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Psychometric Properties of the French Version of the Pictorial Scale of Perceived Movement Skill Competence for Young Children (PMSC)

Propriétés Psychométriques de la Version Française du Pictorial Scale of Perceived Movement Skill Competence for Young Children (PMSC)

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Abstract

The objective of this study was to examine the psychometric properties of a French version of the pictorial scale of Perceived Movement Skill Competence for Young Children (PMSC), which is aligned with the third version of the Test of Gross Motor Development. A sample of 219 French-speaking Canadian children (5 to 12 years old) participated in this study. Results supported the factor validity and reliability of a 13-item version of the PMSC encompassing two factors (i.e., ball skills and locomotor skills). Subsequent analyses supported the weak, partial strong, and partial strict invariance of responses to the PMSC as a function of sex. Additionally, analyses revealed that boys displayed significantly higher perceived ball skill competence than girls. Results also supported a lack of differential item functioning (DIF) and latent mean differences as a function of body mass index and physical activity/sport involvement, but revealed evidence of DIF and latent mean differences as a function of age. More precisely, these results show that older children displayed significantly: (a) higher scores on the sliding item and lower scores on the kicking item relative to younger children; and (b) lower scores on perceived locomotor skills competence than younger children. Overall, results suggest that the French version of the PMSC has acceptable psychometric properties and can be confidently used in research or practice to assess children's perceived movement skill competence.

Keywords: Perceived Movement Skill Competence; French; measurement invariance; differential item functioning; age; body mass index; physical activity; sex.

Résumé

L'objectif de cette recherche était d'étudier les propriétés psychométriques de la version française du *pictorial scale of Perceived Movement Skill Competence for Young Children* (PMSC) qui est alignée sur la troisième version du *Test of Gross Motor Development*. Un échantillon composé de 219 enfants Canadiens francophones (5 à 12 ans) a participé à cette étude. Les résultats confirment la validité factorielle et la fidélité des 13 énoncés de la version du PMSC comprenant deux facteurs (i.e., compétences perçues avec des balles/ballons et compétences perçues de locomotion). D'autres analyses soutiennent l'invariance (complète au niveau de la saturation des énoncés et partielle aux niveaux de la moyenne et de l'erreur de mesure des énoncés) des réponses au PMSC selon le sexe des enfants. Par ailleurs, les analyses ont révélé que les garçons affichaient des scores de compétences perçues avec des balles/ballons significativement plus élevés que les filles. Les résultats ont également montré : (a) une absence de fonctionnement différentiel des énoncés (FDE) et de différences de moyenne au niveau des variables latentes du PMSC selon l'indice de masse corporelle et la pratique d'une activité physique/sportive des enfants ; et (b) la présence d'un FDE et des différences de moyennes au niveau des variables latentes du PMSC selon l'âge des enfants. Plus précisément, ces résultats montrent que les enfants plus âgés affichent de manière significative: (a) des scores plus élevés pour l'énoncé « se déplacer de côté » et des scores plus faibles pour l'énoncé « frapper un ballon avec le pied » par rapport aux enfants plus jeunes; et (b) des scores de compétences perçues de locomotion perçues inférieurs à ceux des enfants plus jeunes. Dans l'ensemble, les résultats suggèrent que la version française du PMSC a des propriétés psychométriques acceptables et qu'elle peut être utilisée en toute confiance dans la recherche ou la pratique pour évaluer les compétences motrices perçues des enfants.

Mots-clefs: Compétences motrices perçues ; Français ; invariance ; fonctionnement différentiel des énoncés ; Âge ; indice de masse corporelle ; activité physique ; sexe.

Introduction

In children, actual and perceived motor skills are generally conceptualized as encompassing two main components (locomotor skills, and object control or ball skills), although a third component (stability/balance skills) is also sometimes considered (De Meester et al., 2020; Estevan et al., 2021). Actual and perceived competence in these skills have been hypothesized to play a significant role in the development of physical activity and sport involvement, health-related indicators of physical fitness, and weight status from early to late childhood (Robinson et al., 2015; Stodden et al., 2008). In a recent meta-analytic review of research focusing on actual and perceived motor skills competence among youth and young adults, De Meester et al. (2020) identified small but significant associations between actual and perceived motor competence that seemed to occur both at the global (global motor competence) and specific (the subdomains of locomotor, object control and stability/balance) levels. Their results also indicated that these associations seemed to generalize across age, sex, developmental status and type of measure used to assess perceived motor competence. However, most of the studies conducted so far in this area suffer from several limitations (Estevan & Barnett, 2018; Robinson et al., 2015). More precisely, these studies tended to: (a) focus on a broader construct of physical self-conception rather than on perceived motor competence; (b) be limited to a reduced subset of motor competencies; and (c) have a mismatch between the actual motor skills assessed and the perception items (Estevan & Barnett, 2018; Robinson et al., 2015). These issues led to the development of the pictorial scale of Perceived Movement Skill Competence (PMSC) scale for young children, aligned with the second version of the Test of Gross Motor Development (TGMD-2; Ulrich, 2000).

