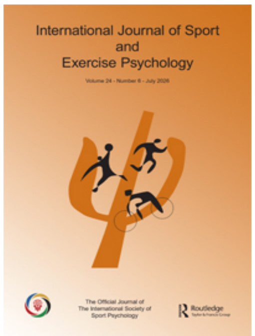

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Psychometric properties of a questionnaire for the measurement of self-concept of motor abilities across adolescents and young adults

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ABSTRACT

Motor abilities are central to adolescents' physical and psychological development, yet existing self-concept measures often lack full dimensional coverage and robust psychometrics. This study developed and validated a concise, theory-based instrument assessing five core motor abilities: endurance, strength, speed, coordination, and flexibility. Data from 5,353 adolescents and young adults across two independent waves of the MoMo Study were used for item selection, construct validation, and measurement invariance testing, with a school-based sample ($N = 237$) providing test – retest reliability data. The 15-item scale demonstrated a clear five-factor structure, high internal consistency ($\alpha = 0.82$–0.88), good test – retest reliability ($r = 0.78$–0.86), and invariance across age and gender. Criterion validity was supported through positive associations with objective motor performance and physical activity in both structured and unstructured sports contexts. This brief, reliable tool facilitates efficient assessment of motor ability self-concept in research, educational, and health-promotion settings.

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Motor abilities; self-concept; adolescents; psychometric validation; measurement invariance

Introduction

Adolescence represents a critical ontogenetic stage characterised by various physiological, psychological, and socio-emotional transitions that collectively influence the construct of self-concept (Eccles et al., 1997). Within the multi-dimensional architecture of self-concept, the domain of physical self-concept emerges as a sub-component, incorporating perceptions related to physical and motor abilities as well as physical appearance (Shavelson et al., 1976). The spectrum of motor abilities encompasses endurance, strength, speed, coordination, and flexibility (Bös & Mechling, 1983; Burton & Miller,

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1998). These motor abilities not only determine physical performance but also influence a wide range of psychosocial outcomes, including self-esteem, peer relationships, and academic achievement (Harter, 2012; Krug et al., 2012; Stodden et al., 2008; Wagner et al., 2012). In addition, self-perceptions of motor abilities are theorised to influence engagement in physically demanding activities, thereby linking physical self-concept to actual physical activity behaviour across developmental contexts (Jekauc et al., 2017). The development of motor ability self-concept during adolescence reflects a dynamic interaction between physiological maturation and psychological self-appraisal, contributing to a nuanced and adaptive physical self-concept (Marsh & Redmayne, 1994).

The concept of motor abilities

Motor abilities are generally defined as relatively stable, general traits that underpin and support the acquisition and execution of specific motor skills, which are context-dependent, learned behaviours reflecting the application of learned techniques in specific tasks. Furthermore, motor abilities are considered foundational capacities such as endurance, strength, speed, coordination, and flexibility, which are not directly observable but can be inferred through standardised performance tasks (Burton & Miller, 1998).

Motor abilities have been more specifically conceptualised by Bös and Mechling (1983) as intra-individual regulatory and executive capacities that enable efficient postural control and kinesthetic action. According to this model, motor abilities represent prerequisites for effective movement execution and are influenced by both genetic predispositions and environmental conditions (Bös et al., 2025). This conceptual framework offers a hierarchical taxonomy comprising three levels (see Figure 1). The primary level demarcates between energetically-determined abilities related to physical fitness, information-based coordinative abilities and so called passive energy transmission systems. The second level specifies five core motor abilities: endurance, strength, speed, coordination, and flexibility. These dimensions are most relevant for self-perception and psychological representation. At the tertiary level, each core ability is further differentiated into subcomponents, for example, aerobic and anaerobic endurance; maximal strength and strength endurance; explosive strength, action speed, and reaction speed; or coordination under time and

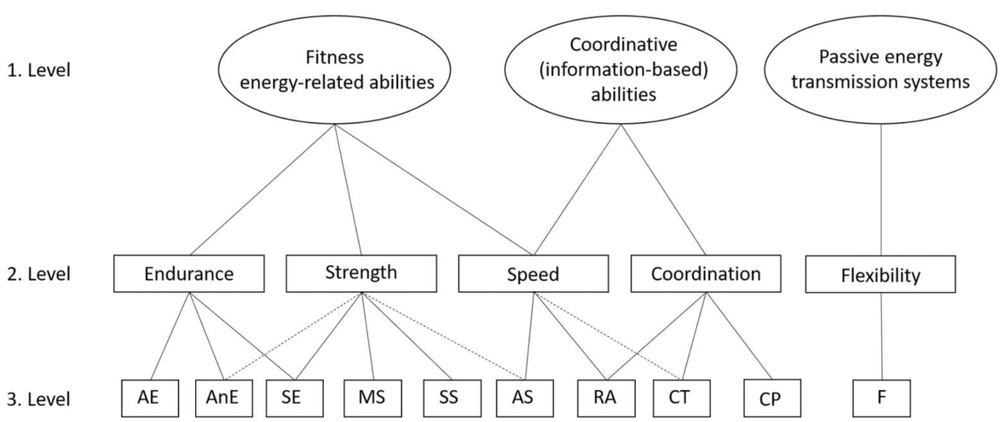

Figure 1. Concept of motor abilities according to Bös and Mechling (1983).

precision pressure (Bös, 2017; Bös & Tittlbach, 2006). The selection of this model was guided by three criteria: conceptual alignment with motor abilities as relatively stable underlying capacities rather than task-specific skills, feasibility of a balanced and parsimonious representation in questionnaire form, and compatibility with the established motor performance framework of the MoMo study used for validation (Bös et al., 2009).

While alternative approaches (e.g., Burton & Rodgerson, 2001) have suggested a more integrative conception of motor abilities in terms of "movement skill foundations" (Wagner et al., 2011), the current study adopts the structured dimensional approach articulated by Bös and Mechling (1983), which provides a precise, operationalizable foundation for assessing self-concept in motor ability domains.

