

# Competencies for a healthy physically active lifestyle: Second-order analysis and multidimensional scaling

Johannes Carl (✉ [johannes.carl@fau.de](mailto:johannes.carl@fau.de))

Friedrich-Alexander University Erlangen-Nürnberg, Department of Sport Science and Sport  
<https://orcid.org/0000-0001-7393-0450>

**Gorden Sudeck**

University of Tübingen, Institute of Sports Sciences

**Klaus Pfeifer**

Friedrich-Alexander University Erlangen-Nürnberg, Department of Sport Science and Sport

---

## Research Article

**Keywords:** physical activity, health literacy, PAHCO model, physical literacy, validity

**Posted Date:** May 6th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-27115/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

**Version of Record:** A version of this preprint was published on December 21st, 2020. See the published version at <https://doi.org/10.3389/fpsyg.2020.558850>.

# Abstract

The model of physical activity-related health competence (PAHCO) assumes that individuals require movement competence, control competence, and self-regulation competence to lead a healthy, physically active lifestyle. Although previous research has already established some measurement factors ( $n = 8$ ) of the three dimensions, no attempts have so far been made to statistically aggregate them on the sub-competence level. Therefore, the goal of the present study was to test two additional factors for PAHCO and subsequently model the second-order structure with two samples from the fields of rehabilitation and prevention. We conducted two questionnaire surveys with persons with multiple sclerosis ( $n = 475$ ) and teaching students undergoing a basic qualification course in physical education ( $n = 502$ ). After performing exploratory items analysis, we used second-order confirmatory factor analysis (CFA) and multidimensional scaling to investigate whether the scales could be bundled in accordance with the PAHCO model. The CFAs with ten factors (42 items) demonstrated a good model fit. In contrast, the second-order analysis with a simple loading structure on the three sub-competencies revealed an unacceptable model fit. Instead, a second-order model variant was preferred (CFI = 0.926, RMSEA = 0.048, SRMR = 0.065) in which body awareness and self-efficacy had theory-conform cross-loadings. The results of multidimensional scaling (two-dimensional solution) were in line with the extracted second-order structure. The present results suggested that the extension of the measurement instrument to ten first-order factors was psychometrically justified. The results from the second-order analyses provided the basis for the creation of sum scores, representing manifest indicators of movement competence, control competence, and self-regulation competence. Future studies are needed that relate the sub-competencies of PAHCO to indicators of health-enhancing physical activity in relevant target Groups.

## 1. Introduction

There is considerable evidence that physical activity (PA) behavior exerts a beneficial effect on individuals' health (Warburton and Bredin, 2017; Lee et al., 2012). Accordingly, having people and populations adhere to a physically active lifestyle can be considered an important goal of our societies. However, several international studies have illustrated that a large percentage of individuals is not sufficiently active (Guthold et al., 2018, 2020; Hallal et al., 2012). To counteract these tendencies, the World Health Organization (2018) has recently released the "Global Action Plan on Physical Activity 2018–2030" (GAPPA) with the recommendation of focusing on individuals' characteristics and behaviors on the one hand as well as on structures and environments on the other. The consideration of these two major pillars is compatible with socioecological theories, pointing out that PA behavior depends on both individual and environmental factors (Sallis et al., 2015; Bauman et al., 2012). With respect to the person-related factors, the GAPPA repeatedly suggests addressing people's literacy and competencies (World Health Organization, 2018). Against the background of the frequent use of these two notions, a crucial question arises: What are those competencies and literacy aspects that have to be targeted when people want to adopt or maintain a healthy, physically active lifestyle? When overviewing the literature on health-enhancing physical activity (HEPA) and approaches underlying the two terms "literacy" and

“competence”, it becomes apparent that the corresponding descriptions highlight multifaceted and multidimensional requirements for a physically active lifestyle as they integrate physical, motivational, and cognitive aspects (Cairney et al., 2019b; Sudeck and Pfeifer, 2016; Gunnell et al., 2018; Carl et al., in press a; Whitehead, 2007; Tremblay et al., 2018; Edwards et al., 2017). In line with this understanding, the literacy and competence approaches assume that an isolated focus on physiological and motor aspects on the one hand (e.g., Lubans et al., 2010) or on motivational and self-regulatory components on the other (e.g., Rhodes et al., 2019) does not account for the complex interplay of personal factors involved when people perform activities on a regular basis. In summary, the approaches using the terms “literacy” and “competence” share a considerable number of commonalities. Nevertheless, there are some conceptual differences (for details, see Carl et al., in press b) that are in line with their separate mentions within the GAPP (World Health Organization, 2018).

The physical literacy approach has gained increasing attention during the last two decades (Edwards et al., 2017) and has put the literacy aspect within the GAPP on a very solid and elaborate level. However, the approach has not fully exhausted its health potential, since the links to health as an important outcome have not been sufficiently discussed so far (Cairney et al., 2019b). The inclusive character of the framework also comprises competitive and more risky forms of movement (Durdin-Myers et al., 2018; Robinson et al., 2018) – forms that may even counteract the promotion of an individual’s health.

The competence concept has the potential to offer a different perspective on physically active lifestyles within the GAPP by highlighting the domain-specificity, context-boundedness, goal-directedness, and action-relatedness of personal factors (Robinson et al., 2015; Carl et al., in press b). While movement competence as a specific sub-aspect has frequently been the subject of scholarly endeavors (Robinson et al., 2015), there have not yet been academic debates centering on multidimensional competencies for a healthy, physically active lifestyle. To stimulate scientific discussions in this area, the physical activity-related health competence model has recently been introduced in the international literature (Figure 1).

## **2. Theoretical Background And Purpose**

The physical activity-related health competence (PAHCO) model (Sudeck and Pfeifer, 2016; Pfeifer et al., 2013; Carl et al., in press b) constitutes an integrative framework at the intersection of health literacy and physical literacy (Carl et al., in press b) that assumes three interrelated and equivalent sub-competencies as essential for a healthy, physically active lifestyle: first, people require movement competence, allowing them to participate in planned exercise sessions and be physically active in leisure time (e.g., swimming) or to master important challenges of daily life (e.g., climbing stairs or carrying bags); second, self-regulation competence serves as the psychological component, designed to ensure the regular execution of these activities; and third, control competence is needed, guaranteeing that individuals not simply apply any stimulus as frequently and intensively as possible. As a rather “qualitative” (Pesce, 2012) domain, this competence component ensures that people do not merely follow the slogan “the more, the better.” Instead, meeting the complex demands of health (Sørensen et al., 2012), this component is geared

toward assigning an adequate load to the body, for the promotion of physical health and mental well-being.

According to the PAHCO Model, these three competence areas are, in turn, the result of the integration and coupling of basic elements (see the left side of Figure 1). For example, movement competence is formed by the interplay of basic motor abilities, basic motor skills, and a sound body awareness. The basis of control competence is a solid knowledge base in terms of the health-related benefits of PA (effect knowledge) and the appropriateness of certain methods and exercises to achieve these benefits (action knowledge). Finally, the model names positive attitudes toward PA as well as high PA-specific self-efficacy as the basis of self-regulation competence. In addition to these pathways characterizing a transformation of basic elements from the same vertical height, the model also explicitly considers the integration of basic elements from another vertical height into the three competence areas (Sudeck and Pfeifer, 2016; Carl et al., in press b). For instance, a good body awareness not only contributes to movement competence but can also be used as a feedback source for the identification of an adequate training load (Thiel et al., 2018). Another example is the assertion that at least a minimum amount of task-specific self-efficacy is necessary to master given locomotor tasks (movement competence).

The PAHCO model has been the subject of some publications in the German-speaking area (e.g., Sudeck and Pfeifer, 2016; Pfeifer et al., 2013; Peters et al., 2013; Schmid et al., 2020; Gawlik et al., 2018) and on the international level (e.g., Carl et al., 2020; Carl et al., in press b; Sudeck et al., 2018; Haible et al., 2020). Also, this framework has already served as the theoretical foundation for interventions and programs (e.g., Haible et al., 2019; Bruland et al., 2019; Geidl et al., 2017; Ley et al., 2014; Streber and Pfeifer, 2018). However, there is currently no diagnostic tool that meets the multidimensional and integrative character of the PAHCO model and, hence, provides consultants, coaches, or therapists with the opportunity to comprehensively assess the competence status of their patients or clients. Nevertheless, two studies including four samples were highly important in the past, as they paved the way for a potential assessment tool (Table 1).