First and Second Versions of the PMSC

A first version of the PMSC included 12 items, and was developed to measure children's perceived locomotor (e.g., running, hopping) and object control (e.g., bouncing, catching) skill competence aligned with the TGMD-2 (Barnett et al., 2015). Children provide their response using a two-step procedure. In the first step, two figures are presented: one representing a boy or a girl that is competent in a specific movement skill, and another one representing a boy or a girl not competent in this skill. Children are then asked to point to the figure in which the boy or the girl performing the skill is most like them. In the second step, children choosing the figure representing the competent boy or girl are asked if they are "really good at" (coded 4) or "pretty good at" (coded 3) this skill. Conversely, children choosing the boy or girl who is not competent are asked if they are "sort of good at" (coded 2) or "not too good at" (coded 1) this skill. The authors were able to demonstrate the face validity (e.g., identification and comprehension of the pictures and skills) and reliability of this initial version among a sample of 81 children aged between 5 to 8 years. Their results revealed satisfactory estimates of scale score reliability (object control α = .63-.72; locomotor α = .64-.68) and test-retest reliability over seven days (object control intra-class correlations [ICC] = .78; locomotor ICC = .82) for both subscales.

This initial version was then expanded via the addition of six additional items focusing on active play skills (Barnett et al., 2016a). These skills were developed to assess "childhood active skills related to play activities", for example cycling, riding a bike, etc. (Barnett et al., 2016a, p. 295). Barnett et al. (2016a) examined the psychometric properties of this 18-item version of the PMSC among a sample of 303 children aged between 4 to 5 years. The authors' contrasted two factor structures: (a) three 6-items factors: active play, object control and locomotion; and (b) an alternative three factors: active play (6 items), object control-hand skills (4 items) and fundamental movement skills (FMS) with leg action (8 items). Their results revealed that both models resulted in an acceptable level of fit to the data, although the fit of the second model was superior to the first one. This model was thus retained for further analyses, which supported the scale score reliability of this solution (active play α = .78; object control-hand skills α = .76; FMS with leg action α = .84), and showed that boys tended to present higher scores than girls in object control-hand skills. However, no significant association was found between weight status and PMSC scores. This version was also found to be reliable (test retest and scale score reliability) in 91 Australian preschool children (4 and 5 years) (Moulton et al., 2019).

The second version of the PMSC has since been cross-validated in a variety of studies. These studies were generally able to support a two-factor model of the TGMD in terms of locomotor and object control skills slightly different to Barnett et al.'s (2016a) final solution (object control-hand skills and fundamental movement skills with leg action). Thus, Lopes et al. (2016) supported a two-factor model in Portuguese-speaking children (from Portugal) with acceptable scale score reliability (locomotor skills: 6 items, α = .68; object control skills: 6 items, α = .73). Morano et al. (2020)

supported a three-factor model (i.e., active play skills, object control skills, and locomotor skills, with 5 items each) in Italian children. Finally, in Portuguese (from Brazil) - and Spanish- speaking children, Valentini et al. (2018) and Estevan et al. (2018) respectively supported a distinct two-factor model (6-12 items and 6-6 items) with acceptable scales scores reliability: (a) active play skills (6 items, α = .83; and FMS (12 items, α = .77) in Valentini et al. (2018); and (b) locomotor (6 items, α = .68) and object control skills (6 items, α = .76) in Estevan et al. (2018). Additional results obtained by Estevan et al. (2018) and Morano et al. (2020) revealed that boys and older children (7 years) tended to present significantly higher scores than girls and younger children (6 years) in object control skills. It is important to note that the Barnett et al.'s (2016a) study had younger children than all subsequent validations, likely contributing to the different final solution. It is also noteworthy that all of these cross-validation studies were conducted among different linguistic groups which could also explain some of these discrepancies.

An Updated Version of the PMSC Aligned with the TGMD-3

An updated version of the PMSC (Johnson et al., 2016) was developed in order to maintain alignment with the third version of the TGMD (TGMD-3; Ulrich, 2019). In this updated version, some items were removed (i.e., leaping and rolling underhand) and items referring to new skills were added (i.e., skipping, throwing underhand, and hitting a ball with one hand – strike) (Estevan et al., 2019). This updated version first incorporated 13 items, aligned with the TGMD-3, and measured perceived ball skills (7 items) and locomotor skills (6 items) competence, as well as 6 items measuring active play skills. To our knowledge, this updated third version has not yet been validated in English, aside from reliability for the seven TGMD-3 perceived object control skills (test retest reliability, ICC =0.86, α: test 1 = 0.66, test 2 = 0.78, Johnson et al., 2016) and only three studies have examined its psychometric properties among samples of Chinese (Diao et al., 2018), Greek (Venetsanou et al., 2018), and Spanish (Estevan et al., 2019) participants. All of these studies converged on the same two-factor solution in which 13 out of the proposed items were used to assess ball skills (7 items, α = .76-.86) and locomotor skills (6 items, α = .60-.77). Additional results obtained by Estevan et al. (2019) also showed that boys presented significantly higher scores than girls in ball skills, locomotor skills and on the global PMSC score.

