliminary construct validity of the scale, we measured usual level of physical activity using the Saltin-Grimby Physical Activity Level Scale (SGPALS) (Grimby et al., 2015). Participants were asked to answer the following question: “How much do you move and exert yourself physically during your leisure time? If your activity varies greatly from week to week, try to estimate an average. The question refers to the past year.” Participants were instructed to choose an answer between “Physically inactive” (level 1), “Some light physical activity” (level 2), “Regular physical activity” (level 3) and “Regular hard physical training for competitive sports” (level 4).

Data analyses

Dimensional structure was first examined using principal component analysis on the 18-item version of the scale. Items were then reduced using item response theory analyses. Confirmatory factor analysis was conducted on an 8-item shortened version of the scale (see details below). The content validity of this shortened scale was assessed by the four experts who are authors of this article to verify that the items still covered the relevant dimensions, and the global reliability of each subscale (i.e., approach and avoidance tendencies toward physical effort) was assessed using Cronbach’s alpha. Finally, the preliminary construct validity of the

8-item version of the physical effort scale was assessed using multiple linear regression analyses. All analyses were conducted using R version 4.3.1 (R Core Team, 2022).

Data and code sharing

In accordance with good research practices (Boisgontier, 2022), the data and code are publicly available: https://zenodo.org/uploads/8358572

Results

Descriptive statistics. A total of 680 English-speaking undergraduate students at the University of Ottawa completed the questionnaire in exchange for course credit. The students were from the Faculty of Social Sciences (161, 24%), Faculty of Health Sciences (157, 23%), Telfer School of Management (149, 22%), Faculty of Science (131, 19%), Faculty of Arts (52, 8%), Faculty of Engineering (28, 4%), and Faculty of Medicine (n = 1). One student did not specify their faculty. 85% of the students were in the first year or second year of their program. Participants had a mean age of 19.1 ± 2.2 years, and 69% (472) were female. Based on the SGPALS (Grimby et al., 2015), participants self-reported being inactive (n = 143, 21%) or engaging in light (n = 232, 34%), moderate (n = 192, 28%), or vigorous physical activity (n = 113, 17%). The mean approach and avoidance tendency toward physical effort was of 3.45 ± 0.92 and 2.46 ± 1.00, respectively (Table 1).

Table 1. *Descriptive statistics*

		Study 2	**Study 3**
Characteristics	**Categories**	**n (%)**	**n (%)**
Sex	Female	472 (69.5)	210 (70.7)
	Male	200 (29.5)	79 (26.6)
	Prefer not to disclose	4 (0.6)	3 (1.0)
	These options do not apply to me	4 (0.4)	5 (1.7)
Age		19.1 (2.2)	20.3 (3.5)
Faculty or School	Social Sciences	161 (23.7)	64 (21.5)
	Health Sciences	157 (23.1)	77 (25.9)
	School of Management	149 (21.9)	22 (7.4)
	Science	131 (19.3)	88 (29.6)

	Arts	52 (7.7)	21 (7.1)
	Engineering	28 (4.1)	20 (6.7)
	Medicine	1 (0.15)	3 (1.0)
	Education	-	1 (0.3)
	Not reported	1 (0.15)	1 (0.3)
Program year	1st	388 (57.1)	88 (29.6)
	2nd	190 (27.9)	75 (25.3)
	3rd	52 (7.6)	71 (23.9)
	4th	34 (5.0)	55 (18.5)
	5th	13 (1.9)	4 (1.3)
	Other	3 (0.4)	4 (1.3)
Usual physical activity level (SGPALS)	Inactive	143 (21.0)	54 (18.1)
	Light physical activity	232 (34.1)	98 (33.0)
	Moderate physical activity	192 (28.3)	102 (34.3)
	Vigorous physical activity	113 (16.6)	40 (13.5)
Score, mean (SD)	Approach to physical effort	3.45 (0.92)	3.59 (0.88)
	Avoid to physical effort	2.46 (1.00)	2.48 (0.99)

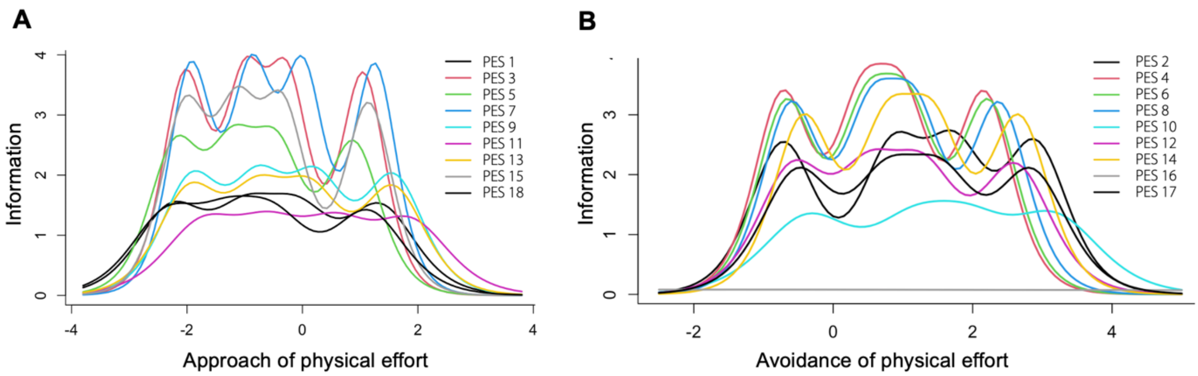
Notes. PA = physical activity. The usual level of physical activity was assessed using the Saltin-Grimby Physical Activity Level Scale (SGPALS) (Grimby et al., 2015). Scores from the approach and avoidance tendencies toward effort were based on the 8-item scale.

Structure of the instrument. The results of the principal component analysis conducted on the 18 items suggested a 3-component solution based on eigenvalues greater than 1, while the scree plot favored a 1-factor solution. Since the theoretical model suggested 2 factors, we conducted three subsequent factor analyses with 1, 2, and 3 factor solutions. The results of the 3-factor analysis showed that one item (item 10) loaded on a factor, while the results of the 1-factor analysis clearly showed that the items theoretically related to the approach dimension loaded positively on this factor and that the items theoretically related to the avoid dimension loaded negatively on this factor. Moreover, the 2-factor analysis showed that the 9 items related to the approach dimension loaded on factor 1 (> 0.639) and that 8 items related to the approach dimension loaded on factor 2 (> 0.603). Only one item (item 16) had a low loading on factor 2 (0.318) (Table 2).

