Competencies for a healthy physically active lifestyle – Validation of an integrative model

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Abstract

Purpose: The model of physical activity-related health competence (PAHCO) provides an integrative and interdisciplinary view on the multitude of competencies that are necessary when people want to lead a physically active lifestyle. For further validation of this framework, the goal of the present study was to extend first measurement models on PAHCO (Sudeck & Pfeifer, 2016) and thereby contribute to the development of a standardized assessment tool.

Method: In Study 1, a measurement model with five predictors on PAHCO was tested with 341 COPD patients undergoing inpatient rehabilitation. In Study 2, data from 745 apprentices were used to create an extended eight-factor measurement model. We undertook reliability analysis, confirmatory factor analysis (CFA), and structural equation modeling (SEM) to assess the validity of the models.

Results: The analyses showed good results for the reliability and discriminant validity of the factors. Accordingly, the CFA revealed satisfactory overall fits for the five-factor as well as for the extended eight-factor measurement model. In addition, the significant associations with physical activity and physical health parameters indicated criterion validity of almost all PAHCO factors. The explained variance of the multivariate models lay between 9.8% and 10.4% in Study 1 and between 9.5% and 21.3% in Study 2.

Conclusion: In the present study, it was possible to extract a well-fitting eight-factor measurement model and accumulate further evidence on the validity of the PAHCO model. Future research should strive for a cross-validation of the measurement model and more deeply investigate the internal structure of the eight factors.

Introduction

Background

Due to its beneficial long-term effects, there is no doubt that physical activity (PA) plays an important role in the maintenance and promotion of health (Warburton & Bredin, 2017). Fostering people’s PA behavior not only exerts a beneficial influence on biomedical parameters and the prevention of certain diseases (Booth, Roberts, & Laye, 2012) but also contributes to psychological well-being (e.g., Lubans et al., 2016) and social functioning (Shvedko, Whittaker, Thompson, & Greig, 2018). Accordingly, supporting people in adhering to a physically active lifestyle can be considered a worthwhile goal of our societies (World Health Organization, 2018). Nevertheless, most programs and interventions of our health systems are not explicitly geared toward this important task (e.g., Geidl et al., 2018). The main reason for this problem may lie in the fact that many professions such as exercise therapists, fitness instructors, and health consultants prioritize foci on physical conditioning and the recovery of body functions (Geidl et al., 2018). For an active lifestyle, however, it is also necessary to equip individuals with certain skills that empower them to perform physical activities in a self-responsible, self-organized, autonomous and, ideally, self-determined manner (Best, Miller, Eng, & Routhier, 2016).

In this regard, exercise psychology research has a considerable tradition of identifying mechanisms supporting the adherence to regular PA (for an overview, see Rhodes, McEwan, & Rebar, 2019). For example, it is important to have a positive attitude (McEachan, Conner, Taylor, & Lawton, 2011), high self-efficacy and strategies of self-control (Sniehotta, Scholz, & Schwarzer, 2005). This scientific field, in turn, tends to mask qualitative aspects of PA (e.g., Rhodes et al., 2019). Qualitative, in this context, means that individuals should not only mechanically apply a physical stimulus to themselves as frequently and intensively as possible but also should be able to ensure that the corresponding stimulus has a certain health-related quality (Sudeck & Pfeifer, 2016). To achieve this, persons should acquire basic knowledge about the appropriateness of exercises and the health-related effects of PA (Hui, Hui, & Xie, 2014). In addition, they can benefit if they learn how to distribute their energetic resources over the course of an exercise session as well as for PA in everyday life (Thiel, Pfeifer, & Sudeck, 2018) and to adequately interpret sensory signals from the body (e.g., increased heart rate).

Given the complex nature of the skills required, it would be a crucial step to gain an integrative understanding of the person-related factors favoring the adoption of a healthy, physically active lifestyle. An integrative understanding in this context implies that functional-conditional and psychological-pedagogical factors have to be taken into account at the same time. Such a perspective necessarily has to involve different scientific disciplines, such as exercise psychology, sports medicine, and sports pedagogy (Kirk & Haerens, 2014). With their philosophical foundations rooted in monism, existentialism, and phenomenology (Whitehead, 2007), the *physical literacy* concept was formed an important approach integrating these different perspectives within a theoretically sound framework. This approach has gained increasing popularity over the past two decades (Edwards, Bryant, Keegan, Morgan, & Jones, 2017). Highlighting the claim that there is “something for everyone” (Durden-Myers, Green, & Whitehead, 2018; Robinson, Randall, & Barrett, 2018), this concept was designed to engage the maximum number of people in physical activities for life, regardless of the underlying motives. Correspondingly, the term of physical literacy is very inclusive with regard to the purpose of physical activities, comprising adventure, athletic, fitness and health, aesthetic-expressive, competitive, and interpersonal forms of movement (Durden-Myers et al., 2018; Robinson et al., 2018). HDue to this openness, however, according to Cairney et al. (Cairney, Dudley, Kwan, Bulten, & Kriellaars, 2019), the physical literacy approach has not fully exhausted its health potential and public health impact as the links to health as an outcome have not yet been sufficiently conceptualized.

In line with this basic idea, Pfeifer, Sudeck, Geidl, and Tallner (2013) as well as Sudeck and Pfeifer (2016) worked out a model from more of a health literacy perspective (e.g., Sørensen et al., 2012). The researchers adapted a general health competence model (Lenartz, 2012) and created a domain-specific framework through the specification and pooling of competencies that are necessary to execute physical activities in a health-oriented way (see Figure 1). The approach adhered to the notion of competence that underscores the domain-specificity, context-boundedness, and action-relatedness of personal factors (Koeppen, Hartig, Klieme, & Leutner, 2008). Accordingly, this approach tends to stress the functional role of latent abilities and skills (Klieme, Hartig, & Rauch, 2010), which, unlike the physical literacy approach, has thus far mainly entailed applications with adults and persons suffering from chronic diseases (e.g., Bruland, Voß, Schulenkorf, & Latteck, 2019; Geidl et al., 2017; Ley et al., 2014; Pfeifer et al., 2013; Sudeck, Jeckel, & Schubert, 2018; Sudeck & Pfeifer, 2016).