The goal of these studies was to develop competence-oriented items and multidimensional scales on the sub-competence level. In a first article, Sudeck and Pfeifer (2016) successfully tested three single aspects of PAHCO with two different samples from both the fields of rehabilitation and prevention (Table 1). Inspired by this work, Carl et al. recently extended this questionnaire in two consecutive steps, resulting in a five-factor and lastly in an eight-factor measurement model (in press a). These measurement models, however, have been developed with two specific samples, which limits the generalizability of the assessment. Therefore, it would be a value per se to cross-validate (Blackford, 2017) the measurement models previously extracted. Comparing the current status of the assessment with conceptualizations in publications (Sudeck and Pfeifer, 2016; Pfeifer et al., 2013), two model aspects could still be theoretically considered when striving for a multidimensional operationalization of the sub-competence level. First, no attempts have been undertaken in the context of PAHCO to empirically capture the cognitive-rational attitude component. Second, there is currently no assessment of body awareness. In this context, it is worth mentioning that the exploratory analyses in the second sub-study of Carl et al. (in press a) rejected

a first operationalization of the body awareness aspect for both content-related and statistical reasons. Thus, it would be important to reconsider this factor without detaching from a competence-oriented operationalization.

Adding the two elements of body awareness and cognitive attitude toward PA to the existing assessment would lead to a ten-factor measurement model. In a case of successful testing, it would further be relevant to explore whether the ten factors can be mathematically pooled into three overarching factors called movement competence, control competence, and self-regulation competence, as theoretically postulated by the PAHCO model. The results of the analysis would be decisive for the creation of sum scores for the three sub-competence areas of the PAHCO model. Such an empirical bundling (Cairney et al., 2019a), in turn, would provide future studies with the opportunity to inspect the associative power of the three sub-competencies (not only of the ten single scales) with indices of HEPA.

Therefore, the goal of the present study was to (1) cross-validate the three-, five-, and eight-factor measurement models on PAHCO with further populations, (2) subsequently investigate the reliability and validity of two further aspects of PAHCO (i.e., body awareness and the cognitive-rational attitude component) including the testing of a ten-factor measurement model, and (3) finally bundle these ten first-order PAHCO factors to model-conform second-order factors. To achieve these goals, we again used two diverse samples (Table 1) from the two major strands of HEPA, namely the fields of rehabilitation (Study 1) and prevention (Study 2). The selection of these populations was based on the approval of two research projects in which PAHCO had an important role. Study 1 comprised persons with multiple sclerosis (pwMS), while Study 2 involved teaching students acquiring a basic qualification certificate in physical education.

## **3. Materials And Methods**

### **3.1 Participants**

#### **3.1.1 Persons with Multiple Sclerosis (Study 1)**

The previous step within the successive validation and assessment development strategy (Table 1) was conducted with a comparably healthy (apprentices) population (Carl et al., in press a). Since the manageability of balance demands (MBD) factor has not been associated with indicators of PA in the last study (Carl et al., in press a), we subsequently decided to examine persons with multiple sclerosis (pwMS) who typically have problems with motor control (Kister et al., 2013). Data was taken from a baseline online survey of the project "MS bewegt" [Engl. ms moves], which was specifically installed to launch an internet-based and competence-oriented program for the promotion of PA in pwMS.

Between February and April 2019, voluntary participants were recruited via website newsletters, social network groups, and a mailing list. A total of 484 people followed the link in the message and fully completed the questionnaire survey. We had to exclude the self-report of nine participants due to incomplete consent to data protection ( $n = 6$ ) or not confirming the existence of an official medical diagnosis of multiple sclerosis ( $n = 3$ ). The remaining 475 participants were predominantly female (73.5

%), on average  $47.8 \pm 10.0$  years old, and had a BMI of  $25.2 \pm 5.6$  kg/m<sup>2</sup>. The included pwMS had a mean PDDS value of  $2.74 \pm 1.96$ , with their first official diagnosis being made  $15.22 \pm 9.27$  years ago. Among the participants, 61.9% were undergoing immunotherapy, and 62.7% were still employed.

### 3.1.2 Teaching Students (Study 2)

To cross-validate the potential ten-factor measurement model with a different population from the prevention sector, we additionally recruited a sample of teaching students undergoing a basic qualification program in physical education. In Bavaria, Germany, the basic qualification program is a compulsory compact certificate for all ongoing elementary, middle, and special education teachers who choose physical education neither as a primary subject (German: Hauptfach) nor as a minor subject (German: Didaktikfach). Within the scope of the PArC-AVE Study (Popp et al., 2020), as a part of the research consortium Capital4Health (here project phase 2), we asked all representatives of the Working Group Sport Science and Sport of the Universities in Bavaria (AKS), who coordinate the basic qualification programs in physical education at their universities ( $n = 8$ ), to support the statewide survey in the winter term 2018/2019. All members were willing to organize the distribution and collection of paper-pencil questionnaires or, if desired, to provide the students with access to an equivalent online survey. This combined assessment strategy led to a final sample of  $n = 502$ : ongoing elementary school teachers 61.8 %, middle school teachers 27.0 %, and special education teachers 11.2 %. The participants were predominantly female (87.6 %), had a mean age of  $23.1 \pm 3.7$  years, and showed an average BMI of  $22.6 \pm 3.7$  kg/m<sup>2</sup>.

### 3.2 Measures

We used the latest version of the PAHCO questionnaire with eight subscales (Carl et al., in press a). The cognitive attitude component toward PA was measured using a German subscale for the assessment of attitude components in physical exercise (Brand, 2006). This tool comprised four items, rated on a seven-point Likert scale. Within the questions, we replaced the term “sport” with “physical activity” to relate the items to the more inclusive and, for this study, more convenient concept. Since the empirical results from the validation study (Brand, 2006) and our first experiences from a project in the context of pulmonary rehabilitation (Geidl et al., 2017) had shown that participants had some problems with the negatively formulated item “useless,” we decided to modify it by adopting the positively connotated adjective “useful” instead (ATCOG3, see Appendix Table 1). Body awareness was assessed with five items on a five-point Likert scale. For the competence-oriented construction of the scale, we followed the basic differentiation between basic sensory and interpretative aspects (Ginzburg et al., 2014) on the one hand (e.g., item BAW2, having a good feeling for one’s posture) and more complex aspects of use (e.g., item BAW7, the adequate use of body signals) on the other (Appendix Table 1). We profited from the experiences of a previous study with apprentices in which the initial operationalization of body awareness was not successful (Carl et al., in press a). Two items were adopted as-is, one item underwent terminological change, and two items were newly developed. All sociodemographic (e.g., age, gender, height, weight), relevant medical (Study 1: e.g., subtype of MS, time since the last relapse), and

education data (Study 2: e.g., study program, locality) were captured with self-report questions. However, since there was no validated German self-report tool for the assessment of the severity of the multiple sclerosis disease, we relied on the English version of the PDDS Questionnaire with its nine severity graduations (Learmonth et al., 2013). The first author of this study and a certified German-English translator independently performed a literal translation of this tool, seeking an agreement by consensus afterwards.

### 3.3 Statistics

All items were exploratively screened on the basis of common statistical parameters on the one hand (item difficulty, variance within the sample, Cronbach's  $\alpha$ , part-whole correlation) and of content-related arguments on the other. As the Mardia test revealed significant violations of multivariate normality (skewness and kurtosis,  $p < .001$ ), we relied on robust maximum likelihood estimators (MLR) with Satorra-Bentler-scaled statistics to interpret the fit of the models. In addition to the chi-square ( $SB-\chi^2$ ) statistics, which tend to systematically reject models of high complexity and models that are tested with huge sample sizes (Cheung and Rensvold, 2002), we paid attention to a variant that takes into account the underlying degrees of freedom ( $SB-\chi^2/df$ ). We also followed suggestions by Hu and Bentler (1998), who recommended indicating standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA) and comparative fit index (CFI). To evaluate the magnitude of these coefficients, we adhered to guidelines indicating good ( $\chi^2/df \leq 2.0$ ,  $RMSEA \leq .05$ ,  $SRMR \leq .05$ ,  $CFI \geq .95$ ) or satisfactory/acceptable ( $\chi^2/df \leq 3.0$ ,  $RMSEA \leq .08$ ,  $SRMR \leq .10$ ,  $CFI \geq .90$ ) model fits (Weiber and Mühlhaus, 2015; Schermelleh-Engel et al., 2003). Missing values were treated by applying full information maximum likelihood (FIML) procedures. After the interpretation of the models, we extracted information on indicator and factor reliability. Discriminant validity was determined by following the criterion of Fornell and Larcker (1981), which postulates that discriminant validity is given when the average variance extracted (AVE) of each construct is higher than the squared correlation with any other construct.