Representation of the motor abilities in self-concept questionnaires

The self-concept of motor abilities, as a domain of physical self-concept, has traditionally been assessed using instruments such as the Physical Self-Description Questionnaire (PSDQ; Marsh et al., 1994). The original PSDQ comprises 70 items distributed across 11 dimensions, including strength, endurance, flexibility, coordination, body fat, health, appearance, activity, and sport competence, as well as broader constructs like physical self-concept and self-esteem. A validated short form, the PSDQ-S, includes 40 items also covering nine specific and two global domains (Marsh et al., 2010). Both versions have demonstrated sound psychometric properties and structural validity in international samples (Braun et al., 2018; Stiller & Alfermann, 2007).

However, despite their widespread use, the PSDQ and its short form exhibit important limitations. Most notably and in contrast to Bös and Mechling's (1983) conception of motor abilities, both scales do not include speed as a distinct factor. In this sense, the PSDQ's dimensional structure does not align with the five theoretically grounded motor abilities proposed by Bös and Mechling (1983). Instead, the PSDQ merges conceptually adjacent but distinct constructs, such as general fitness or sport competence, which hinders specificity in measuring the self-concept of motor abilities.

To address some of these issues, Stiller et al. (2004) developed the Physical Self-Concept Scales (PSK), a German-language questionnaire comprising 46 items. The PSK includes six items each for the five key motor dimensions – strength, endurance, speed, coordination, and flexibility – alongside ten items on physical appearance and an additional scale for general physical fitness. This structure more closely reflects the construct of motor abilities; however, the PSK also presents certain psychometric limitations. Specifically, factor analytic studies identified dual loadings for items within the speed and coordination subscales, raising concerns about construct clarity. Furthermore, while a short-form version adapted for younger children exists (Dreiskämper et al., 2015), it involves substantial wording changes that compromise comparability with versions used for adolescents and adults.

To address these limitations, there is a need for a revised instrument that aligns with the model of motor abilities. The model, with its hierarchical categorisation of motor abilities, provides a theoretically grounded basis that can enhance the specificity and relevance of the scale. By focusing exclusively on motor abilities as defined by Bös and Mechling (1983), such a revised scale can provide a more parsimonious and refined assessment of motor ability self-concept. The purpose of this study is to develop and validate a more concise, yet parsimonious and psychometrically robust measure of self-concept of motor abilities based on the PSK scales. Specifically, the study aims to examine the test-retest reliability, internal consistency, construct validity, criterion-related validity, and measurement invariance across age groups, and gender of the scale for adolescents and young adults.

Material and methods

Procedure

This study utilised data from three samples drawn from two separate research projects. First, data from the first wave of the data collection of the Motorik-Modul (MoMo) Longitudinal Study were used for item reduction and the development of a short-form questionnaire measuring the self-concept of motor abilities (Sample 1). Second, an independent cross-sectional sample from the second wave of the MoMo Longitudinal Study was used to validate the newly developed scale and to assess measurement invariance (Sample 2). To ensure independence at the participant level, Sample 2 included only individuals who had not participated in Sample 1, resulting in two non-overlapping samples. In addition, a separate sample was collected solely to assess short-term test – retest reliability of the self-concept scale using two self-report assessments administered one week apart (Sample 3).

Data collection in samples 1 and 2

This study used data from two independent cross-sectional waves of the MoMo Longitudinal Study, a nationwide research project examining the health, fitness, and physical activity of children, adolescents, and young adults in Germany (Wagner et al., 2014). Specifically, Sample 1 consisted of participants from the first MoMo wave (2009–2012; N = 3,137; 1606 female) with a mean age of 16.2 (SD = 3.5; range = 11.0-26), while Sample 2 included participants from the second MoMo wave (2015–2017; N = 2,216; female 1147) with a mean age of 15.4 (SD = 3.4; range = 11.0-30.6). In line with prior MoMo publications, the term "young adults" refers to participants beyond adolescence who are still embedded in the MoMo sampling framework, extending into the third decade of life (Arnett, 2000). Both samples were drawn to be representative of German youth and young adults. Ethical approval for the MoMo study was granted by the Ethics Committee of the University of Konstanz for Sample 1 and the Karlsruhe Institute of Technology for Sample 2. Informed consent was obtained from all participants or their legal guardians, in accordance with the Declaration of Helsinki. Detailed descriptions of the MoMo sampling procedures and study design are provided elsewhere (Wagner et al., 2014; Woll et al., 2017; Woll et al., 2021).

Test – retest reliability sample (Sample 3)

Sample 3 was included exclusively to assess short-term test – retest reliability of the motor ability self-concept scale. The study was preregistered on the Open Science Framework on January 9, 2024. Data were collected between December 2023 and December 2024 in a school-based adolescent sample recruited from 11 schools across Germany. A total of 237 students (48.1% female; M_age = 13.12 years, SD = 1.64; range 11–17 years) completed the first assessment, and 223 participants (94.1%) completed the second assessment one week later. This sample was not intended for factorial or criterion validation; evidence for factorial validity and measurement invariance across age is derived from the larger MoMo samples. The study was approved by the Ethics Committee of the Karlsruhe Institute of Technology (application number A2023-077). Written informed consent was obtained from all participants and their legal guardians.

Measurement

In Samples 1 and 2, physical self-concept was assessed through self-report, and motor abilities were measured using the MoMo test profile (Hanssen-Doose et al., 2021). In Sample 3, self-concept of motor abilities was assessed using the short version developed based on the data from Sample 1.

Development of the questionnaire for assessment of motor abilities self-concept

The basis for the 15-item motor abilities self-concept scale was the adapted German version of the Physical Self-Concept Scales (PKS; Stiller & Alfermann, 2007), originally derived from the PSDQ (Marsh & Redmayne, 1994). The full PSK includes 46 items distributed across seven dimensions: endurance, strength, speed, coordination, flexibility, sports competence (each represented by 6 items), and physical appearance (represented by 10 items). All items are rated on a 4-point Likert scale.

In the context of the MoMo Study, the appearance dimension was not administered, as it does not pertain to motor abilities. Furthermore, for the present analyses, the sports competence dimension was excluded. Although part of the original PSK, sports competence represents a higher-order construct that aggregates across the five core motor domains and does not correspond to a distinct motor ability (Stiller et al., 2004). In our data, the sports competence scale showed a very high correlation ($r = 0.88$) with the composite index of the five motor dimensions endurance, strength, speed, coordination, and flexibility, indicating substantial conceptual and statistical redundancy.