(Figure 1)

The model of Physical Activity-related Health Competence

According to their model, the superordinate construct *Physical Activity-related Health Competence* (PAHCO) comprises three major competence areas (Sudeck & Pfeifer, 2016). First, people should acquire *movement competence* that allows them to master the locomotor challenges of daily life (e.g., climbing stairs, carrying heavy bags) and participate in a variety of health-related activities (e.g., walking, swimming or cycling). The second area, *self-regulation competence,* encompasses psychological factors that can guarantee regular PA. The third area, *control competence*, ultimately ensures that individuals do not merely apply any stimulus as frequently and intensively as possible. Instead, covering the qualitative side of health, this dimension refers to the adequate alignment of physical loads in terms of physical health (competence for "control of physical load") and subjective well-being (competence for PA-specific "affect regulation).

These three major competence areas are formed by the specific interplay of basic elements (see the left part of Figure 1). For example, movement competence is characterized by sophisticated motor skills/abilities (e.g., strength, endurance, coordination) in combination with good body awareness. The term control competence means that people require (declarative) effect knowledge about the health-related benefits of physical activity as well as (procedural) action knowledge about how and when (e.g., training methods, situation-specific adaptation) to practically apply these loads to one's own body. According to the PAHCO model, possessing a positive attitude toward PA, as well as strong task- and behavior-specific self-efficacy are central and important elements of self-regulation competence.

Current state of empirical validation

Physical activity-related health competence has several times been the target of education and interventions (e.g., Bruland et al., 2019; Geidl et al., 2017; Haible et al., 2019; Ley et al., 2014; Streber & Pfeifer, 2018). The promotion of PAHCO has even gained access into the classification of therapeutic services by the German pension insurance. But even though health sport organizations and institutions have already acknowledged the importance of physical activity-related health competence, the underlying "conceptual basis is still in its infancy" (Sudeck & Pfeifer, 2016, p. 75). Empirical validations are necessary to clarify the structural relationships between different competence areas or investigate associations with central outcomes (i.e., physical activity).

Translating a theoretical model into a model that is empirically testable is a complex, yet crucial step in research in general and in competence approaches in particular (Klieme et al., 2010). In a first article, Sudeck and Pfeifer (2016) examined the structure of three selected PAHCO aspects (see the yellow factors in the background of Figure 1). The authors considered the control of physical load and affect regulation as aspects of control competence, while PA-specific self-control served as an indicator of self-regulation competence. In two different samples (persons undergoing medical rehabilitation, participants from the prevention sector), confirmatory factor analyses (CFAs) revealed a satisfactory global fit for their three-factor measurement model as well as evidence of construct validity and reliability. In addition, the researchers could register substantial associations of the three PAHCO aspects with habitual sport activities and indicators of motor function (Sudeck & Pfeifer, 2016). Specifically, a latest study found that the trait competence measure of affect regulation significantly moderated the association between the individuals' PA level and concrete affective reactions in real-life situations (Sudeck et al., 2018). In summary, these first validations concentrated on single aspects attributable to the domains of control competence and self-regulation competence (see the yellow factors in the middle of Figure 1). To reinforce the substance of these two competence areas, it is important to cross-validate these model findings with other populations, which would strengthen the generalizability and external validity of the results (Blackford, 2017). Moreover, the current status of operationalization (one indicator) does not sufficiently account for the multifaceted character of self-regulation competence (Pfeifer et al., 2013; Sudeck & Pfeifer, 2016). Therefore, it is necessary to undertake further operationalizations of this sub-competence by relying on additional constructs named in the original model (Figure 1). Ultimately, to live up to the claim of a multidimensional concept, it would be central to promote the empirical validation of aspects of movement competence. This step has not been done with any operationalizable factor yet. In summary, the present study addressed the question as to whether it was possible to cross-validate and extend measurement models on PAHCO meeting the integrative, multidimensional, and competence-oriented character of the framework.

Goals of the study

More specifically, the goals of the present study were to (1) re-examine the factorial structure of the three-factor PAHCO model with two further samples, (2) extend the model validation across further aspects of self-regulation competence, (3) extend the model validation across all three dimensions of PAHCO (movement competence, control competence, self-regulation competence), and, parallel to that, (4) contribute to the development of a standardized assessment tool of PAHCO.

To achieve these model-based goals, we followed a two-step validation approach using two diverse, yet specific samples from the two major fields of health-enhancing physical activity (HEPA), namely the rehabilitation (Study 1) and the prevention (Study 2) sectors. The selection of these populations was linked to the approval of two research projects in which PAHCO had an important role. Study 1 involved persons with Chronic Obstructive Pulmonary Disease (COPD) at the beginning of inpatient pulmonary rehabilitation, and Study 2 included apprentices from nursing care and car mechatronics.

Methods

The successive model validation included the following circular steps (Bühner, 2011): (1) selection of appropriate instruments for the assessment of constructs specified in the model, (2) explorative item analysis – removal of inadequate items (if necessary), (3) inspection of factorial validity using CFA, (4) evaluation of reliability and discriminant validity, and (5) analysis of associations with measures of physical activity and physical health (criterion validity) using structural equation modeling (SEM).

All statistical analyses (steps 2-5) were performed using the software R (version 3.4.3) with the Lavaan package (Rosseel, 2017). Explorative item selection was based on the interplay of statistical coefficients on one hand (Cronbach's α for internal consistency, part-whole correlation, item difficulty, variance within the sample) and content-related arguments on the other. For the specification of CFA models, we constantly fixed the factor loadings of the first items of each construct to 1. As the Mardia test indicated substantial violations against multivariate normality for both samples (skewness and kurtosis, $p < .001$), we relied on robust maximum likelihood estimators (MLRs) with Satorra-Bentler-scaled statistics to evaluate the fit of the models. We calculated the chi-squared test (SB-χ^2), and since this test tends to systematically reject models of high complexity and models tested with huge sample sizes (Cheung & Rensvold, 2002), we placed more attention on a variant that takes into account the degrees of freedom (SB-χ^2/df). Furthermore, we followed the suggestions by Hu and Bentler (1996), who recommended reporting standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), and comparative fit index (CFI). For the interpretation of the magnitude of these coefficients, we adhered to common guidelines indicating good ($\chi^2/df \leq 2.0$, RMSEA $\leq .05$, SRMR $\leq .05$, CFI $\geq .95$) or acceptable/satisfactory ($\chi^2/df \leq 3.0$, RMSEA $\leq .08$, SRMR $\leq .10$, CFI $\geq .90$) model fits (Schermelleh-Engel, Mossbrugger, & Müller, 2003; Weiber & Mühlhaus, 2015, p. 222). Missing values were treated by applying full information maximum likelihood (FIML) procedures. After the selection of appropriate models, we extracted information with regard to indicator and factor reliability. Discriminant validity was determined by following the criterion of Fornell and Larcker (1981), which posits that discriminant validity is given when the average variance extracted (AVE) of each construct is higher than the squared correlation with any other construct. Ultimately, the CFA was extended to a SEM in order to analyze associations with physical activity. We ran separate analyses for the single predictors (univariate) but also calculated multivariate models with all factors in combination.