To inspect whether the ten factors could be bundled into three overarching factors, we extended the measurement model to a second-level CFA (Chen et al., 2005). In accordance with the outlined model assumptions, we statistically pooled manageability of strength demands (MSD), manageability of endurance demands (MED), manageability of balance demands (MBD), and body awareness into a second-order factor called movement competence, the factors affect regulation and control of physical load to a second-order factor control competence and, ultimately, emotional attitude, cognitive attitude, self-efficacy, and self-control to a second-order factor self-regulation competence. Since the model posits that body awareness can be viewed as an important aspect of control competence and self-efficacy an important aspect of movement competence (see introduction), we successively compared this simple loading model (Figure 2a) to a variant that freely estimated these two cross-loadings (Figure 2b). We interpreted the model comparisons by using the Satorra-Bentler scaled  $\chi^2$  difference test ( $\Delta SB-\chi^2$ ) as well as the information criteria by Akaike (AIC) and Bayes (BIC).

Furthermore, we transformed the standardized covariance (correlation) matrix with the first-order factors into a distance matrix (with the formula  $1-r$ ). Afterwards, metric multidimensional scaling (MDS) was performed to more deeply analyze the suitability of a second-order solution and to visually examine the conceptual proximity between the first-order factors. Due to the number of first-order factors ( $n = 10$ ), we limited the analysis to a two-dimensional ( $k = 2$ ) MDS solution ( $Q = 2.25$ ). This decision was supported by the  $Q$  coefficient (Backhaus et al., 2015), which would not have surpassed the critical value of 2.00 for three dimensions ( $Q = 1.50$ ). Accordingly, applying more dimensions would have inhibited the interpretability of the solution. All analyses were run with the software R (Version 3.4.3), including the package Lavaan (Rosseel, 2017).

## 4. Results

### 4.1 Persons with Multiple Sclerosis (Study 1)

There was a good fit for the three- ( $SB-\chi^2/df = 2.14$ , CFI = 0.978, RMSEA = 0.049 [CI90=0.039–0.058], SRMR = 0.032) and five-factor ( $SB-\chi^2/df = 2.18$ , CFI = 0.973, RMSEA = 0.050 [CI90=0.044–0.056], SRMR = 0.047) measurement models on PAHCO. The eight-factor variant, which had recently been worked out with apprentices, showed a satisfactory fit ( $SB-\chi^2/df = 2.82$ , CFI = 0.938, RMSEA = 0.062, [CI90=0.058–0.065], SRMR = 0.040), which also demonstrates the validity of the measurement models for this population.

Subsequently, we submitted the five new items of the body awareness factor and the four items of the factor cognitive attitude toward PA to exploratory item analysis. Both factors had good internal consistency with Cronbach's  $\alpha = .93$ . All five items of the body awareness factor ranged in the middle of the scale (item difficulty: 0.58–0.61), thereby displaying no further statistical anomalies. In contrast, there was high agreement to the items of the cognitive attitude toward PA scale (item difficulty: 0.92–0.93), which was associated with high values for skewness and kurtosis (Appendix Table 2). In summary, however, the items did not lie beyond the critical cut-off of .95, and, more importantly, there is a content-related argument for this finding. PwMS are typically well aware of the array of beneficial effects resulting from PA, especially when it is executed in a disease-adapted fashion (Frau et al., 2015). Therefore, we continued the development process with the inclusion of these two factors. The CFA with the ten factors and the 43 items showed a satisfactory model fit ( $SB-\chi^2/df = 2.48$ , CFI = 0.931, RMSEA = 0.056 [CI90=0.053–0.059], SRMR = 0.042). All items loaded significantly ( $p < .001$ ) on their corresponding factor ( $0.710 \leq \lambda \leq 0.992$ ), and the AVE (0.617–0.906) was good overall (see Table 2). Even though the MBD, MSD, and MED factors were highly correlated ( $0.758 < r < 0.834$ ), the Fornell-Larcker criterion was not violated in this sample. The factor reliabilities were consistently located in a good area ( $0.906 \leq \alpha \leq 0.975$ ).

### 4.2 Teaching Students (Study 2)

The sample with the teaching students undergoing basic qualification in physical education also revealed good model fits for the three (SB- $\chi^2/df = 2.32$ , CFI = 0.975, RMSEA = 0.052 [CI90=0.042–0.062], SRMR = 0.034) and five factor (SB- $\chi^2/df = 2.18$ , CFI = 0.966, RMSEA = 0.049 [CI90=0.042–0.055], SRMR = 0.042) measurement models. The eight-factor measurement model displayed a satisfactory model fit as well (SB- $\chi^2/df = 2.14$ , CFI = 0.941, RMSEA = 0.048 [CI90=0.044–0.052], SRMR = 0.047).

The item analysis with the second sample indicated that the fourth item of the MBD factor was too easy for this population, showing an item difficulty of .96 and a kurtosis of 19.98 (Appendix Table 3). Following the claim that the assessment must fulfill the basic psychometric requirements in healthy populations as well, we decided to remove this item for all further steps. This decision was supported by the argument that the item covered a comparably easy dynamic locomotor task (maintaining balance while going downstairs). Items five and six of this factor also referred to stair climbing but included at least a second task (carrying a full shopping bag, carrying a glass full of water), which means that the dynamic locomotor aspect of balance was still sufficiently represented within the remaining item set of MBD when eliminating this particular question.

The CFA with the ten factors and 42 items demonstrated a good model fit (SB- $\chi^2/df = 1.98$ , CFI = 0.933, RMSEA = 0.044 [CI90=0.041–0.047], SRMR = 0.046). All items loaded highly significantly on their corresponding factors ( $p < .001$ ). Nevertheless, two items showed low regression weights ( $\lambda_{STR5m} = 0.61$ ,  $\lambda_{BAW4} = 0.62$ ). This finding was tolerated, due to the fact that these items had not disclosed any problems in previous studies and that the corresponding indicator reliabilities (0.37 and 0.38) did not fall in an unacceptable area (Weiber and Mühlhaus, 2015). In the sample of teaching students, the AVE was consistently located within an acceptable area ( $0.504 \leq AVE \leq 0.764$ ). However, the AVE of the factors body awareness (AVE = 0.518) and control of physical load (AVE = 0.504) were lower than their squared correlation with each other ( $r^2 = .634$ ). The violation of the Fornell-Larcker criterion indicates that the present assessment could not sufficiently discriminate between these two PAHCO constructs in this sample.

### 4.3 Investigation of the Second-order Structure on PAHCO

The stepwise assessment development on PAHCO comprised a total of six different samples (Table 1). Starting with a three-factor variant, the continuous cross-validation and extension strategy led to a ten-factor measurement model. We next examined whether the ten specified factors could be pooled into three overarching constructs. We combined both samples (PwMS and teaching students) into one dataset ( $n = 977$ ) and computed a ten-factor measurement model with three correlated yet nonoverlapping second-order factors (Figure 2a). This model, however, displayed an insufficient fit (SB- $\chi^2/df = 3.63$ , CFI = 0.913, RMSEA = 0.052 [CI90=0.050–0.052], SRMR = 0.109), with two statistical indicators lying outside the cut-off values (SB- $\chi^2/df > 3.0$  and SRMR  $> .10$ ) for acceptable model fits (Weiber and Mühlhaus, 2015; Schermelleh-Engel et al., 2003).

Congruent with the assumption of the PAHCO model that body awareness can also be interpreted as an aspect of control competence and self-efficacy as an aspect of movement competence (Sudeck and Pfeifer, 2016; Pfeifer et al., 2013), we further tested a second-order variant in which these two cross-loadings were additionally allowed to be freely estimated (Figure 2b). Even though the  $SB-\chi^2/df$  statistics still showed a slightly too high value, the remaining fit indices of this theory-conform second-order CFA were satisfactory ( $SB-\chi^2/df = 3.24$ ,  $CFI = 0.926$ ,  $RMSEA = 0.048$  [ $CI_{90}=0.046-0.050$ ],  $SRMR = 0.065$ ), and the SRMR especially turned into an acceptable area. The two cross-loadings, both significant ( $p < .001$ ) and substantial in magnitude for a second-order model ( $\lambda_{BAW-CC} = 0.634$ ,  $\lambda_{SE-MC} = 0.537$ ), contributed to this finding. The pattern revealed that the two loadings even had a stronger conceptual proximity to the second-order cross-factors than to the primary second-order factors ( $\lambda_{BAW-MC} = .192$ ;  $\lambda_{SE-SRC} = 0.438$ ), occupying a larger loading in comparison. In the case of the movement competence to body awareness loading, the reduction was considerable, falling below a value of 0.20. Even though such a decrease is considered significant in some recommendations (Tabachnick and Fidell, 2001), the loading was still highly significant ( $p = .004$ ), with the pattern being in accordance with the discriminant validity phenomenon described in the PwMS sample. Nevertheless, the direct comparison between both second-order models ( $\Delta SB-\chi^2 = 317.3$ ,  $\Delta df = 2$ ,  $p < .001$ ,  $\Delta AIC = 363$ ,  $\Delta BIC = 358$ ) statistically favored the latter variant of the two solutions.