The goal of developing a short version was to create a brief yet psychometrically sound measure suitable for large-scale studies, while ensuring balanced representation of each motor ability. Therefore, we explicitly aimed to select three items per dimension, resulting in a 15-item scale covering the five core motor abilities. To achieve this, we pursued two complementary approaches for item reduction using data from Sample 1.

First, after conducting a Confirmatory Factor Analysis (CFA), we screened the modification indices for items with high values, which revealed that negatively worded items (e.g., item 28 "My body is stiff and inflexible") and items involving social comparisons (e.g., item 7 "I am stronger than most others my age") showed unique correlation patterns not explained by the latent factors. This suggested that their error terms shared variance unrelated to the underlying constructs (cf., Jekauc, Voelkle, et al., 2012). Additionally, the CFA indicated poor model fit ($\chi^2(435) = 4745.5$; $p < 0.001$; CFI = 0.901; RMSEA = 0.068). Therefore, these problematic items were considered for exclusion.

Second, an Exploratory Factor Analysis (EFA) was conducted to identify the items with the highest factor loadings within each dimension (see Appendix A). Notably, all items flagged for exclusion in the CFA also showed lower factor loadings in the EFA and were consequently omitted. Based on these combined analyses, the three items with the highest standardised loadings for each dimension were retained to construct the final 15-item short version of the scale, which is detailed in Appendix A. The corresponding item formulations are provided in Appendix C and D.

Motor performance

Motor performance was measured using the MoMo test profile, which includes 12 validated items covering the mentioned dimensions (Hanssen-Doose et al., 2021). All assessments were conducted in accordance with the standardised procedures outlined in the MoMo test manual (Worth et al., 2015). For the purposes of this study, tasks representing the motor ability dimensions of strength, endurance, coordination, and flexibility were included. The dimension of speed, although represented as a self-concept dimension, could not be directly validated against an equivalent objective criterion, as the MoMo test battery does not include a measure of running speed.

Strength: Muscular strength was evaluated through three tasks targeting different muscle groups: push-ups for upper body strength endurance (Beck et al., 1995), standing long jump for lower body explosive strength (Kirsch, 1968), and sit-ups for dynamic trunk strength (Worth et al., 2015). A composite index was calculated by standardising and aggregating scores across the three tasks. The internal consistency of the strength composite was acceptable (Cronbach's $\alpha = 0.67$).

Endurance: Cardiorespiratory endurance was measured using the Physical Working Capacity 170 (PWC170) cycle ergometry test (Boutellier et al., 1987; Sjöstrand, 1960), performed on an ERG 911S cycle ergometer (Ergosana, Bitz, Germany). Heart rate was continuously monitored, and power output corresponding to a heart rate of 170 bpm was estimated as the PWC170 score (Worth et al., 2015).

Coordination: Coordination ability was assessed with three tasks: jumping sideways, static stand, and balancing backwards. These tasks evaluate dynamic balance, static postural control, and complex motor coordination. A composite coordination index was computed, demonstrating good internal consistency (Cronbach's $\alpha = 0.73$).

Flexibility: Flexibility was assessed using the stand-and-reach test, which evaluates active trunk flexibility. Participants stood on a standardised wooden box and, with knees fully extended. The task required participants to cross the foot level with their fingertips, aiming to reach the lowest possible point toward the ground. Each participant performed a maximum of two repetitions, and the best performance was recorded as the measure of flexibility (Worth et al., 2015).

Physical activity

For criterion validation, physical activity was measured using the MoMo Physical Activity Questionnaire (MoMo-PAQ), a validated self-report instrument for adolescents that assesses activity across multiple domains, including school, leisure-time, daily routines, and organised sports settings (Jekauc et al., 2013). For the present study, only three domains were considered: (a) physical activity in sports clubs, (b) leisure-time sports not organised in clubs, and (c) physical activity in school. These domains were selected due to their presumed high relevance for the formation of motor ability self-concept (Jekauc et al., 2017). For each domain, four parameters were recorded: activity type, frequency, duration, and seasonal participation. These items were combined to compute indices representing minutes of moderate-to-vigorous physical activity (MVPA) per week in each setting. The

MoMo-PAQ has demonstrated high test – retest reliability over a one-week interval (r_{tt} = 0.64-0.81) in adolescents aged 14–17 years and has shown modest convergent validity with both accelerometer-based activity monitoring (Actigraph GT1M, r = 0.10-0.35) and diary-based recall (Previous Day Physical Activity Recall, r = 0.55) (Jekauc et al., 2013).

Statistical analyses

Reliability

Internal consistency of scales was determined using both Cronbach's alpha and composite reliability according to CFA. Given that Cronbach's alpha may provide a conservative estimate of reliability due to the assumption of non-correlated error terms among indicators, particularly in multi-faceted scales (Bollen, 1989), we also utilised Raykov's (1997) formula for calculating composite reliability. In line with common psychometric practice within the field of motor behaviour, for Sample 3, we compute the one-week test-retest reliabilities.

Criterion-related validity

To assess criterion-related validity, two analytic strategies were employed using data from Sample 2. First, Pearson's correlations were computed between each of the five self-concept dimensions (endurance, strength, speed, coordination, and flexibility) and corresponding objectively measured motor performance (endurance, strength, coordination, and flexibility). Second, to assess the behavioural relevance of the self-concept dimensions, their associations with total weekly physical activity in structured and unstructured sports were analyzed, again using Pearson's correlation coefficients. All statistical tests for validity were conducted with two-tailed significance levels set at $p < 0.05$.