Study 1

Background and methodology of the study

The goal of the first study was to re-examine and cross-validate the three-factor structure already worked out by Sudeck and Pfeifer (2016). Hence, we used the same instrument for the operationalization of the three factors in our survey. The questionnaire comprised 13 items answered on a five-point Likert scale (for details, see Appendix 1).

In addition, we took into account that self-regulation competence not only covers aspects of self-control but also embraces mental processes that play a role before action (see also the link to the basic elements). This assumption has not yet been integrated into assessments and model validations. *Emotional attitudes*, listed at the left bottom of the model (Figure 1), can be viewed as an important determinant for the regular execution of physical activities (Brand, 2006). Conceptualized as the emotionally colored evaluation disposition toward the behavior of concern, the factor was recorded via a German scale for the measurement of the affective attitude component (Brand, 2006). This tool consisted of four items that were rated on a seven-point Likert scale. *Self-efficacy*, also located at the left bottom of the model (Figure 1), was assessed using three self-developed items (Appendix 1). These items referred to the confidence to perform physical activities, whereby there was an increasing difficulty in the labeling of the corresponding activities ("challenging physical activities," "highly challenging physical activities," "most difficult sport activities"). The operationalization of these two additional factors allowed the extension to and evaluation of a five-factor measurement model of PAHCO.

The 20 items were part of the T1 baseline questionnaire of the "Stay Active after Rehabilitation" (STAR) study, which focused on the PA behavior of patients with COPD before and after undergoing inpatient rehabilitation (Geidl et al., 2017). The activity behavior was assessed objectively two weeks before rehabilitation (T0 assessment) using triaxial accelerometry (ActiGraph wGT3X-BT, Pensacola, Florida). In the following analyses, PA was operationalized by the average number of steps per day and the amount of time spent with moderate-to-vigorous physical activity (MVPA). Until June 2018, 418 patients gave consent to study participation, and 341 of them were included in the following model validation. The reasons for exclusion were refuted COPD status (Tiffeneau-Pinelli-Index FEV1/FVC was not < 70%, n = 62), non-realization of the planned clinic stay (n = 3), dropout from the whole study (n = 10), no participation at time point T1 (n = 1) and retrospective withdrawal of consent to data use (n = 1). The included participants were an average of 58.1 ± 5.5 years old, had a BMI of 27.7 ± 7.0, and were predominantly male (68.3%).

Results of the study

As expected, the empirical matrix of the three-factor measurement model deviated significantly from the theoretical covariance matrix (SB-χ^2(62) = 158.27, $p < .001$). Nevertheless, the model showed a satisfactory overall fit (SB-χ^2/df = 2.55, CFI = 0.938, RMSEA = 0.070 [CI_{90}=0.058-0.082], SRMR = 0.056). This result with the sample of patients with COPD supports the factorial validity of the existing three-factor model (cross-validation).

In the first step of the intended model extension, the two additional factors, emotional attitudes and self-efficacy, were subject to initial item analysis (Appendix 2). The item difficulties and part-whole-corrected correlations were located in a satisfactory area. With respect to the self-efficacy scale, it was striking that the third item (SE3) contributed slightly negatively to internal consistency. Since it was fruitful to include an item with the wording of "sport"[1] and there was no other statistical argument to cancel this item, we decided to retain the initial number of items. The emotional attitudes measure also contained one problematic item. The overall scale would be more reliable if the fourth item (ATEM4) was removed. Our main explanation for this finding was the fact that the original instrument (Brand, 2006) provided an inverted scale for this item (as opposed to the other three items). Therefore, we decided to drop this item for the current sample but to reintegrate it in the next sample with a modified scaling direction.

The CFA with the five factors and its 19 items revealed a satisfactory global fit (SB-$\chi^2(142) = 328.56$, $p < .001$, SB-$\chi^2/df = 2.31$, CFI = 0.934, RMSEA = 0.064 [CI_{90}=0.056-0.073], SRMR = 0.063). There was a highly significant loading from all items on their corresponding factors ($p < .001$). However, the last (λ_{CCPL6} = 0.61) and the first items (λ_{CCPL1} = 0.60) of the Control of Physical Load factor displayed comparably low regression weights (see Table 1). Accordingly, the reliability of these two indicators (0.36 and 0.37) was characterized as marginally acceptable (Weiber & Mühlhaus, 2015). From a content perspective, both directly referred to the adjustment of training to their body and physical condition items (see Appendix 1). We suggest that, for people with COPD, this adjustment task could present an outstanding challenge for this population that is somewhat distinct from other aspects of load control (e.g., the development of an endurance or strength program). The AVE was good to acceptable, whereby Control of Physical Load was again the weakest factor ($0.477 \leq AVE \leq 0.852$). The AVE of every factor was higher than its squared correlation with any other factor ($0.177 \leq r_{max}^2 \leq 0.360$), which indicates discriminant validity of the model (Fornell-Larcker-Criterion) and the corresponding assessment. The reliabilities on the factor level showed satisfactory values ($0.819 \leq \alpha \leq 0.943$).