MDS based on the distance matrix (Appendix Table 4) showed that those factors which could be grouped according to PAHCO could be pooled together spatially. The two cross-factors self-efficacy and body awareness were located at the interface of their corresponding superordinate factors (Figure 3). Movement competence (blue surface) and control competence (yellow surface) occupied a field of limited expansion with a well interpretable structure. The subdimension of self-regulation competence (red surface) was comparably broad in its conception and operationalization. MDS unfolded that the cognitive attitude component was somewhat outstanding with respect to the other factors, contributing to a graphical expansion of the self-regulation competence surface. Even though the emotional attitude toward PA and the affect regulation factors displayed an empirical proximity, the graphical solution endorsed a theoretical separation between these two PAHCO aspects.

After flipping and rotating the ten points by  $95^\circ$  around the zero of the coordinate system (transformation formula:  $x' = x \cdot \cos \alpha + y \cdot \sin \alpha$ ;  $y' = -x \cdot \sin \alpha + y \cdot \cos \alpha$ ), the resulting configuration could be interpreted along two dimensions. The x-axis spanned a continuum from a rather isolated level (including the factors of both attitude components) on the left to a complex and more competence-/action-oriented level (such as control of physical load or body awareness) on the right. The points on the y-axis, in contrast, could be ordered from body functions on the top (such as the facets of movement competence MBD, MSD, or MED) to more cognition and emotion-oriented factors (including self-control or the attitude components) at the bottom (Figure 3). In summary, we determined a fit between the configural constellation of the theoretical model (Figure 1) and the empirical data gained through MDS (Figure 3).

Given the model fit of the second-order structure of PAHCO using the basic ten-factor assessment, we were entitled to create sum scores for the ten first-order factors and the three second-order factors. The two first-order factors body awareness and self-efficacy, which displayed theory-conform cross-loadings (Figure 2b), were included in the score of two competence domains, each with a relative weight of 0.70. Documents on the validated instrument (i.e., the questionnaire instrument, an input mask, an evaluation syntax, and an interpretation guide) can be freely downloaded from a website of the local university. When applying this aggregation procedure, the sum scores of self-regulation and control competence were correlated most strongly across both samples ( $r = .709$ ). Albeit slightly lower in magnitude, movement competence was also strongly associated with self-regulation ( $r = .496$ ) and control competence ( $r = .625$ ).

## 5. Discussion

The present article endorsed the factorial structure of measurement models tested in earlier studies (Sudeck and Pfeifer, 2016; Carl et al., in press a), using two different samples from the rehabilitation (pwMS) and prevention (teaching students) context. In addition to the eight-factor measurement model, we also included measures of body awareness and cognitive attitude toward PA, thus allowing the investigation of a ten-factor measurement. In summary, the application of the cognitive attitude toward PA scale, transferred and adapted from Brand (2006), was psychometrically warranted.

In terms of body awareness, we revised and extended operationalizations that had to be rejected in previous studies (Carl et al., in press a). The reliability, factor loadings, and overall model fit with the new item set indicated that the operationalization in this study was more adequate. However, although not found in the pwMS sample, the second study with the basic qualification students raised some concerns regarding the discriminant validity of the body awareness factor showing a significant overlap with the control of physical load factor. Indeed, two items (BAW7, BAW8) could also be interpreted as side aspects of the control of physical load factor. Providing a first explanation of the different findings across both samples, sensory inputs could be an integral part of the identification of an adequate physical load among most individuals and pwMS might present a special population who, due to the impaired motor control system, might also have learned to rely on other information sources than their afferent input to regulate their physical load (e.g., feedback from others, intuition, personal experience, guidelines from disease-specific PA recommendations). Second, the ongoing teachers, who have all refrained from choosing physical education as a special subject, could draw on less experience with physical exercise and may therefore prioritize sensory control strategies and more internal foci of attention to arrange strenuous activities (Perkins-Ceccato et al., 2003; Castaneda and Gray, 2007). Third, the possibility cannot be fully excluded that the theoretical construction strategy was not adequately implemented, because the items may not capture body awareness as conceptually intended. To accumulate evidence on one of these potential explanations, it is necessary to conduct further studies with other populations.

Despite this open point, the present study could extract a theory-conform measurement model that meets the multidimensional and integrative character of the PAHCO model. An initial second-order CFA rejected

a first measurement model with a simple loading structure. The free estimation of two cross-loadings significantly improved the model fit. From a theoretical perspective, these two loadings can be directly deduced from two articles introducing the PAHCO model (Sudeck and Pfeifer, 2016; Pfeifer et al., 2013). In line with the statistical fit of the alternative measurement model, it would have been inappropriate to neglect that (a) sound body awareness can contribute to the identification of an adequate physical load in the context of health-oriented exercise (Williams, 2008) and that (b) the execution of motor actions depends on a minimum level of (task-specific) self-efficacy.

The subsequent MDS could reproduce the identified second-order structure by mapping the first-order factors along two axes. The graphical representation revealed that the cognitive attitude toward PA factor was slightly outstanding, thus widening the PAHCO and, importantly, the self-regulation surface. Following our interpretation along the x-axis (isolated vs. action-/competence-related orientation), this component may have more characteristics of a basic element, similar to the self-efficacy or the emotional attitude factors, which (as self-regulation elements) also have negative values on the abscissa. In this regard, it would be worth identifying self-regulation elements that are even more competence-oriented. For instance, Sudeck and Pfeifer (2016) suggested taking up the idea of motivational competence that describes an individual's capacity to make motive-congruent decisions (Rheinberg and Engeser, 2010). In this context, it would be crucial to transfer this sub-competence to PAHCO by undertaking a theoretical-conceptual discussion first.

From the perspective of behavioral-relatedness, technically named criterion validity, it would be necessary to relate the latent second-order factors or sub-competence scores to pivotal outcomes of HEPA (Figure 1). As outcomes, this would, for example, include the volume of PA performed (Sudeck and Pfeifer, 2016; Carl et al., in press a) or, covering qualitative and health-related aspects of HEPA, parameters such as positive affect (Sudeck et al., 2018), perceived vitality (Schmid et al., 2020), or subjective health (Carl et al., in press a).

Nevertheless, focusing the internal structure of the framework, the present second-order approach could substantiate the integrative and interrelated nature of the PAHCO model. In concert with metatheoretical assumptions, integrative means that competencies do not refer to comparably isolated and context-independent (Klieme et al., 2010) movement characteristics such as motor skills. Instead, they require a combination of different abilities and skills, resulting in a multidimensional conceptualization of competencies. Accordingly, to describe a person as competent, the individual should be able to master a number of tasks and demands in different yet concrete situations (Klieme et al., 2010). The present assessment takes this assumption into account, using a competence-oriented formulation of items, especially in the area of movement and control competence. The interrelated character of PAHCO could be demonstrated by two concrete study results. First, we registered considerable associations within the three sub-competencies, i.e., across the different first-order factors. Second, the sum scores between the three sub-competencies were correlated, which puts the postulated arrows on the sub-competence level of the PAHCO model (Figure 1) on a stronger empirical basis.

Despite the considerable diversity regarding the examined target groups spanning healthy, young, and well-educated people on the one hand and comparably older individuals with a specific chronic condition on the other, restraint is warranted regarding the external validity of the findings. Currently, it is not possible to generalize the model findings to the population level. More specifically, the selection of the samples was linked to the approval of two research projects, meaning that the previous strategy was so far not able to overcome convenience sampling. In addition, we cannot exclude a selection bias on the project level. In Study 2, the recruitment was realized by contacting the official coordinators of the regional universities. Through their involvement, every Bavarian student of the winter semester cohort was personally invited, finally leading to a high participation rate. In Study 1, in contrast, we used different disease-specific social communication channels. This recruitment strategy may have primarily attracted individuals with a special interest in topics of PA and exercise. Against this backdrop, it would be beneficial, as one of the next steps, to conduct a representative study and generate standard values, especially when researchers intend to implement the instrument on a large scale.