Construct validity

Because the data from Sample 1 were used to develop the short version of the questionnaire, an independent dataset from Sample 2 was employed to examine construct validity. This separation of development and validation samples represents a cross-validation approach, reducing the risk of overfitting and providing a more robust assessment of the scale's factorial structure. The postulated dimensionality with 5 latent factors was tested with full-information maximum likelihood methods using the lavaan package (Rosseel, 2012) in R (version 4.4.1; R Core Team, 2024). Under the assumptions of data being either missing completely at random or missing at random, along with multivariate normality, this method yields unbiased parameter estimates (Jekauc, Völkle, et al., 2012). The fraction of unanswered items within each scale was also reported. Model fit was evaluated through multiple criteria. The chi-square (χ^2) test was employed to examine the absolute fit of the model, keeping in mind its high sensitivity to detect even negligible deviations in large samples (Bollen, 1989). The Root Mean Square Error of Approximation (RMSEA) was used to judge the proximity of fit, with values ≤ 0.06 indicative of an acceptable model fit (Hu & Bentler, 1999). Additionally, the 90% Confidence Interval (CI) around the RMSEA should encapsulate zero for an optimal fit. The Comparative Fit Index (CFI) was also employed to gauge relative fit by contrasting the hypothesised model to a null model (Bentler & Bonett, 1980). Acceptable CFI values are approximated at 0.90, while values around 0.95 imply an excellent fit (Hu & Bentler, 1999).

Measurement invariance

To scrutinise measurement invariance across age groups and between genders for the short version of the self-concept questionnaire, we implemented a series of nested models (from Model A to Model E), following multiple group analytical frameworks (Byrne, 2004; Vandenberg & Lance, 2000). Each succeeding model integrated constraints of its predecessor along with new restrictions (Wu et al., 2007). Model A examined structural equivalence, Model B scrutinised factor loadings, Model C assessed measurement intercepts, Model D reviewed structural covariances, and Model E evaluated item uniqueness and correlation of uniqueness across genders (Vandenberg & Lance, 2000). The sequence of nested models underwent χ^2 difference tests. Owing to the sensitivity of the χ^2 test to sample size, additionally, the ΔCFI was utilised. A ΔCFI value ≤ 0.010 and ΔRMSEA value ≤ 0.015 suggest that the null hypothesis of invariance cannot be rejected (Chen, 2007). For the measurement invariance of age, we created two age groups: adolescents, defined as age 11-17, and young adults, defined as age 18-30.

Results

Descriptive results

Descriptive statistics for the five motor ability scales across all samples are presented in Table 1. Mean values and standard deviations were largely consistent across Sample 1 and Sample 2, while slightly elevated means were observed in Sample 3 at both time points (T1 and T2), suggesting marginally higher self-perceptions in this sample. Appendix B reports the intercorrelations among the five dimensions for each sample. Across all samples, significant positive correlations were found between all pairs of dimensions, indicating substantial internal coherence within the physical self-concept construct.

Table 1. Descriptive statistics for each scale across all samples.

Scale	Sample	Mean	SD	95% CI (Lower)	95% CI (Upper)	N
endurance	Sample 1	2.72	0.83	2.69	2.75	3056
endurance	Sample 2	2.70	0.84	2.66	2.73	2174
endurance	Sample 3 – T1	2.77	0.83	2.67	2.88	237
endurance	Sample 3 – T2	2.78	0.85	2.67	2.90	224
strength	Sample 1	2.86	0.72	2.83	2.88	3063
strength	Sample 2	2.84	0.74	2.81	2.88	2174
strength	Sample 3 – T1	3.12	0.67	3.04	3.21	237
strength	Sample 3 – T2	3.15	0.65	3.06	3.23	224
speed	Sample 1	2.87	0.78	2.84	2.89	3063
speed	Sample 2	2.88	0.78	2.84	2.91	2178
speed	Sample 3 – T1	3.02	0.73	2.92	3.11	237
speed	Sample 3 – T2	3.01	0.74	2.91	3.11	224
coordination	Sample 1	3.13	0.58	3.11	3.15	3061
coordination	Sample 2	3.14	0.59	3.12	3.17	2176
coordination	Sample 3 – T1	3.26	0.61	3.18	3.33	237
coordination	Sample 3 – T2	3.22	0.63	3.14	3.30	223
flexibility	Sample 1	2.82	0.72	2.80	2.85	3062
flexibility	Sample 2	2.82	0.76	2.79	2.85	2177
flexibility	Sample 3 – T1	3.01	0.74	2.91	3.10	237
flexibility	Sample 3 – T2	2.98	0.74	2.89	3.08	223

Reliability

Across all samples, the five subscales demonstrated good to high internal consistency, as indicated by Cronbach's alpha (α) and composite reliability estimates (ω) derived from confirmatory factor analyses.

In Sample 1, internal consistency ranged from $\alpha = 0.82$ (coordination) to $\alpha = 0.87$ (endurance), with composite reliability values between $\omega = 0.83$ and $\omega = 0.87$. Similarly, Sample 2 showed α values from 0.82–0.88 and ω values from 0.82–0.88, confirming consistent reliability estimates across both samples.

For Sample 3 – T1, α values ranged from 0.73 (coordination) to 0.85 (endurance), while ω values ranged from 0.71–0.86. Despite slightly lower values for coordination, all subscales retained acceptable reliability. In Sample 3 – T2, reliability was high, with α ranging from 0.79–0.89 and ω values reflecting comparable robustness ($\omega = 0.80$–0.89).

Test-retest reliability over a one-week interval (Sample 3, T1 – T2) was also assessed using Pearson's correlation coefficient. All subscales demonstrated strong temporal stability: strength ($r_{tt} = 0.81$), endurance ($r_{tt} = 0.82$), speed ($r_{tt} = 0.85$), coordination ($r_{tt} = 0.78$), and flexibility ($r_{tt} = 0.83$), providing evidence for the scale's reliability over time.

Construct validity

Sample 2

To evaluate the factorial structure of the physical self-concept scale, a CFA was performed using data from Sample 2. The hypothesised five-factor model exhibited a good fit to the data, as indicated by multiple fit indices: ($\chi^2(80) = 446.6$, $p < 0.001$; RMSEA = 0.047; 90% CI [0.043, 0.051]; CFI = 0.979).

As shown in Table 2, all items loaded significantly on their respective latent constructs, with standardised factor loadings ranging from 0.69 (Coordination Item 1) to 0.88 (Strength Item 1). This range of strong loadings provides empirical support for the distinctiveness and internal coherence of the five self-concept dimensions. Collectively, the results confirm the factorial validity of the scale and support its use as a multidimensional measure of physical self-concept.