(Table 1)

In the univariate models, three and four competence factors, respectively, were significantly and positively associated with the two objective activity indicators (Table 2). The strongest relationships with the number of steps or with MVPA were registered for affect regulation ($\beta_{Steps} = 0.229$, $\beta_{MVPA} = 0.215$, $p < .001$) and self-control ($\beta_{Steps} = 0.224$, $\beta_{MVPA} = 0.245$, $p < .001$), whereas control of physical load displayed the weakest associations ($\beta_{Steps} = 0.087$, $p = 0.225$; $\beta_{MVPA} = 0.073$, $p = 0.302$). In the multivariate models, the magnitude of the single coefficients decreased substantially, with only the affect regulation factor remaining significant for both dependent variables ($\beta_{Steps} = 0.212$, $p = 0.032$; $\beta_{MVPA} = 0.184$, $p = 0.042$). The associations of the control of physical load factor turned to the negative range ($\beta_{Steps} = -0.246$, $p = 0.009$; $\beta_{MVPA} = -0.256$, $p = 0.008$). This suppressor effect could result from the strong correlation with affect regulation ($r = 0.600$), which was a very strong predictor in the multivariate model. Overall, the five PAHCO factors explained 9.8% and 10.4%, respectively, in both activity outcomes. Assuming that the patients' severity of the disease may significantly influence their daily behavior, we ran an additional model with the COPD disease stage (deduced by the FEV1 value after bronchospasmolysis) treated as a covariate (β_{Steps} = -0.350, β_{MVPA} = -0.347, p < .001). Contrary to the unadjusted version, affect regulation was a non-significant predictor in both models (β_{Steps} = 0.146, β_{MVPA} = 0.119, n.s.). Instead, self-control became a significant determinant for the number of steps after the specification of the covariate (β_{Steps} = 0.176, p = .050). Against the background of these results, it must be concluded that the inclusion of the severity of the disease variable shifted the pattern within the predicting factors. Nevertheless, the PAHCO model has a predictive quality for activity behavior that is clearly incremental to the mere knowledge of the severity of an individual's pulmonary disease.

(Table 2)

Discussion and preliminary summary

Study 1 and its sample of patients with COPD allowed the cross-validation of the recently developed three-factor measurement model of PAHCO as well as the extension to a corresponding five-factor measurement model. Analyses of reliability were encouraging even though they indicated the need to invert the scaling of one emotional attitude item in future studies. Forthcoming projects should keep track of two items (λ_{CCPL1}, λ_{CCPL6}) due to their display of surprisingly low values compared with previous samples (Sudeck & Pfeifer, 2016). Notwithstanding, the present study revealed that the five factors could be well delimited from each other (factorial and discriminant validity), which justifies our strategy to strive for a multidimensional operationalization of the sub-competencies by drawing a link to the basic elements of the model (see Figure 1). Furthermore, univariate analyses have shown that three and four factors, respectively, were significantly related to PA behavior. This confirms one of the tenets of the PAHCO model. Nevertheless, the present study could not accumulate evidence with regard to the importance of the control of physical load factor. Since this factor was originally conceptualized as covering mainly the qualitative side of exercise and activity regulation (see the items in Appendix 1), this finding may be partially linked to the quantitative and volume-oriented validation criterion of HEPA in this study (see also the general discussion). The multivariate model, which took into account the interdependencies of the different predictors, demonstrated that two factors seemed to have the most dominant influence on PA. The first major factor was the COPD patients' knowledge and controlling ability to adjust the physical load in terms of their mood and mental wellbeing. The regression coefficients in our sample were considerably higher than in the survey with other health conditions (Sudeck & Pfeifer, 2016). The subjective wellbeing during exercise (or physical activities in general) could present a much more important regulating mechanism for COPD patients than for other populations. This specific group typically faces many physical challenges in daily life and may therefore tend to avoid the orientation on rigid activity goals (e.g., walked kilometers or lifted weights). The second major factor was

the persons' evaluation of self-control, which had a strong predictive power. The latter finding is in line with the behavior change literature, which has repeatedly underscored the importance of these processes for PA behavior (e.g., Sniehotta et al., 2005). Notwithstanding, the regression coefficients were slightly lower than in the previous validation study (Sudeck & Pfeifer, 2016).
The present study could extend validations of the PAHCO model through the specification of further aspects attributable to the overarching competence domain of self-regulation. In the next study, we tried to further expand the measurement models by empirically capturing aspects of movement competence in the context of the framework.

Study 2

Background and methodology of the study

The goal of the second study was to cross-validate the three- and five-factor PAHCO variants using the same compilation of items from Study 1 and to explore a nine-factor measurement model that also includes aspects of movement competence. Most existing measurements on motor components, that are embedded into holistic assessments, follow the literacy approach and rely on objective data from physical or performance tests (e.g., Cairney, Clark, Dudley, & Kriellaars, 2019; Gunnell, Longmuir, Barnes, Belanger, & Tremblay, 2018). Following the competence idea, however, movement competence can also be represented by self-ratings of how an individual is able to master endurance, strength, and balance demands (see Figure 1), thus comprising the qualitative side of exercise and activity regulation. For this three-part differentiation, we adhered to global (World Health Organization, 2010) and national (Rütten & Pfeifer, 2016) recommendations on physical activity that suggest tangible volume-based thresholds for these three goal dimensions. For the competence-oriented formulation of items, we chose concrete situations from daily life. *Manageability of endurance demands* (MED) and *manageability of strength demands* (MSD) were operationalized by developing five items per factor (for details, see Appendix 1). We thereby closely oriented toward the item formulations of the instrument FFB-Mot (Bös et al., 2002). *Manageability of balance demands* (MBD) was assessed with six items that cover static and dynamic challenges on one hand, and tasks of locomotion and object control on the other. In addition to the three motor qualities, we strove for a competence-oriented assessment of *body awareness* which was measured with five self-developed items being rated on a five-point Likert scale (Appendix 1).

Data were taken from the multicenter baseline assessment of the "Physical Activity-related Health Competence in Apprenticeship and Vocational Education" (PArC-AVE) project, which aimed at the promotion of PA among apprentices from two vocational fields in Bavaria (Germany). A total of 496 apprentices from the car mechatronics sector (82.4% male, age: 18.2 ± 2.2 years) as well as 249 apprentices from the nursing care sector (87.0% female, age: 20.8 ± 4.6 years), or if aged under 18 also their parents, provided informed consent for survey participation. In this study, the amount of PA in the past four weeks was assessed using the validated German self-report questionnaire BSA (Fuchs, Klaperski, Gerber, & Seelig, 2015). In concrete terms, the sum scores of regular sport activities[1] and overall physical activity served as primary validation criteria in the SEM. To avoid extreme over-reporting and outlier problems, we applied winsorization technique for every activity dimension by replacing any data points over the 95th percentile (corresponding to a sport activity cutoff of 860 minutes per week) with the value of the 95th percentile. Since the outcomes of the first study referred only to the volume and thus quantitative side of HEPA, we treated physical health as an additional validation criterion by calculating the sum score of the physical dimension of the SF-12 Questionnaire (Morfeld, Kirchberger, & Bullinger, 2011).