## **Declarations**

### **Data Availability Statement**

Both studies are part of a research project and data will be published as soon as the projects are completed.

### **Ethics Statement**

Both projects have been approved by ethics committees (Sign Study 1: F-2018-059; Sign Study 2: 467\_18B). All participants provided informed consent to study participation.

### **Author Contributions**

J.C. defined the validation strategy, developed the new items, initiated and organized the surveys in both studies, performed the analyses, and drafted the manuscript. G.S. contributed to the item development and refined the manuscript. K.P. had the major responsibility for both studies and also refined the manuscript. All authors have approved the final version of the manuscript and agree with the order of presentation of the authors.

### **Funding**

Research was funded by the Techniker Krankenkasse Baden-Württemberg (Study 1) and the Federal Ministry of Education and Research (BMBF) of Germany (Study 2, Funding Number 01EL1821A).

### **Acknowledgements**

We want to thank all Bavarian coordinators of the basic qualification program in physical education (Augsburg, Bamberg, Eichstätt-Ingolstadt, Erlangen-Nürnberg, Munich, Passau, Regensburg, Würzburg) for

their readiness to support the study. Furthermore, we appreciate that Verena Hartung and Alexander Tallner were willing to discuss the results from the project “MS bewegt.” Finally, we thank Hendrik Thedinga for contributing to the translation of the PDDS in Study 1.

### **Conflict of Interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## **References**

- Backhaus, K., Erichson, B., and Weiber, R. (2015). *Fortgeschrittene Multivariate Analysemethoden - Eine anwendungsorientierte Einführung [Advanced methods of multivariate analysis - An application-oriented introduction]*. 3., überarb. u. aktual. Aufl. 2015. Berlin: Gabler.
- Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., and Martin, B. W. (2012). Correlates of physical activity: why are some people physically active and others not? *The Lancet* 380, 258–271. doi: 10.1016/S0140-6736(12)60735-1.
- Blackford, J. U. (2017). Leveraging Statistical Methods to Improve Validity and Reproducibility of Research Findings. *JAMA Psychiatry* 74, 119. doi: 10.1001/jamapsychiatry.2016.3730.
- Brand, R. (2006). Die affektive Einstellungskomponente und ihr Beitrag zur Erklärung von Sportpartizipation [The role of the affective attitudinal component in explaining physical exercise participation]. *Zeitschrift für Sportpsychologie* 13, 147–155. doi: 10.1026/1612-5010.13.4.147.
- Bruland, D., Voß, M., Schulenkorf, T., and Latteck, Ä.-D. (2019). Mit Schwung und Energie durch den Tag. Partizipative Forschung zur Förderung der bewegungsbezogenen Gesundheitskompetenz bei Menschen mit Lernschwierigkeiten [With enthusiasm and energy through the day. Participatory research to promote physical activity-related health literacy in people with intellectual disabilities]. *Präv Gesundheitsf* 14, 368–374. doi: 10.1007/s11553-019-00714-7.
- Cairney, J., Clark, H., Dudley, D., and Kriellaars, D. (2019a). Physical Literacy in Children and Youth—A Construct Validation Study. *Journal of Teaching in Physical Education* 38, 84–90. doi: 10.1123/jtpe.2018-0270.
- Cairney, J., Dudley, D., Kwan, M., Bulten, R., and Kriellaars, D. (2019b). Physical Literacy, Physical Activity and Health: Toward an Evidence-Informed Conceptual Model. *Sports Med* 49, 371–383. doi: 10.1007/s40279-019-01063-3.
- Carl, J., Grüne, E., Popp, J., and Pfeifer, K. (2020). Physical Activity Promotion for Apprentices in Nursing Care and Automotive Mechatronics-Competence Counts More than Volume. *International journal of environmental research and public health* 17. doi: 10.3390/ijerph17030793.

Carl, J., Sudeck, G., Geidl, W., Schultz, K., and Pfeifer, K. (in press a). Competencies for a healthy physically active lifestyle - Validation of an integrative model. *Research Quarterly for Exercise and Sport*. doi: 10.1080/02701367.2020.1752885.

Carl, J., Sudeck, G., and Pfeifer, K. (in press b). Competencies for a healthy physically active lifestyle – Reflections on the Model of Physical Activity-related Health Competence (PAHCO). *Journal of Physical Activity and Health* 17.

Castaneda, B., and Gray, R. (2007). Effects of Focus of Attention on Baseball Batting Performance in Players of Differing Skill Levels 29, 60–77. doi: 10.1123/jsep.29.1.60.

Chen, F. F., Sousa, K. H., and West, S. G. (2005). Testing Measurement Invariance of Second-Order Factor Models. *Structural Equation Modeling: A Multidisciplinary Journal* 12, 471–492. doi: 10.1207/s15328007sem1203\_7.

Cheung, G. W., and Rensvold, R. B. (2002). Evaluating Goodness-of-Fit Indexes for Testing Measurement Invariance. *Structural Equation Modeling: A Multidisciplinary Journal* 9, 233–255. doi: 10.1207/S15328007SEM0902\_5.

Durden-Myers, E. J., Green, N. R., and Whitehead, M. E. (2018). Implications for Promoting Physical Literacy. *Journal of Teaching in Physical Education* 37, 262–271. doi: 10.1123/jtpe.2018-0131.

Edwards, L. C., Bryant, A. S., Keegan, R. J., Morgan, K., and Jones, A. M. (2017). Definitions, Foundations and Associations of Physical Literacy: A Systematic Review. *Sports Med* 47, 113–126. doi: 10.1007/s40279-016-0560-7.

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research* 18, 39–50. doi: 10.1177/002224378101800104.

Frau, J., Coghe, G., Lorefice, L., Fenu, G., Cadeddu, B., Marrosu, M. G., and Cocco, E. (2015). Attitude towards physical activity in patients with multiple sclerosis: a cohort study. *Neurological Sciences* 36, 889–893. doi: 10.1007/s10072-015-2100-x.

Gawlik, A., Streber, R., Flachenecker, P., Gusowski, K., Geidl, W., Tallner, A., and Pfeifer, K. (2018). Konzept eines internetbasierten Programms zur Bewegungsförderung für Personen mit Multipler Sklerose. *Neurol Rehabil* 24, 171–182.

Geidl, W., Semrau, J., Streber, R., Leibert, N., Wingart, S., Tallner, A., Wittmann, M., Wagner, R., Schultz, K., and Pfeifer, K. (2017). Effects of a brief, pedometer-based behavioral intervention for individuals with COPD during inpatient pulmonary rehabilitation on 6-week and 6-month objectively measured physical activity: study protocol for a randomized controlled trial. *Trials* 18, e13. doi: 10.1186/s13063-017-2124-z.

Ginzburg, K., Tsur, N., Barak-Nahum, A., and Defrin, R. (2014). Body awareness: differentiating between sensitivity to and monitoring of bodily signals. *J Behav Med* 37, 564–575. doi: 10.1007/s10865-013-

Gunnell, K. E., Longmuir, P. E., Barnes, J. D., Belanger, K., and Tremblay, M. S. (2018). Refining the Canadian Assessment of Physical Literacy based on theory and factor analyses. *BMC Public Health* 18, 436. doi: 10.1186/s12889-018-5899-2.

Guthold, R., Stevens, G. A., Riley, L. M., and Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health* 6, e1077-e1086. doi: 10.1016/S2214-109X(18)30357-7.

Guthold, R., Stevens, G. A., Riley, L. M., and Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child & Adolescent Health* 4, 23–35. doi: 10.1016/S2352-4642(19)30323-2.

Haible, S., Volk, C., Demetriou, Y., Höner, O., Thiel, A., and Sudeck, G. (2020). Physical Activity-Related Health Competence, Physical Activity, and Physical Fitness: Analysis of Control Competence for the Self-Directed Exercise of Adolescents. *International journal of environmental research and public health* 17. doi: 10.3390/ijerph17010039.

Haible, S., Volk, C., Demetriou, Y., Höner, O., Thiel, A., Trautwein, U., and Sudeck, G. (2019). Promotion of physical activity-related health competence in physical education: study protocol for the GEKOS cluster randomized controlled trial. *BMC Public Health* 19, 26. doi: 10.1186/s12889-019-6686-4.

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., and Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet* 380, 247–257. doi: 10.1016/S0140-6736(12)60646-1.

Hu, L.-t., and Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods* 3, 424–453. doi: 10.1037//1082-989X.3.4.424.

Kister, I., Bacon, T. E., Chamot, E., Salter, A. R., Cutter, G. R., Kalina, J. T., and Herbert, J. (2013). Natural history of multiple sclerosis symptoms. *International journal of MS care* 15, 146–158. doi: 10.7224/1537-2073.2012-053.