Measurement invariance

Sample 2

The results are presented in Tables 3 and 4. For gender, the configural model demonstrated good fit ($\chi^2(160) = 555.9$; $p < 0.001$; RMSEA = 0.049; 90% CI [0.045, 0.053]; CFI = 0.977). Adding constraints in subsequent models did not meaningfully degrade model fit. The metric model showed no change in fit (ΔCFI = 0.000, ΔRMSEA = – 0.002), and scalar invariance yielded only negligible differences (ΔCFI = 0.001, ΔRMSEA = 0.000),

Table 2. Factor loadings for confirmatory factor analysis.

	Endurance	Strength	Speed	Coordination	Flexibility
Item 1	0.86*	0.88*	0.85*	0.69*	0.87*
Item 2	0.76*	0.77*	0.83*	0.82*	0.84*
Item 3	0.87*	0.84*	0.79*	0.82*	0.82*

*All factor loadings are statistically significant ($p < 0.01$). The final version of the questionnaire is presented in Appendix D.

Table 3. Measurement invariance model fit comparisons for gender.

Model	χ^2(df)	CFI	RMSEA	ΔCFI	ΔRMSEA	$\Delta\chi^2$(df)
Configural	555.9 (160)**	0.977	0.049	-	-	-
Metric	559.6 (170)**	0.977	0.047	0.000	−0.002	3.7 (10)
Scalar	589.1 (180)**	0.976	0.047	0.001	0.000	29.6 (10)*
Structural Covariance	614.0 (190)**	0.975	0.046	0.001	−0.001	29.9 (10)*
Item Uniqueness	677.8 (205)**	0.972	0.047	0.003	0.001	63.8 (15)**

*indicates $p < 0.01$; ** indicates $p < 0.001$.

Table 4. Measurement invariance model fit comparisons for age.

Model	χ^2(df)	CFI	RMSEA	ΔCFI	ΔRMSEA	$\Delta\chi^2$(df)
Configural	546.5 (160)**	0.978	0.048	-	-	-
Metric	555.6 (170)**	0.978	0.047	0.000	−0.001	9.1 (10)
Scalar	585.0 (180)**	0.977	0.047	0.001	0.000	29.4 (10)*
Structural Covariance	601.1 (190)**	0.976	0.046	0.001	−0.001	16.1 (10)
Item Uniqueness	636.6 (205)**	0.975	0.045	−0.001	−0.001	35.5 (15)*

*indicates $p < 0.01$; ** indicates $p < 0.001$

despite a significant chi-square difference. Similar minimal changes were observed in the structural covariance and item uniqueness models. These findings support the conclusion that the scale exhibits full measurement invariance across gender.

For age groups (adolescents, n = 269, young adults, n = 1796), the configural model also indicated good model fit ($\chi^2(160) = 546.4$, $p < 001$; RMSEA = 0.048, 90% CI [0.044, 0.053], CFI = 0.978). The metric model showed identical CFI and improved RMSEA (ΔCFI = 0.000, ΔRMSEA = − 0.001), while the scalar model demonstrated small changes (ΔCFI = −0.001, ΔRMSEA = 0.000), with no substantive misfit observed. Structural covariance and item uniqueness models similarly showed stable fit indices. Overall, results support full measurement invariance across age groups.

Criterion validity

Sample 2

Criterion-related validity was examined using two complementary approaches. First, associations between self-concept dimensions and objectively measured motor performance indicators were analyzed for those motor abilities assessed in the MoMo motor test battery. Second, behavioural relevance was examined by relating all self-concept dimensions to weekly physical activity participation across structured and unstructured sport contexts. With respect to objective motor performance, four self-concept dimensions demonstrated statistically significant positive correlations with their respective motor performance indicators. Effect sizes ranged from small to moderate, including endurance self-concept with PWC170 physiological endurance test ($r = 0.12$, $p < 0.001$), strength ($r = 0.30$, $p < 0.001$), coordination ($r = 0.33$, $p < 0.001$), and flexibility ($r = 0.37$, $p < 0.001$). Because the MoMo motor test battery does not include an objective running speed assessment, criterion validity for the speed dimension could not be evaluated at the level of motor performance.

With respect to behavioural criteria, all five self-concept dimensions showed significant positive associations with weekly physical activity across sport contexts. Correlations ranged from r = 0.15 for flexibility to r = 0.31 for endurance, with intermediate effect sizes for strength (r = 0.29), coordination (r = 0.27), and speed (r = 0.22) (all $p < .001$). These findings indicate that higher perceived motor abilities are consistently associated with greater engagement in physical activity, supporting the behavioural relevance of the motor ability self-concept dimensions.

Discussion

The present study aimed to develop and validate a short-form questionnaire for assessing the self-concept of motor abilities in adolescents and young adults, based on the five-factor model of motor abilities proposed by Bös and Mechling (1983). The resulting 15-item instrument demonstrated robust psychometric properties across three independent samples, including strong internal consistency, satisfactory test – retest reliability, factorial validity, criterion-related validity, and measurement invariance across age and gender. These findings provide empirical support for the scale's applicability in both research and practice.

This study contributes to the refinement of the physical self-concept construct by focusing exclusively on the five fundamental motor ability dimensions: endurance, strength, speed, coordination, and flexibility. In contrast to broader instruments such as the PSDQ (Marsh & Redmayne, 1994) or the PSK (Stiller et al., 2004), which include general constructs like sport competence or physical appearance, the present scale emphasises a conceptually and empirically distinct profile of motor abilities. Notably, the inclusion of the speed dimension, which is frequently omitted in prior instruments, aligns the scale more closely with the established theoretical taxonomy of motor performance. This targeted conceptualisation enhances construct clarity and allows for more specific investigations into the developmental, motivational, and behavioural correlates of perceived motor competence.

The short-form scale represents a substantial advancement in measurement efficiency. Item selection was guided by a combination of confirmatory and exploratory factor analyses, ensuring that retained items demonstrated strong factor loadings and minimal cross-loadings. The resulting five-factor model was supported by confirmatory factor analysis in an independent sample with a large sample size. Composite reliability and Cronbach's alpha values across all subscales were consistently high, indicating strong internal consistency. Furthermore, test – retest correlations over a one-week interval demonstrated good temporal stability, affirming the reliability of the scale.