Results of the study

The CFA with this sample revealed a good fit for the three-factor (SB-χ^2(62) = 167.46, $p < .001$, SB-χ^2/df = 2.70, CFI = 0.975, RMSEA = 0.048 [CI_{90}=0.041-0.056], SRMR = 0.034) and the five-factor measurement models on PAHCO (SB-χ^2(160) = 331.61, $p < .001$, SB-χ^2/df = 2.07, CFI = 0.978, RMSEA = 0.038 [CI_{90}=0.033-0.043], SRMR = 0.033). These analyses confirmed the factorial validity of the previous model variants with a further population.

Subsequently, the four new scales were subject to exploratory item analyses (see Appendix 2). The first items of both the MSD and the MBD scales were excluded due to their unacceptable item difficulty ($P_i \geq$ 0.95), which also affected other relevant statistics (e.g., Cronbach's alpha). Due to not detecting any statistical anomalies, we retained all six items of the balance scale. With regard to the body awareness scale, we found that two out of the five items had very bad statistical coefficients (Cronbach's α and Part-Whole-Correlation). We grounded this finding in the fact that these two items had an inverted sense. Since the remaining three items referred only to phenomena of posture and muscular tension, we thought that the factor body awareness would no longer be sufficiently represented (for the multifaceted nature of this construct, see Röhricht et al., 2004). Against this background, we decided to drop the factor and continue with an eight-factor measurement model.

(Table 3)

The CFA displayed a good overall fit for the eight-factor variant and its 34 items (SB-χ^2(499) = 1365.8, p < .001, SB-χ^2/df = 2.74, CFI = 0.936, RMSEA = 0.048 [CI_{90}=0.046-0.051], SRMR = 0.042). All items loaded significantly on their corresponding factors ($p < .001$, see also Table 3). In the present sample with apprentices, the loadings of the two marginal items from Study 1 were satisfactory (λ_{CCPL1} = 0.76, λ_{CCPL6} = 0.75). Although being acceptable in magnitude, it was now an item from the manageability of balance demands factor, which had the lowest regression weight (λ_{BAL2} = 0.66). Nevertheless, the AVE was good to acceptable for all eight latent factors ($0.550 \leq AVE \leq 0.783$). Since these values were always higher than the squared correlation with any other construct ($0.171 \leq r_{max}^2 \leq 0.428$), discriminant validity can be assumed for the eight-factor measurement model (Fornell-Larcker-Criterion). The factor reliabilities were again located in a satisfactory area ($0.830 \leq \alpha \leq 0.923$).

The univariate models (Table 4) revealed that all PAHCO indicators apart from MBD ($\beta = 0.000$) were substantially related to both *activity indicators* ($\beta \geq 0.215$, $p < .05$). Self-control showed the strongest associations with the overall amount of daily PA ($\beta_{Overall.PA} = 0.417$, $p < .001$) and sport activity ($\beta_{Sport} = 0.349$, $p < .001$). All factors that can be assigned to control competence or self-regulation competence correlated stronger with sport activity than with overall PA. Only MSD and MBD, both elements of movement competence, were slightly more associative with regard to overall PA than for sport activity. In the multivariate models, only self-control ($\beta_{Sport} = 0.186$, $p = .002$; $\beta_{Overall.PA} = 0.150$, $p = .012$) and MSD ($\beta_{Sport} = 0.085$, $p = .004$; $\beta_{Overall.PA} = 0.102$, $p = .008$) made significant contributions to the explanation of both indicators. The manageability of balance demands exerted a negative influence in both SEMs ($\beta_{Sport} = -0.145$, $p = .003$; $\beta_{Overall.PA} = -0.119$, $p = .014$). Due to the null-effect in the univariate model, we considered this result as a suppressor effect. Emotional attitude was a significant predictor only in the sport activity model ($\beta_{Sport} = 0.131$, $p = .011$), whereas MED was significant only in the overall PA model ($\beta_{Overall.PA} = 0.128$, $p = .005$). Since the amount of sport activity turned out to be less in older apprentices, we computed a separate model entering age as a covariate ($\beta_{Sport} = -0.084$, $p = .011$). Compared with the unadjusted version, the predictive pattern of this model remained unchanged.

(Table 4)

Moreover, all competence aspects were significantly related to *physical health* in the univariate models. Even MBD displayed a significant association to this criterion of interest ($\beta_{Phys.Health} = 0.133$, $p = .004$). MED showed the strongest association with the SF-12 subscale ($\beta_{Phys.Health} = 0.251$, $p < .001$). When putting the predictors into a multivariate SEM, MED ($\beta_{Phys.Health} = 0.151$, $p = .009$), self-control ($\beta_{Phys.Health} = 0.132$, $p = .035$), emotional attitude ($\beta_{Phys.Health} = 0.121$, $p = .045$), and MBD ($\beta_{Phys.Health} = 0.112$, $p = .024$) still contributed significantly to the explanation of the apprentices' physical health.

The SEM predictors explained a total of 21.3% in the amount of sport activity and 16.3% in overall physical activity but only 9.5% in the amount of physical health. However, when putting the sum scores of the PAHCO factors into multiple linear regressions, model comparisons revealed that the eight factors ($R_{Sport}^2 = 0.204$, $R_{Overall.PA}^2 = 0.164$, $R_{Phys.\,Health}^2 = 0.092$) had a significantly ($p \leq .011$) stronger predictive potential than the three ($R_{Sport}^2 = 0.169$, $R_{Overall.PA}^2 = 0.117$, $R_{Phys.\,Health}^2 = 0.056$) or five factors alone ($R_{Sport}^2 = 0.192$, $R_{Overall.PA}^2 = 0.132$, $R_{Phys.\,Health}^2 = 0.066$). These results showed that the model extensions not only served to specify further constructs of the PAHCO framework but also to increase the explanatory power with regard to the outcomes of HEPA (incremental validity).