Klieme, E., Hartig, J., and Rauch, D. (2010). "The Concept of Competence," in *The Concept of Competence in Educational Contexts*, ed. Hartig, J., Klieme, E. & Leutner, D. (Göttingen: Hogrefe & Huber Publishers), 3–22.

Learmonth, Y. C., Motl, R. W., Sandroff, B. M., Pula, J. H., and Cadavid, D. (2013). Validation of patient determined disease steps (PDDS) scale scores in persons with multiple sclerosis. *BMC neurology* 13, 37. doi: 10.1186/1471-2377-13-37.

- Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., and Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The Lancet* 380, 219–229. doi: 10.1016/S0140-6736(12)61031-9.
- Ley, C., Lintl, E., Bardach, L., Hochedlinger, J., Hofer, V., Strobl, P., Steinmaurer, L. et al. (2014). „Movi Kune - gemeinsam bewegen“: Bewegungstherapie mit Kriegs- und Folterüberlebenden [“Movi Kune - Moving Together“: Movement and Exercise Therapy with War and Torture Survivors]. *Spectrum* 26, 1–27.
- Lubans, D., Morgan, P. J., Cliff, D. P., Barnett, L. M., and Okely, A. D. (2010). Fundamental movement skills in children and adolescents: review of associated health benefits. *Sports medicine* 40, 1019–1035. doi: 10.2165/11536850-000000000-00000.
- Perkins-Ceccato, N., Passmore, S. R., and Lee, T. D. (2003). Effects of focus of attention depend on golfers' skill. *Journal of sports sciences* 21, 593–600. doi: 10.1080/0264041031000101980.
- Pesce, C. (2012). Shifting the Focus From Quantitative to Qualitative Exercise Characteristics in Exercise and Cognition Research. *Journal of sport & exercise psychology* 34, 766–786. doi: 10.1123/jsep.34.6.766.
- Peters, S., Sudeck, G., and Pfeifer, K. (2013). Trainieren, Lernen, Erleben: Kompetenzförderung in Bewegungstherapie und Gesundheitssport [Exercising, learning, and experiencing: Enhancing competences in exercise therapy and health sport]. *Bewegungstherapie und Gesundheitssport* 29, 210–215.
- Pfeifer, K., Sudeck, G., Geidl, W., and Tallner, A. (2013). Bewegungsförderung und Sport in der Neurologie – Kompetenzorientierung und Nachhaltigkeit [Physical activity enhancement and sports in neurology – competence orientation and sustainability]. *Neurologie & Rehabilitation* 19, 7–19.
- Popp, J., Carl, J., Grüne, E., Semrau, J., Gelius, P., and Pfeifer, K. (2020). Physical activity promotion in German vocational education: does capacity building work? *Health Promotion International*, 1–13. doi: 10.1093/heapro/daaa014.
- Rheinberg, F., and Engeser, S. (2010). “Motive Training and Motivational Competence,” in *Implicit Motives*, ed. O. Schultheiss and J. Brunstein (Oxford University Press), 510–548.
- Rhodes, R.E., McEwan, D., and Rebar, A. L. (2019). Theories of physical activity behaviour change: A history and synthesis of approaches. *Psychology of Sport and Exercise* 42, 100–109. doi: 10.1016/j.psychsport.2018.11.010.
- Robinson, D. B., Randall, L., and Barrett, J. (2018). Physical Literacy (Mis)understandings: What do Leading Physical Education Teachers Know About Physical Literacy? *Journal of Teaching in Physical Education* 37, 288–298. doi: 10.1123/jtpe.2018-0135.

- Robinson, L.E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., and D'Hondt, E. (2015). Motor Competence and its Effect on Positive Developmental Trajectories of Health. *Sports Med* 45, 1273–1284. doi: 10.1007/s40279-015-0351-6.
- Rosseel, Y. (2017). "Package lavaan,". <https://cran.r-project.org/web/packages/lavaan/lavaan.pdf>.
- Sallis, J. F., Owen, N., and Fisher, E. (2015). "Ecological models of health behavior," in *Health behavior and Health Education*, ed. K. Glanz, B. G. Rimer, and K. Wiswanath (San Francisco, CA: Jossey-Bass), 43–64.
- Schermelleh-Engel, K., Moosbrugger, H., and Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online* 8, 23–74.
- Schmid, J., Haible, S., and Sudeck, G. (2020). Patterns of physical activity-related health competence: stability over time and associations with subjective health indicators. *German Journal of Exercise and Sport Research*, 1–11. doi: 10.1007/s12662-020-00650-1.
- Sørensen, K., van den Broucke, S., Fullam, J., Doyle, G., Pelikan, J., Slonska, Z., and Brand, H. (2012). Health literacy and public health: A systematic review and integration of definitions and models. *BMC Public Health* 12, 1. doi: 10.1186/1471-2458-12-80.
- Streber, R., and Pfeifer, K. (2018). Bewegungsförderung in der Bewegungstherapie – Konzept eines berufsbegleitenden E-Learning Angebots [Physical activity promotion in exercise therapy: Concept of an E-Learning program for further education]. *Bewegungstherapie und Gesundheitssport* 34, 136–143.
- Sudeck, G., Jeckel, S., and Schubert, T. (2018). Individual Differences in the Competence for Physical-Activity-Related Affect Regulation Moderate the Activity–Affect Association in Real-Life Situations. *Journal of Sport and Exercise Psychology* 40, 196–205. doi: 10.1123/jsep.2018-0017.
- Sudeck, G., and Pfeifer, K. (2016). Physical activity-related health competence as an integrative objective in exercise therapy and health sports – conception and validation of a short questionnaire. *German Journal of Exercise and Sport Research* 46, 74–87. doi: 10.1007/s12662-016-0405-4.
- Tabachnick, B. G., and Fidell, L. S. (2001). *Using multivariate statistics*. 4th ed. Boston: Allyn and Bacon.
- Thiel, C., Pfeifer, K., and Sudeck, G. (2018). Pacing and perceived exertion in endurance performance in exercise therapy and health sports. *Ger J Exerc Sport Res* 48, 136–144. doi: 10.1007/s12662-017-0489-5.
- Tremblay, M. S., Costas-Bradstreet, C., Barnes, J. D., Bartlett, B., Dampier, D., Lalonde, C., Leidl, R. et al. (2018). Canada's Physical Literacy Consensus Statement: process and outcome. *BMC Public Health* 18, S240. doi: 10.1186/s12889-018-5903-x.
- Warburton, D. E.R., and Bredin, S. S.D. (2017). Health benefits of physical activity. *Current Opinion in Cardiology* 32, 541–556. doi: 10.1097/HCO.0000000000000437.

Weiber, R., and Mühlhaus, D. (2015). *Strukturgleichungsmodellierung - Eine anwendungsorientierte Einführung in die Kausalanalyse mit Hilfe von AMOS, SmartPLS und SPSS [Structure Equation Modeling - An application-oriented introduction into causal analysis using AMOS, SmartPLS, and SPSS]*. 2nd ed. Berlin, Springer Gabler.

Whitehead, M. (2007). Physical Literacy: Philosophical Considerations in Relation to Developing a Sense of Self, Universality and Propositional Knowledge. *Sport, Ethics and Philosophy* 1, 281–298. doi: 10.1080/17511320701676916.

Williams, D. M. (2008). Exercise, affect, and adherence: an integrated model and a case for self-paced exercise. *Journal of Sport and Exercise Psychology* 30, 471–496. doi: 10.1123/jsep.30.5.471.

World Health Organization (2018). *More active people for a healthier world: Global action plan on physical activity 2018-2030*. Geneva: World Health Organization.

## Tables

Table 1. An overview of the stepwise approach for the assessment development and validation of PAHCO.

Samples ( <i>n</i> )	Sector	Publication	Number of included PAHCO aspects	Included aspects
Medical rehabilitation ( <i>n</i> = 1,028)	Rehabilitation	Sudeck and Pfeifer (2016)	3	Affect regulation, control of physical load, self-control
University sports ( <i>n</i> = 1,331)	Prevention	Sudeck and Pfeifer (2016)	3	Affect regulation, control of physical load, self-control
COPD rehabilitants ( <i>n</i> = 351)	Rehabilitation	Carl et al. (in press a)	5	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy
Apprentices in nursing care and car mechatronics ( <i>n</i> = 745)	Prevention	Carl et al. (in press a)	8*	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD
Persons with Multiple Sclerosis ( <i>n</i> = 475)	Rehabilitation	Present study	10	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD, body awareness, cognitive attitude
Teacher students undergoing a basic qualification program in PE ( <i>n</i> = 502)	Prevention	Present study	10	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD, body awareness, cognitive attitude

Abbreviations: MED = Manageability of Endurance Demands; MSD = Manageability of Strength Demands; MBD = Manageability of Balance Demands.