Importantly, measurement invariance was confirmed across gender and age groups, permitting meaningful group comparisons. This finding ensures that observed differences in motor self-concept scores reflect true differences in the construct rather than measurement artifacts, thereby supporting the use of the instrument in both developmental and gender-based analyses.

Criterion-related validity was established for four dimensions using objective motor performance indicators, and for all five dimensions using behavioural indicators of physical activity. While perceived strength exhibited the strongest association with measured motor performance, perceived endurance showed a comparatively weaker correlation. This discrepancy may reflect the differential observability of motor domains, with strength and flexibility being more readily monitored and evaluated through everyday experiences, whereas endurance performance may involve more delayed or less tangible feedback. A central limitation of the present validation concerns the speed dimension. Although speed is a theoretically core motor ability within the applied framework, no objective running speed test was available in the MoMo motor test battery. Consequently, criterion validity for speed could only be examined using behavioural indicators of physical activity participation rather than objective motor performance. This represents an incomplete validation of the speed dimension and limits the comprehensiveness of criterion-related evidence for the full five-factor model. In addition, it should be considered that perceived speed may partly reflect broader perceptions of general athletic competence or sport ability, rather than strictly corresponding to objectively measurable running speed.

The association between endurance self-concept and objectively measured cardiorespiratory fitness was small ($r = 0.12$), which warrants careful interpretation. Importantly, the present scale is not intended to serve as a proxy for physiological endurance, but to capture individuals' perceptions of their endurance capacity. Low correspondence between perceived and objectively measured endurance has been reported in prior research and is theoretically plausible (Bezjak & Erpič, 2021). Endurance performance provides relatively delayed and ambiguous feedback compared to other motor abilities such as strength or flexibility, making accurate self-calibration more difficult, particularly during adolescence. In addition, the PWC170 represents a standardised laboratory-based assessment that may only partially reflect the everyday activity contexts in which endurance self-perceptions are formed (Drozd et al., 2025).

In addition, all self-concept dimensions were positively associated with physical activity, suggesting that more favourable self-perceptions are linked to greater engagement in physical activity (Jekauc et al., 2017; Utesch et al., 2018). Nevertheless, the observed associations between perceived speed and physical activity suggest that this dimension captures a psychologically relevant aspect of self-perceived motor competence, even in the absence of direct performance validation. The association between self-concept and physical activity highlights the motivational relevance of motor self-concept and underscores its potential role in promoting health-related behaviours (De Meester et al., 2016). The ability to detect such links through a brief self-report instrument enhances the scale's utility in large-scale population surveys and intervention studies (e.g., Schmidt et al., 2013). The newly developed scale offers a time-efficient and psychometrically sound tool for researchers, educators, and practitioners seeking to assess motor-related self-concept. Its brevity facilitates inclusion in broader health or educational assessments without compromising measurement precision.

Limitations and directions for future research

Despite its strengths, several limitations should be acknowledged. First, we did not validate the speed dimension, which is one of the five theoretically central motor abilities in the applied framework. Future studies should incorporate comprehensive speed tests to enable a more complete evaluation of criterion validity across all dimensions. Second, the scale was validated exclusively with participants aged 11 and older, limiting its applicability to younger children. Although item wording was developmentally appropriate for adolescents and young adults, further validation in preadolescent populations is warranted. Third, the scale was tested in a German-speaking context; thus, cross-cultural generalizability remains untested. Translation and validation studies in other linguistic and cultural settings are necessary to determine the scale's broader applicability. Fourth, although Samples 1 and 2 were independent at the participant level, both were drawn within the MoMo-study framework and therefore share common sampling procedures and assessment contexts. While this strengthens internal consistency and temporal robustness of the findings, future studies should replicate the results in entirely independent cohorts to further establish external validity, including validation in independent national samples and in cross-cultural contexts to examine the generalizability of the scale more comprehensively. Fifth, the current study focused on psychometric validation. Longitudinal research is needed to examine the predictive utility of the scale for future physical activity participation, motor development trajectories, and psychological outcomes such as motivation, self-esteem, and well-being. Sixth, the item reduction process involved removing negatively worded and explicitly comparative items because these showed additional residual associations indicative of method variance rather than substantive motor ability factors. Although self-concept is shaped by normative comparison processes, explicit comparative wording is not required to assess domain-specific motor self-concept. Self-referent evaluations of one's own abilities constitute the core of the construct, whereas social comparison wording represents only one possible mode of expression. Such evaluative judgments are likely shaped by implicit social comparison processes during development, even when items are not explicitly framed in comparative terms. Future research should examine whether incorporating comparative items or modelling them as method factors provides incremental validity. Finally, although Samples 1 and 2 included adolescents and young adults, test – retest reliability was examined only in an adolescent subsample. Therefore, conclusions regarding temporal stability are strongest for adolescents. In addition, the test – retest sample included a relatively high proportion of students attending Gymnasium, which may limit the generalizability of the reliability estimates to adolescents from other educational tracks and socioeconomic backgrounds. By contrast, Samples 1 and 2 were drawn from the population-based MoMo study and therefore cover a substantially broader range of educational and social backgrounds, although the test – retest evidence in Sample 3 should still be interpreted with caution given its school-type composition. Future studies should examine test – retest reliability and responsiveness of the scale in young adult samples and in more socioeconomically diverse populations to further strengthen age-specific and contextual validation.

Conclusion

This study presents a theoretically grounded and psychometrically robust short-form instrument for assessing the self-concept of motor abilities in adolescents and young adults. The scale overcomes key limitations of prior instruments by aligning measurement dimensions with the established model of motor performance and ensuring structural validity, reliability, and measurement invariance. Its strong psychometric properties and practical efficiency render it a valuable tool for research, educational evaluation, and health promotion. As such, it contributes meaningfully to the field of physical self-concept assessment and supports more precise, theory-driven investigations into the psychosocial dimensions of motor development.