Item response theory analyses for each scale separately showed that items 1, 5, 9, 11, and 13 for the approach dimension, and items 2, 8, 10, 14, and 16 for the avoidance dimension could be dropped because their information functions were low, suggesting that they were not very informative, and/or because their item difficulties were redundant with other items (Figure 1). Four items were thus retained per dimension: Items 3, 7, 15, and 18 for the approach dimension, and items 4, 6, 12, and 17 for the avoidance dimension (Table 2).

A principal component analysis of the selected 8 items showed that the first two components explained 68.7% of the variance. The 8-item PES retained good content validity covering both the orientation (i.e., approach vs. avoidance) and the affective aspects (i.e., negative vs. positive affect) of the processing of physical effort. Reliability was good for both dimensions, with a Cronbach's alpha coefficient of 0.897 for the approach dimension and 0.913 for the avoidance dimension.

Figure 1. *Item information curves for the 18 items resulting from the item and scale development process (Study 1), presented by subscale.*



Notes. Subscale numbers correspond to the item numbers in Table 2.

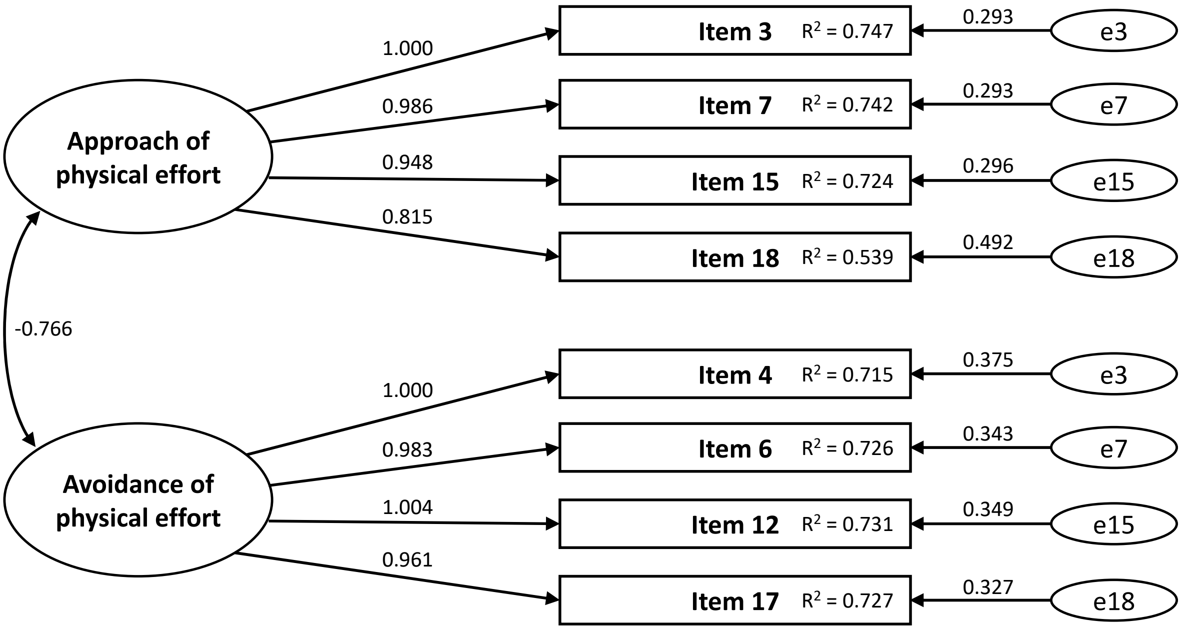
Table 2. *Factor loading of the 18 items resulting from the item and scale development process,*

Items	Factor 1 Approach of physical effort	Factor 2 Avoidance of physical effort
1. I tend to engage in tasks that require physical effort.	0.661	-0.148
2. I generally avoid situations that involve physical effort.	-0.172	0.724
3. I usually like activities that require physical effort.	0.801	
4. I tend to avoid situations in which I have to exert physical effort.		0.852
5. I usually find satisfaction in exerting physical effort.	0.752	
6. I tend to stay away from tasks that require physical effort.		0.841
7. The idea of exerting physical effort usually appeals to me.	0.851	
8. I tend to avoid tasks that require physical effort.		0.880
9. I usually like to engage in physical effort even if there are other possibilities.	0.832	
10. I generally do not find any satisfaction when I make a physical effort.	-0.137	0.603
11. I tend to search for opportunities to exert physical effort.	0.856	0.130
12. Exerting physical effort does not appeal to me.	-0.237	0.654
13. I tend to engage in situations in which I have to exert physical effort.	0.779	
14. When I have to engage in a physical effort, I usually seek to avoid it.		0.843
15. I generally enjoy activities that involve physical effort.	0.753	-0.103
16. I usually exert physical effort when there is no other alternative.		0.318
17. I usually dislike activities that involve physical effort.	-0.154	0.705
18. I am usually willing to engage in activities that involve physical effort.	0.639	

Notes. Promax rotation was used for the factor analysis. The number preceding each item indicates its position in the scale. Loadings below 0.1 in absolute value were not included in the table. Items selected for the final PES are in bold.

To further assess the structural validity of the 8-item PES, a confirmatory factor analysis was conducted using the `sem` function of the `lavaan` R package (Rosseel, 2012). Results showed that the hypothesized 2-factors structure fit the data adequately, yielding Chi^2 (19) = 56.0, $p < 0.001$, CFI = 0.990, TLI = 0.986, SRMR = 0.017, RMSEA = 0.055 (90% confidence interval [90CI] = 0.039 – 0.073; $p \leq 0.05 = 0.274$). The factor loading, variance, and R^2 are presented in Figure 2. Loadings were very similar across items, supporting the possibility of averaging items to obtain scale scores. The approach tendency toward physical effort was significantly and negatively correlated with the avoidance tendency toward physical effort ($r = -0.77$; $p < 0.001$).