Discussion of the study

In the second study, we aimed at extending the existing assessment of PAHCO by operationalizing aspects of movement competence. Based on exploratory analyses, we decided to drop the body awareness factor. Instead, future studies are invited to reconsider this factor and to create a theoretically sound item set again. The multivariate SEM showed that self-control was a central competence component for the prediction of PA indicators among apprentices. This finding concurred with the data from the COPD sample (Study 1) as well as with previous research (Sniehotta et al., 2005). The basic ability to lift and carry weights was also substantially related to both PA outcomes, meaning that a good strength might not only favor the execution of sport-like activities but also facilitate the performance of a wide range of daily activities. Overall, this study highlighted the urgent need to specify constructs of movement competence in order to account for the multidimensional nature of the PAHCO model and its corresponding assessment. Specifically, the results suggested that assessing movement competence via self-reports presents a practical and economic but yet valid solution.

General Discussion

The goal of the present article was to extend first measurement models on PAHCO (Sudeck & Pfeifer, 2016), to accumulate evidence on the validity of the framework, and to provide the basis for a standardized assessment in the future. To meet this purpose, we decided to select a stepwise approach by alternating cross-validations with further model extensions. The satisfactory fits that could be found for the three-factor and the five-factor measurement models across two different populations are in line with the assumption that the global structure of the PAHCO framework has validity across a multitude of populations in the prevention and rehabilitation context. Nevertheless, it would be a central task to confirm the eight-factor measurement model with other populations (e.g., people of higher age or with a chronic disease). Overall, the present samples were quite specific, thus limiting the generalizability of the model extension. Indeed, despite the positive results on the global level of PAHCO, we observed some population-specific particularities on the item level. In the sample of patients with COPD, for example, comparably low regression weights emerged in two items that closely referred to the individual's adjustment of training to their body conditions. This finding is supported by a systematic review highlighting that health status and changing disease conditions represent serious barriers for people with COPD to engage in physical activities (Thorpe, Johnston, & Kumar, 2012). On one hand, such findings can be very informative from a content perspective because they can give a hint as to the extraordinary challenges this population is facing in the context of PA (Nakken et al., 2017). However, on the other hand, maintaining inadequate items could present a technical and therefore conceptual threat to the quality of an instrument. Since the aforementioned items did not fall into an unacceptable range (i.e., indicator reliability ≤ 0.30) while they have proven to be good in other samples (Sudeck & Pfeifer, 2016), we decided to retain these items and eliminate them if they also display marginal values in future investigations.

This study was primarily designed to prove the validity of PAHCO on the sub-competence level. According to our results, the eight factors could be assessed in a reliable and discriminant manner. This confirms our conception to undertake a multifaceted operationalization of the sub-competencies under consideration of the link to the basic elements of the model (Figure 1). Nevertheless, further studies should strive for a valid assessment of model factors that have not yet been captured, such as *body awareness* and the *cognitive-rational attitude* component. In terms of a potential operationalization of body awareness, it can be recommended from this study that future research should strive for an item set with a homogenous sematic direction, meaning that singular inverted questions should be avoided. In addition, these items should then reflect the broad content-related range by covering basic aspects of interoception on one hand (Ginzburg, Tsur, Barak-Nahum, & Defrin, 2014) and, following a competence orientation, complex aspects of use and control on the other. Moreover, it would be a worthwhile challenge to bundle the extracted factors to the three overarching competence domains of movement competence, control competence, and self-regulation competence. Such a step would have the advantage of providing sum scores for each sub-competence. To our understanding, researchers can choose between different approaches to meet this claim. For example, they can continue interpreting the findings on an argumentative-theoretical basis or they can apply second-order CFA modeling (Chen, Sousa, & West, 2005) to inspect whether the factors can be pooled in a statistical way. If researchers prefer the second variant, we think that it would first be necessary to complete the assessment, for example by including the aspects of body awareness and cognitive attitudes.

Nevertheless, we were able to integrate central outcomes of PAHCO into the validation. It was assumed that significant univariate associations with measures of PA (and physical health) could be interpreted as indicating criterion validity. Indeed, the SEM in the second study revealed that all competence factors correlated positively with physical health. In addition, all but one competence aspect were at least in one out of the two studies significantly related to PA outcomes. The only exception was the manageability of balance demands which did not show the expected associations. Despite this result, it can be argued that balance constitutes a central aspect of physical activity-related health competence. Balance is not only a central prerequisite for mastering the physical challenges of daily life but also for preventing severe falls and therefore securing quality of life (World Health Organization, 2012). In this validation study, the manageability of balance demands factor was only included in the second sample with the apprentices. Healthy adolescents and young adults were apparently not the optimal population to demonstrate the importance of balance skills for an active lifestyle. To substantiate the importance of this component, future studies should put a particular focus on older adults or target groups who have problems with their motor control (e.g., persons with neurological conditions). Although clear evidence in relation to the balance factor is still outstanding, the associations with the two outcomes of interest (i.e., physical activity and physical health) strongly plead for the criterion validity of the operationalized factors of PAHCO. As expected, in the multivariate models, not all eight PAHCO aspects were significantly related to

the outcomes any longer. Against the background of the number of predicting items, it would have been a too strict decision if only the significant variables in the multivariate model were accepted as indicating criterion validity.
In this study, we treated both outcome indicators as equal criteria. Future studies could instead test a more ordered SEM in which PA presents the proximal outcome and physical health, in turn, the distal outcome. This is not only in line with the literature evidencing a causal influence of PA on physical health (Warburton & Bredin, 2017) but also with the results of the present study indicating that the predictive power was stronger for activity outcomes compared to health outcome. Overall, the explained variances in the activity indicators were substantial lying between 9.8% and 21.3%. At first glance, researchers might get the impression that this is a rather low value for a person-related concept. However, this statement has to be qualified when considering that (1) the persons' surrounding structures and environments, (2) the cues of a concrete situation, (3) the bias caused by the self-report method and (4) unsystematic measurement errors limit the room for stronger explanation. Another explanation could be the fact that we operationalized the outcome, HEPA, exclusively through the volume of PA. In addition to this quantitative aspect, HEPA also has important qualitative facets (e.g., proper execution of exercises or adequate physical load) - facets that are difficult to capture in an empirical way. This fact might have decreased the magnitude of the registered associations. Against the background of a recent study revealing that the constructs of the adjacent field of physical literacy could only explain 5.2% of the variance in PA (Choi, Sum, Leung, & Ng, 2018), we are, in general, rather optimistic with regard to the behavioral relatedness of the PAHCO approach. In this context, it would be worth investigating in how far the hierarchical and health-related physical literacy model that was recently successfully tested in grade five and grade seven students (Cairney, Clark et al., 2019) is related to PA and health outcomes. The empirical model of the researchers contains aspects such as motivation and enjoyment (Cairney, Clark et al., 2019), which are not directly related to the competence concept but, through the lens of the physical literacy approach, offer a theoretically different perspective on PA.