In addition, this instrument opens new avenues for exploring individual differences in motor abilities self-concept across age groups, social contexts, and developmental stages. It holds potential for use in longitudinal studies tracking the evolution of motor abilities self-perceptions, as well as in the evaluation of interventions to promote physical activity in schools, sports clubs, and public health initiatives. With further validation, the scale may also be adapted for cross-cultural applications, supporting international research efforts. Thus, the tool not only enhances current assessment practices but also contributes to a deeper understanding of the psychosocial impact of development of the self-concept of motor abilities during adolescence.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The datasets generated and analyzed during the current study are subject to the provisions of the General Data Protection Regulation (GDPR/DGSVO) and cannot be made publicly available due to data privacy restrictions. Data may be available from the corresponding author upon reasonable request and with permission from the relevant data protection authorities.

References

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*(5), 469–480.

Beck, J., Bös, K., & Heil, C. (1995). *Normwerte motorischer Leistungsfähigkeit [Standard values of motor performance]*. Sport und Buch Strauss.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*(3), 588–606. https://doi.org/10.1037/0033-2909.88.3.588

Bezjak, R., & Erpič, S. C. (2021). The relationship between actual and self-perceived physical fitness in adolescence. *Kinesiology*, *53*(1), 37–46. https://doi.org/10.26582/k.53.1.5

Bollen, K. A. (1989). *Structural equations with latent variables*. John Wiley & Sons.

Bös, K. (2017). *Handbuch motorische Tests: sportmotorische Tests, motorische Funktionstests, Fragebögen zur körperlich-sportlichen Aktivität und sportpsychologische Diagnoseverfahren*. Hogrefe Verlag.

Bös, K., Jekauc, D., Wagner, M., & Mechling, H. (2025). Dimensionen der Motorik. In R. Dohrenbusch (Ed.), *Psychologische Begutachtung: Rechtliche Grundlagen - Leitlinien - Empfehlungen* (pp. 313–325). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-64797-4_137.

Bös, K., & Mechling, H. (1983). *Dimensionen sportmotorischer Leistungen*. Hofmann.

Bös, K., & Tittlbach, S. (2006). Diagnose physischer Ressourcen. In K. Bös, & W. Brehm (Eds.), *Gesundheitssport. Ein Handbuch, 2., vollst. überarb. Aufl*. Hofmann.

Bös, K., Worth, A., Opper, E., Oberberger, J., Romahn, N., Wagner, M., Jekauc, D., Mess, F., & Woll, A. (2009). Motorik-Modul: eine Studie zur motorischen Leistungsfähigkeit und körperlich-sportlichen Aktivität von Kindern und Jugendlichen in Deutschland; Abschlussbericht zum Forschungsprojekt.

Boutellier, U., Kundig, T., Gomez, U., Pietsch, P., & Koller, E. A. (1987). Respiratory phase detection and delay determination for breath-by-breath analysis. *Journal of Applied Physiology*, *62*(2), 837–843. https://doi.org/10.1152/jappl.1987.62.2.837

Braun, A., Martin, T., Alfermann, D., & Michel, S. (2018). Überprüfung der Reliabilität und Validität der Kurzform des Physical Self-Description Questionnaire (PSDQ-S) in den Altersgruppen des frühen und späten Erwachsenenalters. *Journal of Applied Sport and Exercise Psychology*, *25*(3), 115–127. https://doi.org/10.1026/1612-5010/a000236

Burton, A. W., & Miller, D. E. (1998). *Movement skill assessment*. Human Kinetics.

Burton, A. W., & Rodgerson, R. W. (2001). New perspectives on the assessment of movement skills and motor abilities. *Adapted Physical Activity Quarterly*, *18*(4), 347–365. https://doi.org/10.1123/apaq.18.4.347

Byrne, B. M. (2004). Testing for multigroup invariance using AMOS graphics: A road less traveled. *Structural Equation Modeling*, *11*(2), 272–300.

Chen, F. F. (2007). Sensitivity of goodness of Fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

De Meester, A., Maes, J., Stodden, D., Cardon, G., Goodway, J., Lenoir, M., & Haerens, L. (2016). Identifying profiles of actual and perceived motor competence among adolescents: Associations with motivation, physical activity, and sports participation. *Journal of Sports Sciences*, *34*(21), 2027–2037. https://doi.org/10.1080/02640414.2016.1149608

Dreiskämper, D., Tietjens, M., Honemann, S., Naul, R., & Freund, P. A. (2015). PSK-Kinder – Ein Fragebogen zur Erfassung des physischen Selbstkonzepts von Kindern im Grundschulalter. *Journal of Applied Sport and Exercise Psychology*, *22*(3), 97–111. https://doi.org/10.1026/1612-5010/a000141

Drozd, J., Neubauer, J., Sekanina, J., & Sedlačík, M. (2025). Bridging the gap: aligning physical work capacity testing with actual endurance performance in military settings [Original Research]. *Frontiers in Psychology*, *16*(1536197), https://doi.org/10.3389/fpsyg.2025.1536197

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & Mac Iver, D. (1997). Development during adolescence: The impact of stage–environment fit on young adolescents' experiences in schools and in families (1993). In *D.R. Castellino & R. Lerner (eds.), The evolution of psychology: Fifty years of the American psychologist* (pp. 475–501). American Psychological Association. https://doi.org/10.1037/10254-034

Hanssen-Doose, A., Niessner, C., Oriwol, D., Bös, K., Woll, A., & Worth, A. (2021). Population-based trends in physical fitness of children and adolescents in Germany, 2003–2017. *European Journal of Sport Science*, *21*(8), 1204–1214. https://doi.org/10.1080/17461391.2020.1793003

Harter, S. (2012). Emerging self-processes during childhood and adolescence. In M. T. Leary (Ed.), *Handbook of self and identity, 2nd ed* (pp. 680–715). The Guilford Press.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Jekauc, D., Voelkle, M., Wagner, M. O., Mewes, N., & Woll, A. (2012). Reliability, validity, and measurement invariance of the German version of the physical activity enjoyment scale. *Journal of Pediatric Psychology*, *38*(1), 104–115. https://doi.org/10.1093/jpepsy/jss088

Jekauc, D., Völkle, M., Lämmle, L., & Woll, A. (2012). Fehlende Werte in sportwissenschaftlichen Untersuchungen [Missing values in sport scientific studies. A practical guide to multiple imputation with SPSS]. *Sportwissenschaft*, *42*(2), 126–136. https://doi.org/10.1007/s12662-012-0249-5

Jekauc, D., Wagner, M. O., Herrmann, C., Hegazy, K., & Woll, A. (2017). Does physical self-concept mediate the relationship between motor abilities and physical activity in adolescents and young adults? *PLoS One*, *12*(1), e0168539. https://doi.org/10.1371/journal.pone.0168539

Jekauc, D., Wagner, M. O., Kahlert, D., & Woll, A. (2013). Reliabilität und Validität des MoMo-Aktivitätsfragebogens für Jugendliche (MoMo-AFB). *Diagnostica*, *59*(2), 100–111. https://doi.org/10.1026/0012-1924/a000083

Kirsch, A. (1968). Standard fitnesstest. *Lernhilfen Leibeserziehung*, *17*, 133–140.