Figure 2. *Results of the confirmatory factor analysis of the 8-item physical effort scale (PES) for Study 2 (n = 680)*



Notes. R^2 = percentage of variance explained; e = error variances

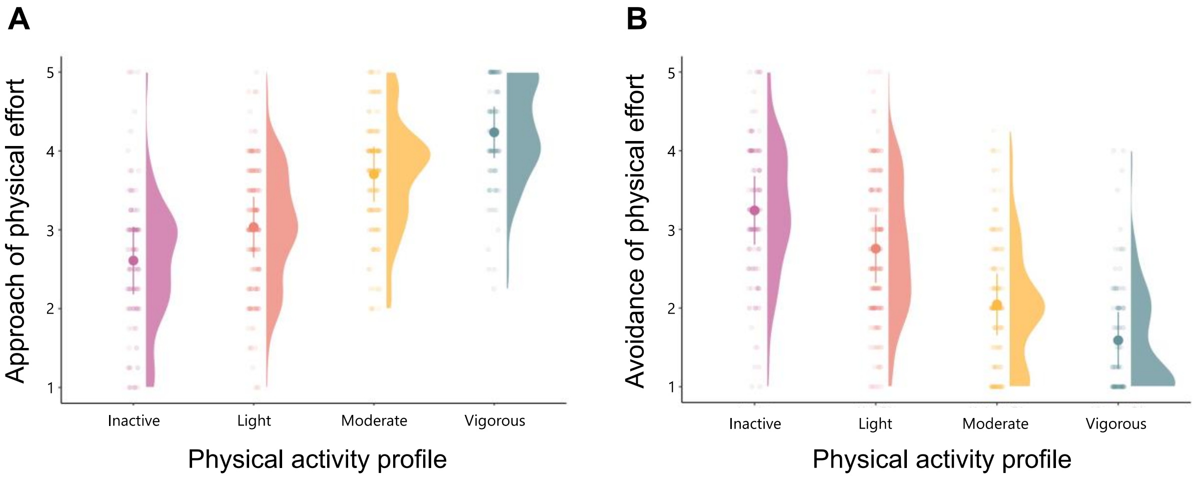
Preliminary construct validity. The results of the multiple linear regression analyses showed that participants' usual level of physical activity was associated with both approach and avoidance tendency toward physical effort (*p* for global effect < 0.001 for both approach and avoidance tendency) (Table 3). Specifically, approach tendency toward physical effort increased with increasing levels of physical activity, whereas the avoidance tendency toward physical effort decreased with increasing levels of physical activity (Figure 3). The percentage of variance explained was of 35.9% and 32.8% for approach and avoidance tendencies toward physical effort, respectively.

Table 3. *Results of the multiple linear regression testing the association of the physical activity levels with approach and avoidance tendencies toward physical effort.*

Outcomes	**Approach physical effort**		**Avoid physical effort**	
	b (95% CI)	*p*	b (95% CI)	*p*
Intercept	2.70 (2.57; 2.82)	< 0.001	3.24 (3.10; 3.38)	< 0.001
Usual level of physical activity (inactive ref.)				
Light physical activity	0.47 (0.31; 0.73)	< 0.001	-0.49 (-0.66; -0.30)	< 0.001
Moderate physical activity	1.15 (0.98; 1.31)	< 0.001	-1.20 (-1.38; -1.01)	< 0.001
Vigorous physical activity	1.59 (1.40; 1.78)	< 0.001	-1.65 (-1.86; -1.44)	< 0.001
Adjusted R^2	0.359		0.328	

Note. 95% CI = 95% confidence interval.

Figure 3. *Association between approach (A) and avoidance tendencies toward physical effort (B) and the usual level of physical activity.*



Note. Physical activity profile was assessed using Saltin-Grimby Physical Activity Level Scale (SGPALS).

Interim discussion

In Study 2, we found evidence for structural validity and reliability of an 8-item version of the PES. We also showed that both the approach and avoidance scores on this scale explain usual levels of physical activity as measured by the SGPALS, providing preliminary evidence of construct validity.

Study 3: Final Scale Validation

This third study was designed to confirm the structural validity and the reliability of the 8-item version of the PES, to further examine its construct validity (i.e., concurrent, convergent, discriminant), and to assess its test-retest reliability.

In terms of structural validity, we hypothesized that the two dimensions theoretically identified in Study 1 and empirically found in Study 2 (i.e., the tendency to approach and the tendency to avoid physical effort) would also be observed in Study 3. In terms of construct validity, our hypotheses were as follows:

First, for concurrent validity, we hypothesized that a higher usual level of physical activity would be associated with a higher tendency to approach physical effort and a lower tendency to avoid physical effort. Moreover, we hypothesized that both dimensions of the PES (i.e., avoidance and approach) would explain additional variance in usual level of moderate-to-vigorous physical activity (MVPA) and time spent sitting after accounting for the variance explained by the other constructs (i.e., age, gender, attitudes, behavioral intentions, self-efficacy). This hypothesis is based on TEMPA (Cheval & Boisgontier, 2021), which suggests that individual differences in the processing of physical effort may play a critical role in the self-regulation of physical activity behavior.

Second, for concurrent and convergent validity, we hypothesized that a higher tendency to approach physical effort would be associated with autonomous motivation, positive affective attitudes, higher self-efficacy, higher intentions to engage in physical activity, and higher exercise automaticity, whereas a higher tendency to avoid physical effort would show the opposite pattern. The first hypothesized association is consistent with the findings of Bieleke et al. (2023), who demonstrated positive associations between a higher value of physical effort and both physical activity behavior and intrinsic motivation. For the remaining associations, our hypotheses are based primarily on indirect empirical evidence: The positive correlations found between usual physical activity behaviors and self-efficacy, intentions, affective attitudes, and automaticity (Hagger et al., 2002; Maltagliati et al., 2023; Rhodes et al., 2009).

Third, for discriminant validity, we hypothesized moderate correlations of the PES (i.e., both approach and avoidance dimensions) with controlled motivation, instrumental attitudes, general approach-avoidance temperament, and the tendency to engage in cognitive effort. The Approach-Avoidance Temperament Questionnaire (ATQ) (Elliot & Thrash, 2010) was used to test whether the PES is distinct from general approach-avoidance tendencies. The Need for Cognition Scale (Cacioppo & Petty, 1982; Cacioppo et al., 1996) was used to test whether the PES is distinct from a measure of cognitive effort, ensuring that the PES targets a construct that differs from a general effort processing. The hypothesized moderate correlation between the PES and the tendency to engage in cognitive effort is consistent with recent findings showing a dissociation between the valuation of physical and mental effort (Wolff et al., 2023). Similarly, the PES aims to capture specific tendencies to approach and avoid physical effort, rather than a broader approach or avoidance tendency that generalizes across domains. Accordingly, from a theoretical perspective, it is crucial to make this distinction between the approach-avoidance dimensions of the PES and a general approach-avoidance tendency in order to ensure the specificity of the scale to the domain of physical effort. The hypothesized moderate correlations with controlled motivation and instrumental attitudes were also based on indirect empirical evidence showing associations between these variables and physical activity behavior (Hagger et al., 2002).