Besides the technical question of validity, our analyses illustrated that not all predictors contributed equally to the execution of PA among the two populations. In COPD patients, for instance, the ability to use exercise for the regulation of one's affect and wellbeing seemed to be more decisive for an active lifestyle than in the sample of apprentices. Furthermore, the more intensive and planned forms of activity (i.e., the time spent with MVPA in COPD patients or the weekly amount of sport activity in apprentices) could be slightly better predicted by the PAHCO variables than the lighter forms of daily PA (i.e., the number of daily steps or the amount of leisure-time PA). In this article, such content-related results were not the subject of extensive discussion. The main reason for this restraint is grounded in the fact that the more technical questions related to the model had priority in this article. Nevertheless, such a validation study can be used to identify patterns that can be examined in more detail as soon as the model validation and the questionnaire development are concluded.

Against the backdrop of the large number of potential applications, this study marked an important step in the context of PAHCO in specifying further constructs related to self-regulation competence in the first step (Study 1) and capturing aspects of movement competence in the second step (Study 2). Overall, the validations not only underscored the multidimensional and integrative character of the framework, and thereby contributed to a better understanding of the model, but also paved the way for a standardized assessment of PAHCO.

What Does This Article Add?

The present article highlights the need for an integrative view on the competencies that are necessary for a healthy, physically active lifestyle. The current article is the first to present extensive validations of the Physical Activity-related Health Competence (PAHCO) model using data from two different samples. The first study involved persons with COPD resulting in a well-fitting five-factor measurement model. The second study dealt with apprentices, which led to an extended measurement model with eight factors. In summary, the results were in line with the core assumptions of the model. Almost all PAHCO aspects were significantly related to PA outcomes. Nevertheless, the study revealed that the factors seem to contribute differently to the execution of PA across diverse samples.

Declarations

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Footnote (from lines 228 and 334, marked in the text with a superscript “1”)

In the German literature, the term “sport“ not only refers to competitive forms of activity but also includes all forms of physical exercise.

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Tables

Table 1. *Final analyses of the reliability and discriminant validity of the five-factor measurement model on PAHCO.*

	Loading	Indicator Reliability	Factor Reliability	Fornell-Larcker-Criterion Average Variance Extracted	Highest Squared Correlation
Control of Physical Load			0.846	0.477	0.360
CCPL1	0.598	0.358			
CCPL2	0.743	0.552			
CCPL3	0.763	0.582			
CCPL4	0.710	0.504			
CCPL5	0.706	0.498			
CCPL6	0.608	0.370			
Affect Regulation			0.879	0.657	0.360
AR1	0.701	0.491			
AR2	0.862	0.743			
AR3	0.879	0.773			
AR4	0.788	0.621			
Self-Efficacy			0.819	0.643	0.177
SE1	0.759	0.576			
SE2	0.953	0.908			
SE3	0.666	0.444			
Self-Control			0.845	0.663	0.285
SC1	0.715	0.511			
SC2	0.861	0.741			
SC3	0.859	0.738			
Emotional Attitude			0.943	0.852	0.247
ATEM1	0.867	0.752			
ATEM2	0.947	0.897			
ATEM3	0.953	0.908			
ATEM4	excluded after exploration				

Table 2. *SEM-based associations of the PAHCO factors with objective indicators of PA (Study 1).*

	Moderate-to-Vigorous Physical Activity			Number of Steps		
	Univariate Models	Multivariate Model	Multivariate Model (adj.[1])	Univariate Models	Multivariate Model	Multivariate Model (adj.[1])
Control of Physical Load	0.073	-0.256**	-0.258**	0.087	-0.246**	-0.251**
Affect Regulation	0.215**	0.184*	0.119	0.229**	0.212*	0.146
Emotional Attitude	0.202**	0.103	0.095	0.194**	0.087	0.079
Self-Control	0.245**	0.217*	0.230**	0.224**	0.162	0.176*
Self-Efficacy	0.089	0.027	0.039	0.133*	0.079	0.094
Covariate Severity of Disease (GOLD)			-0.347**			-0.350**
Explained Variance R^2		0.104	*0.205*		0.098	*0.200*

Note: $*p < .05$, $**p < .01$, [1]Model adjusted for the severity of the disease (COPD Severity Stages 1-4)

Table 3. *Final analyses of the reliability and discriminant validity of the eight-factor measurement model on PAHCO.*

	Loading	Indicator Reliability	Factor Reliability	Fornell-Larcker-Criterion Average Variance Extracted	Highest Squared Correlation
Manageability of Endurance Demands (MED)			0.880	0.661	0.194
END10	excluded after exploration				
END30	0.850	0.723			
END60	0.880	0.774			
END10s	0.733	0.537			
END30s	0.781	0.610			
Manageability of Strength Demands (MSD)			0.830	0.597	0.171
STR5m	excluded after exploration				
STR15	0.834	0.696			
STR25	0.814	0.663			
STR5m	0.688	0.473			
STR15m	0.745	0.555			
Manageability of Balance Demands (MBD)			0.908	0.639	0.176
BAL1	0.783	0.613			
BAL2	0.657	0.432			
BAL3	0.846	0.716			
BAL4	0.892	0.796			
BAL5	0.900	0.810			
BAL6	0.682	0.465			
Body Awareness	Factor excluded after item exploration				
Control of Physical Load			0.880	0.550	0.421
CCPL1	0.755	0.570			
CCPL2	0.795	0.632			
CCPL3	0.695	0.483			
CCPL4	0.734	0.539			
CCPL5	0.720	0.518			
CCPL6	0.746	0.557			
Affect Regulation			0.923	0.761	0.428
AR1	0.827	0.684			
AR2	0.917	0.841			
AR3	0.925	0.856			
AR4	0.815	0.664			
Self-Efficacy			0.905	0.783	0.354
SE1	0.845	0.714			
SE2	0.969	0.939			