Note: \*In exploratory analyses, the ninth factor body awareness has shown bad coefficients of reliability. Therefore, it was excluded in this step.

Table 2. Analyses of reliability and discriminant validity of the final ten-factor measurement model on PAHCO with the sample of persons with multiple sclerosis.

	Loading	Indicator Reliability	Factor Reliability	Average Variance Extracted	Highest Squared Correlation
<b>Manageability of Endurance Demands (MED)</b>			.941	0.800	0.646
END30	0.891	0.794			
END60	0.930	0.865			
END10s	0.855	0.731			
END30s	0.901	0.812			
<b>Manageability of Strength Demands (MSD)</b>			.929	0.756	0.696
STR15	0.822	0.676			
STR25	0.845	0.714			
STR5m	0.893	0.797			
STR15m	0.914	0.835			
<b>Manageability of Balance Demands (MBD)</b>			.957	0.785	0.696
BAL1	0.873	0.762			
BAL2	0.836	0.699			
BAL3	0.847	0.717			
BAL4	0.940	0.884			
BAL5	0.932	0.869			
BAL6	0.883	0.780			
<b>Body Awareness</b>			.933	0.715	0.572
BAW2	0.783	0.613			
BAW4	0.804	0.646			
BAW3b	0.815	0.664			
BAW7	0.920	0.846			
BAW8	0.897	0.805			
<b>Control of Physical Load</b>			.906	0.617	0.572
CCPL1	0.767	0.588			
CCPL2	0.820	0.672			
CCPL3	0.787	0.619			
CCPL4	0.785	0.616			
CCPL5	0.838	0.702			
CCPL6	0.710	0.504			
<b>Affect Regulation</b>			.947	0.820	0.493
AR1	0.867	0.752			
AR2	0.913	0.834			
AR3	0.945	0.893			
AR4	0.895	0.801			
<b>Self-Efficacy</b>			.918	0.816	0.486
SE1	0.838	0.702			

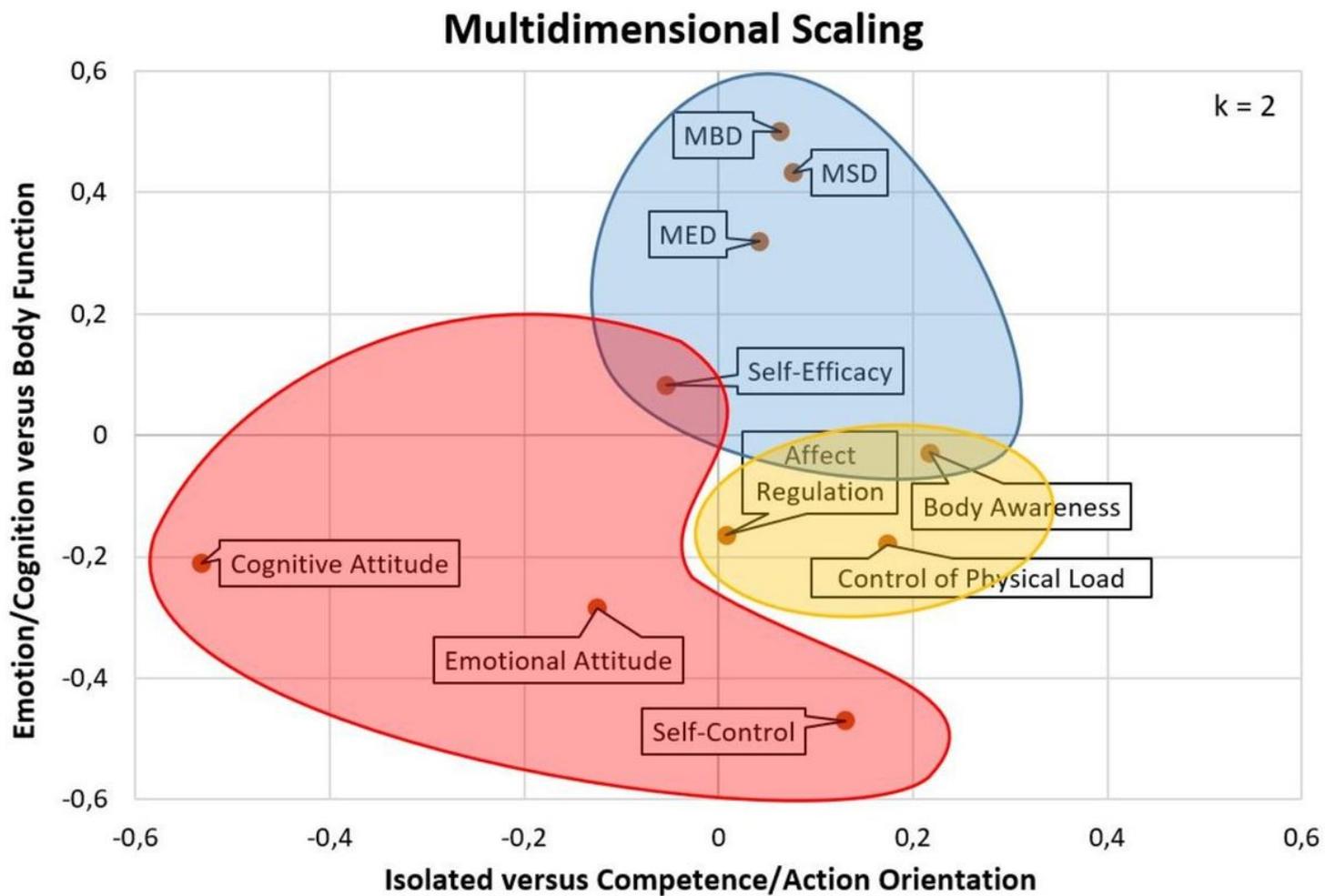
SE2	0.992	0.984			
SE3	0.873	0.762			
<b>Self-Control</b>			.923	0.801	0.482
SC1	0.869	0.755			
SC2	0.916	0.839			
SC3	0.900	0.810			
<b>Emotional Attitude</b>			.975	0.906	0.493
AEM1	0.914	0.835			
AEM2	0.957	0.916			
AEM3	0.974	0.949			
AEM4	0.962	0.925			
<b>Cognitive Attitude</b>			.933	0.781	0.260
ATCOG1	0.892	0.796			
ATCOG2	0.856	0.733			
ATCOG3	0.916	0.839			
ATCOG4	0.869	0.755			

Table 3. Analyses of reliability and discriminant validity of the final ten-factor measurement model on PAHCO with the sample of teaching students.

	Loading	Indicator Reliability	Factor Reliability	Average Variance Extracted	Highest Squared Correlation
<b>Manageability of Endurance Demands (MED)</b>			.836	0.585	0.246
END30	0.680	0.462			
END60	0.772	0.596			
END10s	0.783	0.613			
END30s	0.818	0.669			
<b>Manageability of Strength Demands (MSD)</b>			.800	0.543	0.171
STR15	0.787	0.619			
STR25	0.803	0.645			
STR5m	0.610	0.372			
STR15m	0.732	0.536			
<b>Manageability of Balance Demands (MBD)</b>			.899	0.594	0.224
BAL1	0.783	0.613			
BAL2	0.756	0.572			
BAL3	0.857	0.734			
BAL5	0.774	0.599			
BAL6	0.672	0.452			
<b>Body Awareness</b>			.841	0.518	0.634
BAW2	0.633	0.401			
BAW4	0.617	0.381			
BAW3b	0.632	0.399			
BAW7	0.863	0.745			
BAW8	0.815	0.664			
<b>Control of Physical Load</b>			.855	0.504	0.634
CCPL1	0.766	0.587			
CCPL2	0.728	0.530			
CCPL3	0.662	0.438			
CCPL4	0.640	0.410			
CCPL5	0.722	0.521			
CCPL6	0.733	0.537			
<b>Affect Regulation</b>			.926	0.763	0.419
AR1	0.821	0.674			
AR2	0.899	0.808			
AR3	0.928	0.861			
AR4	0.841	0.707			
<b>Self-Efficacy</b>			.876	0.738	0.362
SE1	0.759	0.576			
SE2	0.989	0.978			