Fourth, for test-retest reliability, we hypothesized satisfactory test-retest agreement, given that the tendency to approach and avoid physical effort are conceptualized as rather stable individual differences.

Methods

Participants and procedure

The recruitment procedure was identical to Study 2, except that to assess test-retest reliability, respondents from Study 3 were asked if they would be willing to complete a short (approximately 5 minutes) questionnaire again one week later.

Measures

Participants completed the 8-item version of the PES and several questionnaires to assess construct validity.

Physical effort: Physical effort was assessed using the 8-item version of the PES. Participants are instructed to indicate their level of agreement with each item on a Likert scale anchored with (1) I completely disagree, (2) I disagree, (3) I neither agree nor disagree, (4) I agree, (5) I completely agree. The 8-item version of the PES takes approximately 2 minutes. The 8-item version of the PES takes approximately 2 minutes to complete. The PES and its manual are available in the Supplementary Material.

***Concurrent validity*:** Usual level of physical activity including moderate physical activity, vigorous physical activity, walking time, and sitting time, was measured by the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003).

***Convergent validity*:** For convergent validity, the following variables were used: Autonomous motivation for physical activity (Brunet et al., 2015; Maltagliati et al., 2021; Sheldon & Elliot, 1998), automaticity toward physical activity (Gardner et al., 2012), affective attitudes toward physical activity (Ekkekakis et al., 2021), and self-efficacy toward physical activity (Ajzen, 1991).

***Discriminant validity*:** For discimrinant validity, the following variables were used: Controlled motivation for physical activity (Brunet et al., 2015; Maltagliati et al., 2021; Sheldon & Elliot, 1998), instrumental attitudes toward physical activity (Ajzen, 1991), approach-avoidance temperament (Elliot & Thrash, 2010), and the need for cognition (Cacioppo & Petty, 1982; Cacioppo et al., 1996).

Data analyses

The dimensional structure was tested using a confirmatory factor analysis. Global reliability of each subscale was assessed using Cronbach's alpha. Similarity of scores between the baseline survey and the one-week retest was assessed using the weighted kappa statistic for items and the intraclass coefficient of correlation for subscale scores. Construct validity (i.e., concurrent, convergent, and discriminant validity) was assessed using univariate and hierarchical regression analyses.

Results

Descriptive statistics. A total of 297 English-speaking undergraduate students from the University of Ottawa completed the questionnaire in exchange for course credit. The students came from the Faculty of Sciences (n = 88, 30%), Faculty of Health Sciences (n = 77, 26%), Faculty of Social Sciences (64, 21%), Telfer School of Management (n = 22, 7%), Faculty of Arts (n = 21, 7%), Faculty of Engineering (n = 20, 7%), Faculty of Medicine (n = 3, 1%), and Faculty of Education (n = 1). One student did not specify their faculty. Students were in the first (n = 88, 29.6%), second (n = 75, 25%), third (n = 71, 24%), fourth (n = 55, 18%), or fifth (n = 4, 1%) year of their program. Four participants (1%) were in another situation. The mean age of the participants was 20.3 $\pm$ 3.5 years and 71% (n = 210) were female. Based on the SGPALS, participants self-reported being inactive (n = 54, 18%) or engaging in light (n = 98, 33%), moderate (n = 102, 34%), or vigorous physical activity (n = 40, 13%). Three participants did not report their level of physical activity. The mean approach tendency toward effort was 3.59 $\pm$ 0.88, while the mean avoidance tendency toward effort was 2.48 $\pm$ 0.99 (Table 1).

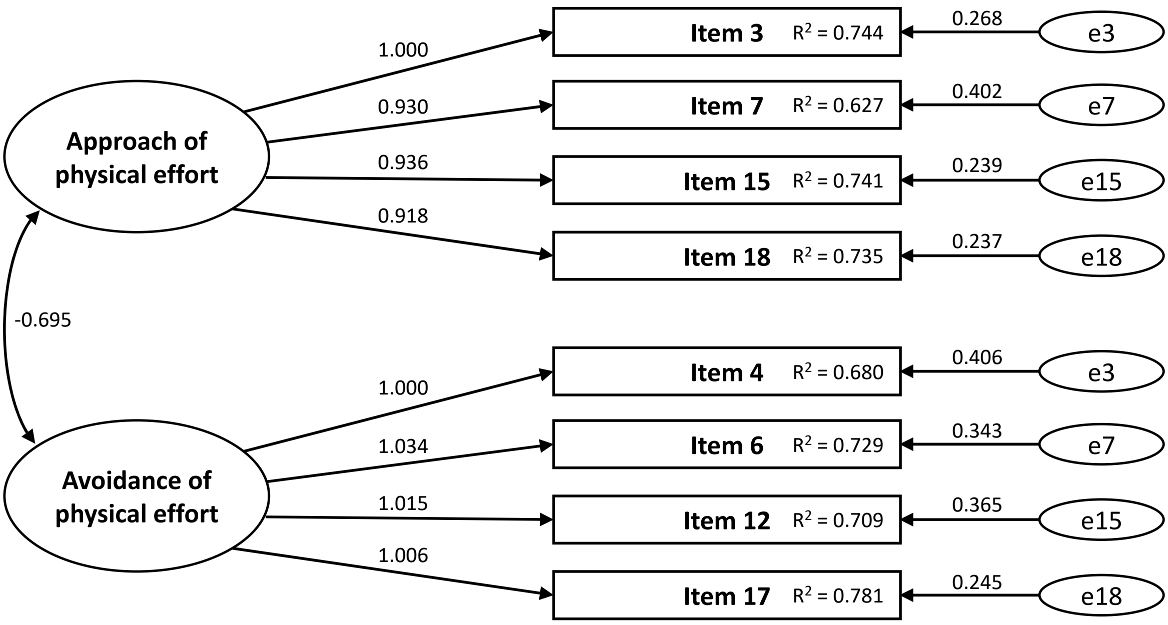
Table 4. *Dimensions and items of the 8-item Physical Effort Scale (PES)*

Dimension	**Item**
Approach of physical effort	3. I usually like activities that require physical effort. 7. The idea of exerting physical effort usually appeals to me. 15. I generally enjoy activities that involve physical effort. 18. I am usually willing to engage in activities that involve physical effort.