SE3	0.835	0.697			
Self-Control			0.898	0.747	0.428
SC1	0.847	0.717			
SC2	0.888	0.789			
SC3	0.858	0.736			
Emotional Attitude			0.905	0.710	0.384
ATEM1	0.735	0.540			
ATEM2	0.894	0.799			
ATEM3	0.916	0.839			
ATEM4	0.814	0.663			

Table 4. *SEM-based associations of the PAHCO factors with self-report measures of PA (Study 2).*

	Sport Activity			Overall Physical Activity		Physical Health	
	Univariate Models	Multivariate Model	Multivariate Model (age-adjusted)	Univariate Models	Multivariate Model	Univariate Models	Multivariate Model
Control of Physical Load	0.353**	0.075	0.076	0.285**	0.010	0.217**	0.034
Affect Regulation	0.363**	0.047	0.058	0.305**	0.052	0.177**	-0.073
Emotional Attitude	0.373**	0.131*	0.130*	0.307**	0.082	0.210**	0.121*
Self-Control	0.417**	0.186**	0.176**	0.349**	0.150*	0.232**	0.132*
Self-Efficacy	0.295**	0.088	0.080	0.248**	0.069	0.140**	-0.086
Manageability of Endurance Demands (MED)	0.298**	0.041	0.047	0.319**	0.128**	0.251**	0.151**
Manageability of Strength Demands (MSD)	0.215**	0.085*	0.085*	0.236**	0.102**	0.172**	0.041
Manageability of Balance Demands (MBD)	0.000	-0.145**	-0.150**	0.000	-0.119*	0.133**	0.112*
Covariate Age			-0.084*				
Explained Variance R^2		0.213	*0.219*		0.168		0.095

Table 4. *SEM-based associations of the PAHCO factors with self-report measures of PA (Study 2).*

Note: *$p < .05$, **$p < .01$

Figures

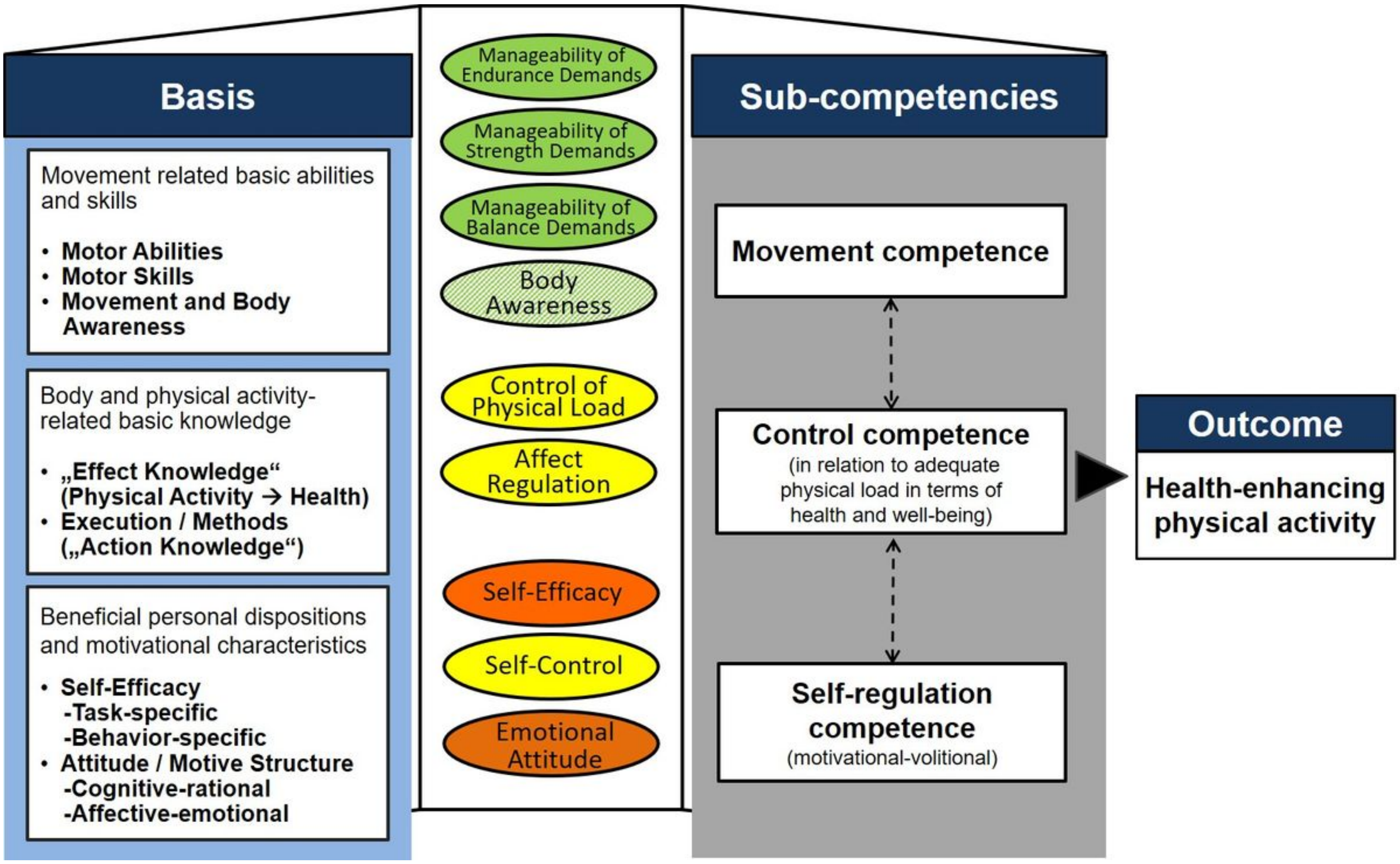

Figure 1

The Model of Physical Activity-related Health Competence in the foreground and the operationalization level with the factors (see the circles) in the background.

Supplementary Files

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

- Table1Appendix.docx
- Table2Appendix.docx