Krug, S., Jekauc, D., Poethko-Müller, C., Woll, A., & Schlaud, M. (2012). Relationship between physical activity and health in children and adolescents. Results of the German health interview and examination survey for children and adolescents (KiGGS) and the "Motorik-Modul" (MoMo). *Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz*, *55*(1), 111–120.

Marsh, H. W., Martin, A. J., & Jackson, S. (2010). Introducing a short version of the physical self description questionnaire: New strategies, short-form evaluative criteria, and applications of factor analyses. *Journal of Sport and Exercise Psychology*, *32*(4), 438–482. https://doi.org/10.1123/jsep.32.4.438

Marsh, H. W., & Redmayne, R. S. (1994). A multidimensional physical self-concept and its relations to multiple components of physical fitness. *Journal of Sport and Exercise Psychology*, *16*(1), 43–55. https://doi.org/10.1123/jsep.16.1.43

Marsh, H. W., Richards, G. E., Johnson, S., Roche, L., & Tremayne, P. (1994). Physical self-description questionnaire: Psychometric properties and a multitrait-multimethod analysis of relations to existing instruments. *Journal of Sport and Exercise Psychology*, *16*(3), 270–305. https://doi.org/10.1123/jsep.16.3.270

Raykov, T. (1997). Estimation of composite reliability for congeneric measures. *Applied Psychological Measurement*, *21*(2), 173–184. https://doi.org/10.1177/01466216970212006

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*, 1–36.

Schmidt, M., Valkanover, S., Roebers, C., & Conzelmann, A. (2013). Promoting a functional physical self-concept in physical education: Evaluation of a 10-week intervention. *European Physical Education Review*, *19*(2), 232–255. https://doi.org/10.1177/1356336X13486057

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, *46*(3), 407–441.

Sjöstrand, T. (1960). Functional capacity and exercise tolerance in patients with impaired cardiovascular function. In B. Gordon, & R. Kory (Eds.), *Clinical cardiopulmonary physiology* (pp. 201–219). Grune and Stratton.

Stiller, J., & Alfermann, D. (2007). Die deutsche übersetzung des physical self-description questionnaire (PSDQ). *Journal of Applied Sport and Exercise Psychology*, *14*(4), 149–161.

Stiller, J., Würth, S., & Alfermann, D. (2004). Die Messung des physischen Selbstkonzepts (PSK). *Zeitschrift für Differentielle und Diagnostische Psychologie*, *25*(4), 239–257.

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest (Grand Rapids, Mich)*, *60*(2), 290–306. https://doi.org/10.1080/00336297.2008.10483582

Utesch, T., Dreiskämper, D., Naul, R., & Geukes, K. (2018). Understanding physical (in-) activity, overweight, and obesity in childhood: Effects of congruence between physical self-concept and motor competence. *Scientific Reports*, *8*(1), 5908. https://doi.org/10.1038/s41598-018-24139-y

Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods*, *3*(1), 4–70.

Wagner, M. O., Bös, K., Jascenoka, J., Jekauc, D., & Petermann, F. (2012). Peer problems mediate the relationship between developmental coordination disorder and behavioral problems in school-aged children. *Research in Developmental Disabilities*, *33*(6), 2072–2079.

Wagner, M. O., Bös, K., Jekauc, D., Karger, C., Mewes, N., Oberger, J., Reimers, A. K., Schlenker, L., Worth, A., & Woll, A. (2014). Cohort profile: The Motorik-Modul longitudinal study: Physical fitness and physical activity as determinants of health development in German children and adolescents. *International Journal of Epidemiology*, *43*(5), 1410–1416. https://doi.org/10.1093/ije/dyt098

Wagner, M. O., Macha, T., Kastner, J., Petermann, F., Jekauc, D., Worth, A., & Bös, K. (2011). *Frühdiagnostik motorischer Funktionen*. Diagnostica.

Woll, A., Albrecht, C., & Worth, A. (2017). Motorik-Module (MoMo) - the KiGGS wave 2 module to survey motor performance and physical activity. *J Health Monit*, *2*(Suppl 3), 63–70. https://doi.org/10.17886/rki-gbe-2017-110

Woll, A., Klos, L., Burchartz, A., Hanssen-Doose, A., Niessner, C., Oriwol, D., Schmidt, S. C. E., Bös, K., & Worth, A. (2021). Cohort profile update: The Motorik-Modul (MoMo) longitudinal study—physical fitness and physical activity as determinants of health development in German children and adolescents. *International Journal of Epidemiology*, *50*(2), 393–394. https://doi.org/10.1093/ije/dyaa281

Worth, A., Woll, A., Albrecht, C., Karger, C., Mewes, N., Oberger, J., Schlenker, L., Schmidt, S., Wagner, M., & Boes, K. (2015). *MoMo-Längsschnittstudie" Physical fitness and physical activity as determinants of health development in children and adolescents": Testmanual zu den motorischen Tests und den anthropometrischen Messungen (KIT Scientific Reports; 7700) (Vol. 7700)*. KIT Scientific Publishing.

Wu, A. D., Li, Z., & Zumbo, B. D. (2007). Decoding the meaning of factorial invariance and updating the practice of multi-group confirmatory factor analysis: A demonstration with TIMSS data. *Practical Assessment, Research, and Evaluation*, *12*(1), 3. https://doi.org/10.7275/mhqa-cd89