Avoidance of physical effort	4. I tend to avoid situations in which I have to exert physical effort. 6. I tend to stay away from tasks that require physical effort. 12. Exerting physical effort does not appeal to me. 17. I usually dislike activities that involve physical effort.

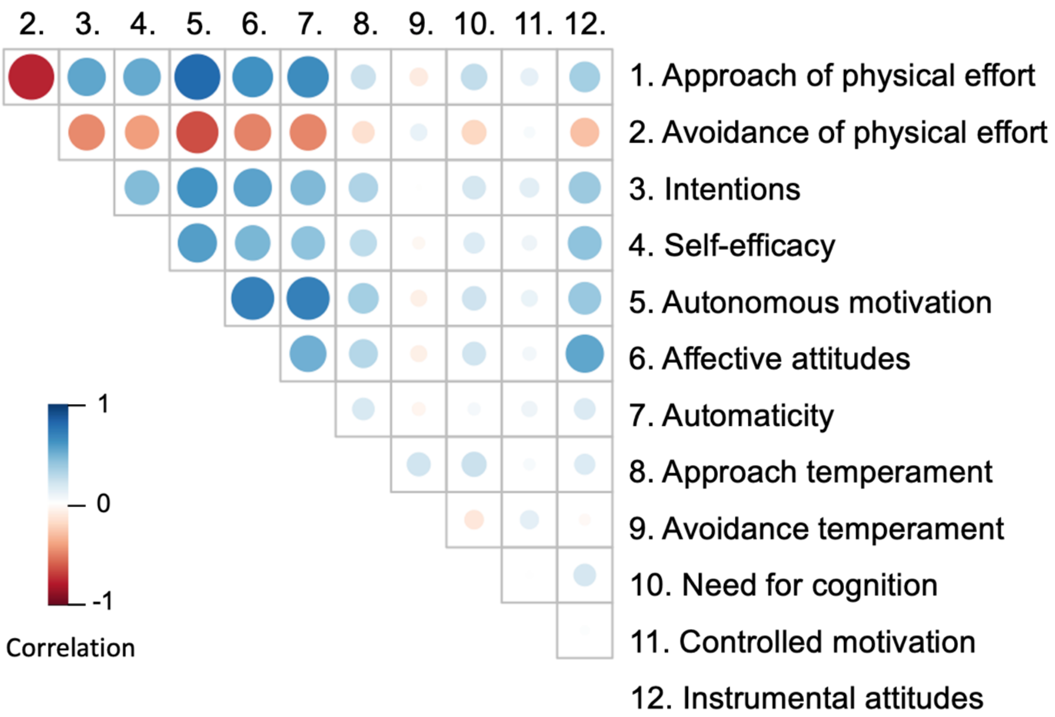
Structure validation. To assess the structural validity of the 8-item PES (Table 4), another confirmatory factor analysis was conducted using the `sem` function of the `lavaan` R package (Rosseel, 2012). The results showed that the hypothesized 2-factor structure fitted the data adequately, with Chi^2 (19) = 76.506, p < 0.001, CFI = 0.970, TLI = 0.955, SRMR = 0.027, although RMSEA = 0.101 (90CI = 0.078 – 0.125, $p \geq 0.08$ = 0.934). Reliabilities of both dimensions were good, with Cronbach's alpha coefficients of 0.907 for the approach dimension and 0.913 for the avoidance dimension.

Figure 4. *Results of the confirmatory factor analysis of the 8-item Physical Effort Scale (PES) for Study 3 (n = 297)*



Notes. R^2 = percentage of variance explained; e = error variances

Figure 5. Illustration of the correlation between the approach and avoidance dimension of physical effort and the other assessed variables.



Notes. Correlation coefficients are represented as colored circles, with the bluer and larger circles indicating the coefficients were closer to +1, the redder and larger circles indicating the coefficients were closer to -1, and the whiter and smaller circles indicating a coefficient closer to 0.

Construct validity. Table 5 shows the associations between the approach and avoidance dimension of the PES and other variables to assess concurrent (usual level of physical activity as measured by the IPAQ), convergent (autonomous motivation, affective attitudes, self-efficacy, intentions), and discriminant validity (controlled motivation, instrumental attitudes, general approach-avoidance temperament, and the tendency to engage in cognitive effort). The associations were tested using univariate linear regressions and all the variables were scaled (i.e., mean of 0 and standard deviation of 1) to obtain standardized coefficients. As expected, the approach and avoidance dimensions of the PES were correlated with the usual level of physical activity and sitting time, supporting the concurrent validity of the scale. In addition, they had correlations ranging from 0.50 to 0.77 with autonomous motivation, affective attitudes, automaticity, and self-efficacy, demonstrating convergent validity. Finally, the approach and avoidance dimensions of the PES showed correlations ranging from 0.10 to 0.33 with controlled motivation, instrumental attitudes, approach-avoidance temperament, and need for cognition, confirming its discriminant validity. Overall, the PES demonstrated concurrent, convergent, and discriminant validity.

Table 5. *Concurrent, convergent, and discriminant validity of the approach and avoidance tendencies toward physical effort.*

	Approach of physical effort			**Avoidance of physical effort**		
	N	**β**	***p***	**N**	**β**	***p***
Concurrent validity						
Usual level of PA						
MVPA	296	0.29	<.001	296	-0.18	.002
Moderate PA	296	0.20	<.001	296	-0.13	.029
Vigorous PA	296	0.32	<.001	296	-0.20	<.001
Walking	296	-0.004	.945	296	-0.001	.984
Sitting	296	-0.26	<.001	296	0.25	<.001
Convergent validity						
Autonomous motivation	296	0.77	<.001	296	-0.64	<.001
Affective attitudes	295	0.61	<.001	295	-0.49	<.001
Self-efficacy	295	0.50	<.001	295	-0.41	<.001
Intentions	294	0.52	<.001	294	-0.47	<.001
Automaticity	294	0.61	<.001	294	0.48	<.001
Discriminant validity						
Controlled motivation	296	0.10	.091	296	0.03	.579
Instrumental attitudes	295	0.33	<.001	295	-0.29	<.001
Approach temperament	296	0.21	<.001	296	-0.16	.006
Avoidance temperament	296	-0.11	.059	296	0.10	.093
Need for cognition	296	0.24	<.001	296	-0.23	<.001

Notes. Usual level of PA = Physical activity as assessed by the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003); MVPA = usual level of moderate-to-vigorous physical activity. Univariate linear regressions were used to assess the associations. All the variables were scaled to obtain standardized coefficients.