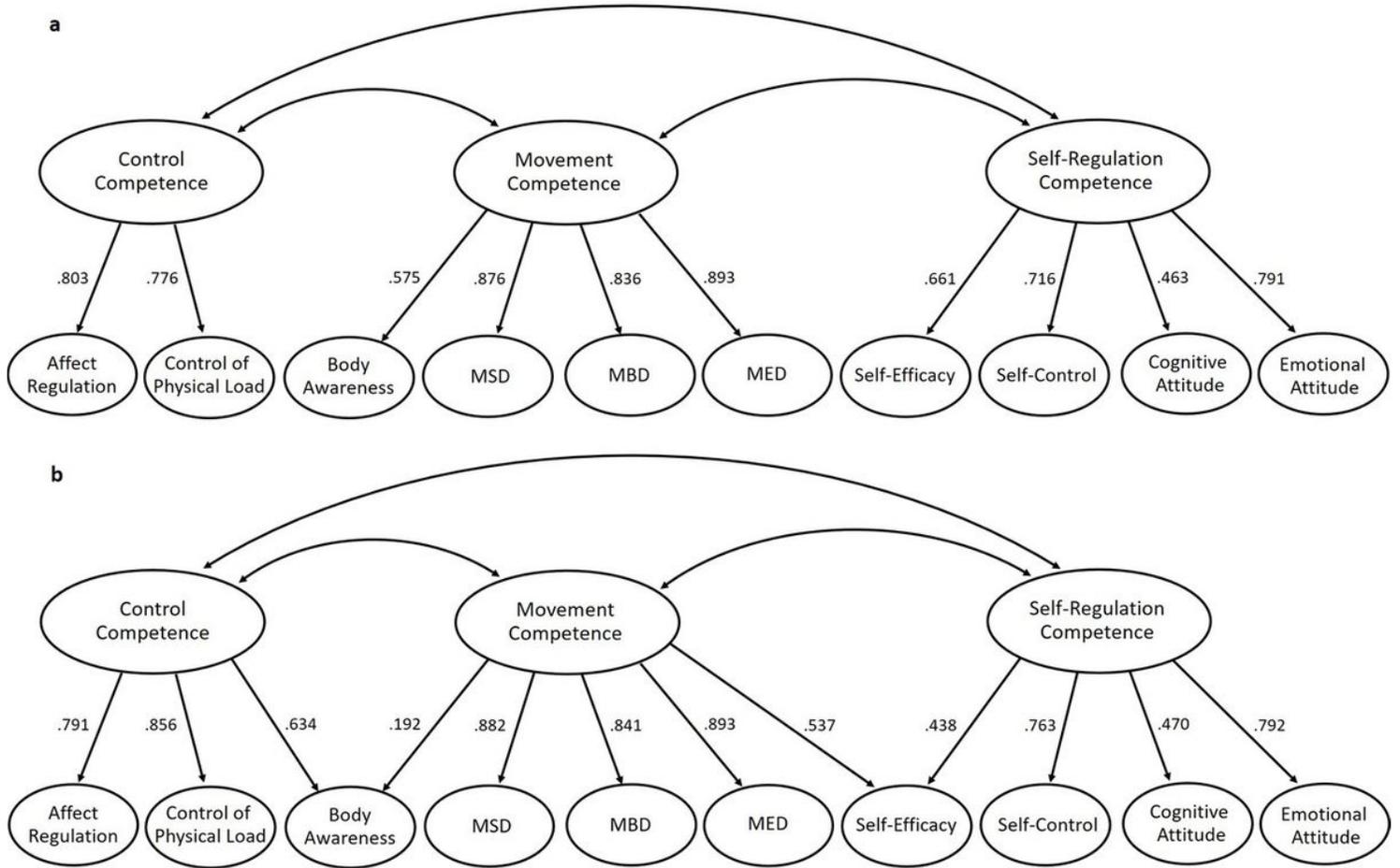
SE3	0.812	0.659			
<b>Self-Control</b>			.906	0.767	0.372
SC1	0.811	0.658			
SC2	0.920	0.846			
SC3	0.892	0.796			
<b>Emotional Attitude</b>			.920	0.746	0.419
AEM1	0.823	0.677			
AEM2	0.876	0.767			
AEM3	0.894	0.799			
AEM4	0.860	0.740			
<b>Cognitive Attitude</b>			.871	0.637	0.136
ATCOG1	0.805	0.648			
ATCOG2	0.783	0.613			
ATCOG3	0.792	0.627			
ATCOG4	0.812	0.659			

## Figures



**Figure 1**

The physical activity-related health competence (PAHCO) model (Sudeck and Pfeifer, 2016).



**Figure 2**

Second-order CFA modeling with the ten first-order factors. 2a) and a one-on-one allocation (simple structure). 2b) and two theory-conform cross-loadings

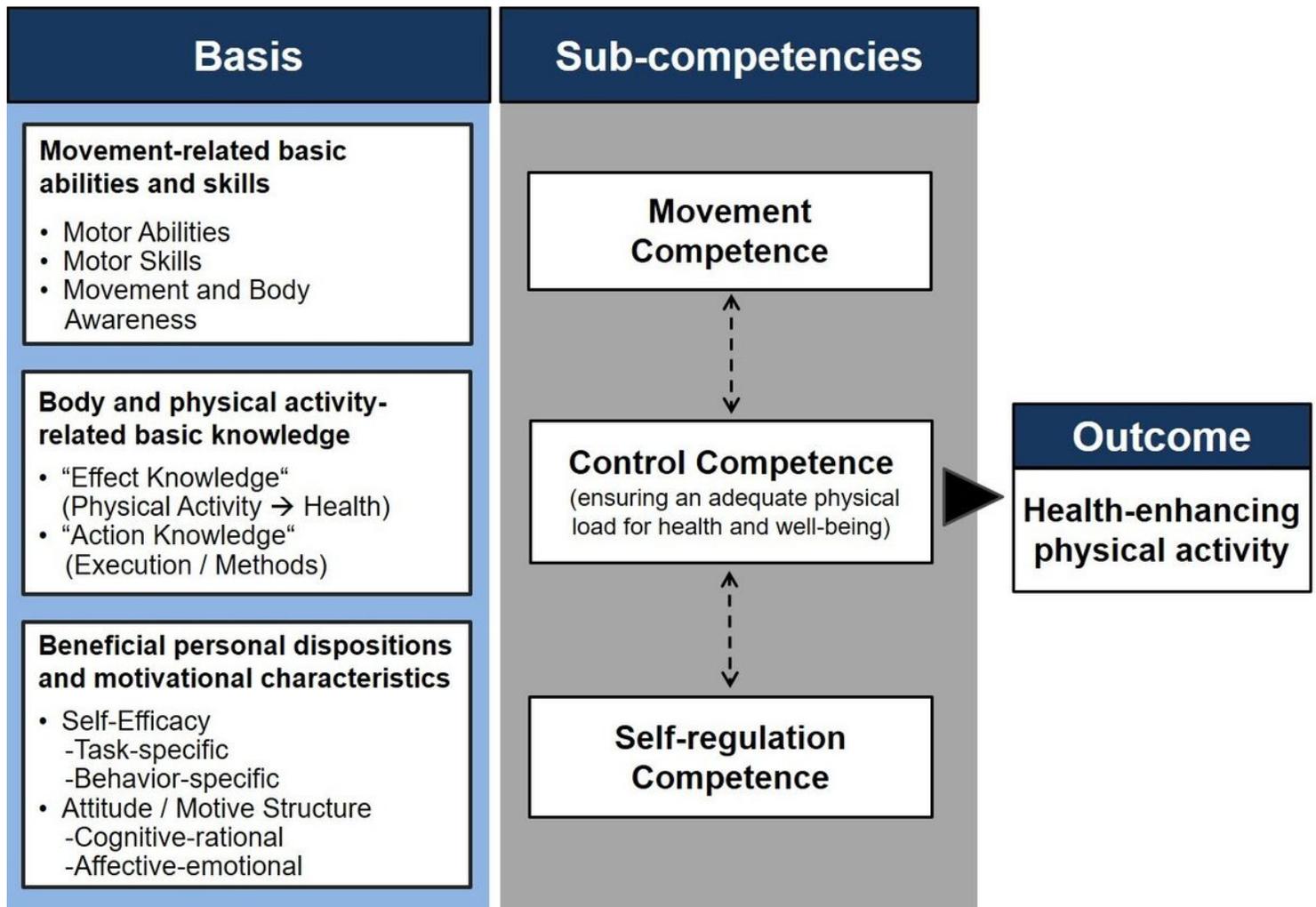


Figure 3

Multidimensional scaling (two-dimension solution).

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [FrontPsycholSupplementaryMaterial.docx](#)