Table 6 presents the results of the hierarchical regression analyses that explained MVPA. In Step 1, age, gender, instrumental attitudes, self-efficacy, and intentions were entered. In this model, gender (β = 0.29, $p = 0.023$) and intentions (β = 0.29, $p < 0.001$) were significantly associated with MVPA, explaining 11.0% of the variance in MVPA. In Step 2, approach of physical effort only, avoidance of physical effort only, and both approach and avoidance of physical effort were entered. Results showed that both approach or avoidance tendency toward physical effort were positively (β = 0.16, $p = 0.029$) and negatively (β = -0.16, $p = 0.022$) associated with MVPA, respectively. The model including the approach tendency explained 12.1% (i.e., an increase of 1.1%) of the variance in MVPA, and the model including the avoidance tendency explained 12.2% of the variance (i.e., an increase of 1.2%). In these models, intentions remained significantly associated with MVPA and the effect of gender became marginal (*ps* < 0.058). In the model that included both approach and avoidance tendencies, the associations between these tendencies and MVPA time became non-significant.

Table 6. *Results of the hierarchical regression analyses for explaining the usual level of MVPA.*

	Baseline		***Approach only***		***Avoidance only***		***Both tendencies***	
	β	***P***	**β**	***P***	**β**	***P***	**β**	***P***
Dependent variable: MVPA								
Step 1								
Age	0.06	0.262	0.06	0.32	0.05	0.362	0.05	0.357
Gender (ref. women)								
Men	0.29	0.023	0.25	0.058	0.25	0.051	0.24	0.064
Intention	0.29	< 0.001	0.23	< 0.001	0.23	< 0.001	0.22	0.002
Instrumental attitudes	-0.03	0.628	-0.04	0.556	-0.04	0.556	-0.04	0.544
Self-efficacy	0.07	0.306	0.01	0.840	0.01	0.03	0.01	0.544
Step 2								
Approach			0.16	0.029			0.08	0.380
Avoidance					-0.16	0.022	-0.09	0.298
$\mathbf{R^2}$								
Adjusted R^2	0.108		0.121		0.122		0.121	

Notes. MVPA = usual level of moderate-to-vigorous physical activity. Multiple linear regressions were used to assess the associations. All the variables were scaled to obtain standardized coefficients.

We repeated the same analyses as in the previous section with usual sitting time replacing MVPA as the dependent variable (Table 7). In the model without approach and avoidance tendencies, intentions were significantly associated with usual sitting time ($\beta = -0.23$, $p < 0.001$). This model explained 4.8% of the variance in usual sitting time. In the models including either approach or avoidance tendencies, the latter were negatively ($\beta = -0.22$, $p = 0.003$) and positively ($\beta = 0.29$, $p = 0.006$) associated with usual sitting time, respectively. Intentions became non-significant in these models. The model including the approach tendency explained 7.5% (i.e., an increase of 2.7%) of the variance in usual sitting time, and the model including the avoidance tendency explained 7.0% of the variance (i.e., an increase of 2.2%). In the model that included both approach and avoidance tendencies, the associations between these tendencies and usual sitting time became non-significant.

Therefore, based on these results, we decided to calculate a score that captures the relative tendency to approach rather than avoid physical effort as follows: Relative tendency to approach physical effort = Averaged score for tendency to approach physical effort – Averaged score for tendency to avoid physical effort. A higher score indicates a greater tendency to approach (rather than avoid) physical effort. We ran the same regression analyses as above using the relative score instead of the approach and avoidance scores separately. Results showed that intentions ($\beta = 0.19$, $p = 0.002$) and relative tendency toward physical effort ($\beta = 0.16$, $p = 0.014$) were significantly associated with MVPA, explaining 12.4% of the variance in MVPA. We observed a similar pattern of results for time spent sitting, with intentions ($\beta = -0.14$, $p = 0.040$) and relative tendency toward physical effort ($\beta = -0.23$, $p = 0.002$) were significantly associated with time spent sitting. The model explained 7.7% of the variance in usual time spent sitting.

Table 7. *Results of the hierarchical regression analyses for explaining usual level of time spent sitting.*

	Baseline		*Approach only*		*Avoidance only*		*Both tendencies*	
	β	***P***	**β**	***P***	**β**	***P***	**β**	***P***
Dependent variable: Usual sitting time								
Step 1								
Age	-0.03	0.613	-0.02	0.731	-0.01	0.801	-0.02	0.785
Gender (ref. women)								
Men	-0.12	0.369	-0.05	0.691	-0.07	0.608	-0.05	0.715
Intention	-0.23	<0.001	-0.16	0.026	-0.16	0.021	-0.15	0.040
Instrumental attitudes	0.05	0.444	0.06	0.361	0.06	0.370	0.06	0.353
Self-efficacy	-0.05	0.462	0.02	0.586	-0.001	0.991	0.02	0.724
Step 2								
Approach			-0.22	0.003			-0.16	0.127
Avoidance					0.19	0.006	0.09	0.355
R^2								
Adjusted R^2	0.048		0.075		0.070		0.074	

Notes. Multiple linear regressions were used to assess the associations. All the variables were scaled to obtain standardized coefficients.

Test-retest reliability. The test-retest agreement was satisfactory for all items of the PES (weighted kappa range: 0.41 to 0.61, mean = 0.49). For the 4-item subscales, test-retest agreement was 0.78 (95CI: 0.72 – 0.83) for the approach physical effort dimension and 0.66 (95CI: 0.57 – 0.73) for the avoidance physical effort dimension. These results confirmed the satisfactory test-retest reliability of the PES.

Interim discussion

In Study 3, we confirmed the structural validity and reliability of the 8-item version of the PES. In addition, we demonstrated its concurrent, convergent, and discriminant validity, confirming its construct validity. Lastly, we found support for the one-week test-retest reliability of the scale.

Discussion

Based on 3 studies, we developed and validated the PES that includes 8 items and measures individual differences in approach and avoidance tendencies toward physical effort.

After item generation, content validity, and cognitive interviews for item improvement (Study 1), factor analysis conducted on a first sample (n = 680, Study 2) indicated that the two tendencies (i.e., approach and avoidance) could each be measured by 4 items. The resulting 8-item PES had very high internal consistency for both the approach (Cronbach alpha = 0.913) and avoidance dimension (Cronbach alpha = 0.897). Using a confirmatory factor analysis, the hypothesized 2-factor structure fitted the data well, confirming the structural validity of the 8-item PES. Finally, we showed that usual level of physical activity (as assessed by the SGPALS) was positively associated with the approach tendency toward physical effort, whereas it was negatively associated with the avoidance tendency, providing preliminary evidence for the construct validity of the PES. These findings were consistent with our conceptual reasoning that general tendencies to approach and to avoid physical effort could be empirically observed. They also provide initial evidence that these general tendencies toward physical effort may be involved in the self-regulation of physical activity.

In a second independent sample (n = 297, Study 3), the structural validity and the internal consistency of the PES were confirmed. In terms of construct validity, the approach dimension of the PES was positively associated with MVPA and negatively associated with usual sitting time (both assessed by the IPAQ). The avoidance dimension of the PES showed the opposite pattern of associations. These findings confirm that individual differences in the approach and avoidance tendencies toward physical effort could be involved in the self-regulation of physical activity and sedentary behavior. It should be noted, however, that the associations were of small to moderate magnitude on average ($r < 0.32$).

As hypothesized, approach and avoidance tendencies toward physical effort showed moderate to strong correlations with autonomous motivation, affective attitudes, automaticity, and self-efficacy ($rs > 0.41$ in absolute value) and small correlations with controlled motivation, instrumental attitudes, approach-avoidance temperaments, and need for cognition ($rs < 0.29$ in absolute value). These observations supported the convergent and discriminant validity of the PES. Importantly, with respect to discriminant validity, the weak correlations suggested that the PES measures a construct that is distinct from the general approach-avoidance personality traits (Carver & White, 1994; Elliot & Thrash, 2010) and general effort processing (Cacioppo & Petty, 1982; Cacioppo et al., 1996). This finding is significant because it was imperative to confirm that the scale could effectively capture a construct related to the specific processing of physical effort, rather than more global individual differences, such as the inclination to approach or avoid daily life events, or the processing of other types of effort, such as cognitive effort.

We found that both the approach and avoidance dimensions of the PES were significantly associated with MVPA (as measured by the IPAQ), after controlling for the effects of age, gender, intentions, instrumental attitudes, and self-efficacy. However, as in the univariate models, the additional variance explained was small (i.e., approximately 1%). Notably, the associations between these tendencies and MVPA became non-significant in the model that included both tendencies simultaneously. This result can be explained by the fact that the correlation between the two dimensions of the PES, although conceptually and empirically distinct, was high. We observed a similar pattern of results for sitting time: The approach tendency was negatively associated with sitting time, whereas the avoidance tendency was positively associated with sitting time, over and above the effects of age, gender, intention, self-efficacy, and instrumental attitudes. In the model including both tendencies, neither the effect of the approach dimension nor the effect of the avoidance dimension remained significant. As for MVPA, the latter result could be explained by the high correlation between the two dimensions of the PES. Future research is needed to better understand whether the two dimensions of the scale could predict different outcomes (e.g., physical activity maintenance for the approach dimension *and* physical activity initiation for the avoidance dimension).

However, from a practical standpoint, researchers interested in exploring the role of these tendencies in the self-regulation of movement-based behaviors should examine each of these tendencies separately. Alternatively, it is also possible to create a relative score based on both tendencies by subtracting the avoidance tendency score from the approach tendency score. Our results showed that this relative score was significantly related to MVPA and time spent sitting, accounting for the effect of gender, intentions, self-efficacy, and attitudes.

One-week test-retest reliability was good (intraclass correlation coefficient for the 4-item approach physical effort dimension = 0.78 and for the 4-item avoidance physical effort dimension = 0.66). These findings are consistent with our conceptualization of the approach and avoidance tendencies toward physical effort as corresponding to rather stable dispositional tendencies toward physical effort. Of note, within the TEMPA framework, the tendency to minimize effort is expected to involve both stable and labile dimensions. This malleability suggests a potential for interventions designed to help individuals develop a more positive evaluations of physical effort (Cheval, Finckh, et al., 2021) and/or to enhance their ability to overcome the perceived cost of this effort (Farajzadeh, Goubran, Fessler, et al., 2023), thereby promoting engagement in physical activity behaviors. For example, recent studies have focused on instilling the value of effort through computerized tasks that reward engagement in cognitive effort (Lin et al., 2021). Although no interventions have been developed specifically for physical effort, exploring similar interventions in this context is worthy of investigation. Importantly, such interventions may be particularly effective for individuals who tend to avoid rather than engage in physical effort. Interestingly, in the present study we found that the approach dimension was more stable than the avoidance dimension in test-retest analyses. Although this observation needs to be confirmed, it would suggest that the tendency to avoid physical effort may be more labile and sensitive to situational changes than the tendency to approach physical effort. Future studies should examine whether the approach and avoidance tendencies respond differently to changes in individual situational states such as fatigue, stress, or a lack of available cognitive resources.

Lastly, descriptive results showed that, on average, participants reported a higher tendency to approach physical effort, as indicated by a score above the midpoint of the 1-5 scale (3.45 and 3.59 in Study 2 and Study 3, respectively), than to avoid physical effort (2.46 and 2.48 in Study 2 and Study 3, respectively). At first glance, this finding may seem inconsistent with the current literature in neuroscience and psychology, which has robustly demonstrated that humans tend to avoid physical effort (Bernacer et al., 2019; Cheval & Boisgontier, 2021; Klein-Flügge et al., 2016; Prévost et al., 2010; Skvortsova et al., 2014). Yet, this gap can be explained by the well-known limitations associated with self-report measures, which can lead to inaccuracies in measuring the true value of physical effort in real-life situations due to processes such as social desirability bias or inability to self-evaluate. Future studies may include a social desirability scale to assess the extent to which scores on this scale may moderate responses on the PES. For example, it might be expected that individuals higher on social desirability would overestimate their tendency to approach physical exertion and underestimate their tendency to avoid it. These findings may also be influenced by the characteristics of our sample, which tends to be young, well-educated, and healthy. Nonetheless, what seems critical here is not to be able to determine whether, on average, participants were more inclined to approach or avoid physical effort, but to capture individual differences in these tendencies and to determine whether these differences can explain behavioral observations regarding decision-making processes related to effortful behaviors. Consistent with this reasoning, we found that participants showed some variability in their responses, with a standard deviation slightly below 1 for both dimensions, and with scores that ranged across the possible values of PES (i.e., from 1 to 5) – although fewer participants scored 4 and 5 for the tendency to avoid physical effort. This large interindividual variability is consistent with the existing literature, which reports such individual differences in the tendency to avoid physical effort (Strasser et al., 2020; Treadway et al., 2012).

In contrast to the VoPE scale (Bieleke et al., 2023), which focuses on specific activities, our scale aims to capture individual differences in the processing of physical effort in general. This approach is consistent with TEMPA (Cheval & Boisgontier, 2021), which posits an innate tendency to minimize effort while recognizing that individual differences in approaching or overcoming this general tendency significantly influence one's engagement in physical activity. However, it is important to acknowledge the influence of context on the perception of physical effort. For example, engaging in sports activities with children may be perceived as more positive and less effortful than activities such as running on a treadmill. While the PES aligns well with TEMPA, it is important to emphasize that its focus on a general tendency to process physical exertion may mask nuanced, context-specific perceptions. Thus, depending on the theoretical framework, researchers may choose to capture a general tendency to process physical effort in order to predict broad movement-based behavior patterns. Conversely, they may prefer to focus on how individuals perceive the effort associated with specific activities in order to predict behavior within those specific contexts.

Limitations and Strengths

The current study has several limitations. First, we used self-reported data to measure physical activity behaviors, which may provide an inaccurate estimate of participants' actual physical activity levels. Second, the characteristics of the sample, which consisted mostly of young, healthy, and well-educated adults, limit the generalizability of the current findings to other populations, such as clinical populations or older adults, who have shown different approach-avoidance tendencies toward physical activity (Farajzadeh, Goubran, Beehler, et al., 2023). Future studies using device-based measures of physical activity and recruiting a more diverse sample are needed. Third, testing the ability of the approach and avoidance dimensions to predict subsequent engagement in physical activity would allow the predictive validity of the PES to be assessed. Fourth, although the use of a self-report measure to capture effort perception is relevant to our conceptualization of the conscious sensation experienced during the performance of a physically active behavior (Kent, 2006; Marcora, 2009), additional measures that target more rapid, unconscious, and involuntary processes that contribute to effort perception may also be highly relevant. This would provide an opportunity to capture not only the reflective mechanisms that lead to the perception of effort, but also the automatic mechanisms (Cheval et al., 2022). Finally, the decision to include some scales over others to assess the construct validity of the PES may seem rather arbitrary. Importantly, some relevant scales could be considered as missing, such as the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) (Ekkekakis et al., 2005) or the Exercise Addiction Inventory (Terry et al., 2004), both of which have shown strong correlations with the value of physical effort as assessed by the VoPE (Bieleke et al., 2023).

However, these limitations are outweighed by several strengths. We followed the recommended steps for scale development (Boateng et al., 2018): Domain identification, comparison with multiple existing scales, content validity of the items developed by nine independent experts, cognitive interview, internal consistency, construct validity (i.e., concurrent, convergent, and discriminant validity), and test-retest reliability. In addition, we relied on two relatively large independent samples, in which the scale's structural validity, internal consistency, and concurrent validity were tested and validated.

In conclusion, the PES has sound psychometric properties for the study of individual differences in the valuation of physical effort. Because it is a short questionnaire (i.e., 4 items for the approach dimension and 4 items for the avoidance dimension), the PES can easily be included in research projects on physical activity, sedentary behavior, or physical effort in general. The PES could be used to examine the extent to which the large individual differences in the processing of physical effort consistently found in previous studies can be explained by these tendencies (Strasser et al., 2020; Treadway et al., 2012). Future research is needed to adapt this scale to different populations, including children, older adults, or individuals with a clinical condition. The PES and its manual are available in the Supplementary Material.

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Supplementary Material – Physical Effort Scale – Manual

Physical Effort Scale (PES) – Manual

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1. Introduction

The Physical Effort Scale (PES) operationalize the tendencies to approach and to avoid physical effort and provides the following information:

(1) Mean overall score to approach physical effort.
(2) Mean overall score to avoid physical effort.

2. Administration

The Physical Effort Scale can be administered in person or online. The questionnaire has been used with respondents 18 years of age and older. Participants indicate their level of agreement with each of the 8 items on a Likert scale anchored with (1) I completely disagree, (2) I disagree, (3) I neither agree nor disagree, (4) I agree, (5) I completely agree. The Physical Effort Scale takes approximately 2 minutes to complete.

3. Scoring

Calculation of a total mean score for the items belonging to the *Approach* dimension of the physical effort. A higher score indicates a greater tendency to approach physical effort.

Calculation of a total mean score for the items belonging to the *Avoidance* dimension of the physical effort. A higher score indicates a greater tendency to avoid physical effort.

Dimension	**Item Numbers**
Approach physical effort	1, 3, 6, 8
Avoid physical effort	2, 4, 5, 7

A relative tendency to approach rather than avoid physical effort can be computed as follows:

Relative tendency to approach physical effort = Average score for tendency to approach physical effort – Average score for tendency to avoid physical effort.

A higher score indicates a greater tendency to approach (rather than avoid) physical effort. This score is useful when researchers want to predict movement-based behaviors considering both the approach and the avoidance dimensions of physical effort.

Physical Effort Scale

<u>Instructions:</u> This questionnaire is about physical effort, which is usually associated with increased heart rate and breathing. Please read each of the following statements carefully and indicate the extent to which you agree or disagree with the statement. There are no right or wrong answers. Choose your response using the following scale:

I completely disagree	I disagree	I neither agree nor disagree	I agree	completely agree
(1)	(2)	(3)	(4)	(5)

1.	I usually like activities that require physical effort.	1	2	3	4	5
2.	I tend to avoid situations in which I have to exert physical effort.	1	2	3	4	5
3.	The idea of exerting physical effort usually appeals to me.	1	2	3	4	5
4.	I tend to stay away from tasks that require physical effort.	1	2	3	4	5
5.	Exerting physical effort does not appeal to me.	1	2	3	4	5
6.	I generally enjoy activities that involve physical effort.	1	2	3	4	5
7.	I usually dislike activities that involve physical effort.	1	2	3	4	5
8.	I am usually willing to engage in activities that involve physical effort.	1	2	3	4	5

4. References

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