This version still has to be adapted and validated among French-speaking children. As there are still no self-report questionnaires available to assess perceived movement skills competence among French-speaking children, the development of a validated French version of this questionnaire would represent a significant contribution to cross-cultural research. Indeed, French remains one of the two most commonly spoken language in many European (e.g., Belgium, France, Switzerland), American (e.g., Canada, Haiti, French Guiana), and African (e.g., Algeria, Morocco, Tunisia) countries or territories. This is the main objective of the present study.

Measurement Invariance and Latent Means Differences of the PMSC

To date, there is very little evidence that any versions of the PMSC are able to provide reliable information when used to compare subpopulations of children presenting different attributes or characteristics (e.g., age, body mass-index, physical activity/sport involvement, sex). Among exceptions, Valentini et al. (2018) and Venetsanou et al. (2018) both examined the measurement invariance of the factor structure of the PMSC as a function of children's sex and found evidence of weak invariance (i.e., equivalence of the factor loadings across boys and girls). However, their analyses remain incomplete as they only focused on the equivalence of one type of parameter estimates (loadings), thus neglecting other equally important tests of invariance. Thus, it is currently unknown whether boys and girls will tend to score higher or lower on specific items (items intercepts or thresholds: strong invariance), and whether item-level measurement error (item uniquenesses: strict invariance) will remain unchanged as a function of sex. This lack of information is particularly problematic given that strong invariance is an important pre-requisite to the realization of mean comparisons across subgroups of children, whereas strict invariance is a prerequisite to any form of group comparisons relying on manifest scale scores (e.g., the mean of each participant across all items forming a subscale) rather than latent factors (e.g., Meredith, 1993; Millsap, 2011).

Additionally, none of the reviewed studies has examined any form of measurement invariance, or the presence of differential item functioning (DIF; i.e., the presence of systematic responses tendencies that differ across groups), and possible latent mean differences on the PMSC as a function of children's body mass-index (BMI) and involvement in physical activity/sport. This is surprising given that these characteristics are frequently considered in research focusing on perceived motor competence among children (e.g., Barnett et al., 2016a; Carcamo-Oyarzun et al., 2020; Clark et al., 2018; Estevan et al., 2018; Morano et al., 2020). Therefore, it is currently unknown whether the PMSC could be used for any type of mean comparisons as function of children's age, BMI or involvement in physical activity/sport.

Study's Objectives

The main objective of this study was to examine the psychometric properties of the French version of the third version of PMSC (aligned to the TGMD-3) among a sample of French-speaking Canadian children. First, the PMSC was adapted to French. Second, the factor validity and composite reliability of the two-factor model validated in recent studies (Diao et al., 2018; Estevan et al., 2019; Venetsanou et al., 2018) was examined. Third, the measurement invariance of this two-factor model was examined across subsamples of boys and girls. Finally, the presence of DIF in responses to the PMSC was examined as a function of children's age, BMI and physical activity/sport involvement.

Method

Participants

A convenience sample of 219 French-speaking Canadian children (5 to 12 years old, M_{age} = 8.00, SD_{age} = 1.74; BMI: 11.29 to 31.86 kg/m², M_{BMI} = 16.64, SD_{BMI} = 3.01) participated in this study. Among these: (a) 50.7% were girls (N = 111) and 49.3% were boys (N = 108); (b) 82.9% (N = 180) were involved in a physical activity/sport outside of school; (c) 6% were 5 years-old (N= 13), 14.2% were 6 years-old (N = 31), 25.2% were 7 years-old (N = 55), 16.1% were 8 years-old (N = 35), 16.5% were 9 years-old (N = 36), 13.3% were 10 years-old (N = 29), 6.4% were 11 years-old (N = 14), and 2.3% were 12 years-old (N = 5); and (d) 20.2% (N = 39) were underweight, 60.1% (N = 116) were normal weight, 17.6% (N = 34) were overweight, and 2.1% (N = 4) were obese based on the sex- and age-specific BMI revised cut-off scores provided by the International Obesity Task Force (Cole & Lobstein, 2012). Potential participants targeted by this study had to display a typical development (i.e., no developmental delay, neurological disorder, sensory or physical disabilities, or the need to receive assistance to move).

Measures

Characteristics of the children. Parents or legal representatives reported their child's sex, age, height, weight, and involvement in physical activity/sport practice outside of the school context (i.e., "*Does your child practice a physical activity or a sport outside of school?*"). BMI was estimated (in kg/m^2) based on children's height and weight [(Weight/(Height²)].

PMSC. The PMSC (Johnson et al., 2016) was adapted into French using standardized translation back-translation techniques (Hambleton, 2005) by two independent professional bilingual translators. Discrepancies between the original and back-translated versions were resolved in a committee including four members of the research team and the translators. The French items (excluding the figures themselves which are copyrighted and cannot be reproduced) are presented in the Appendix. Authors seeking to obtain a complete copy of the testing material should directly contact the first author.

Procedures

Authorization to conduct the present study was granted by the first author's University research ethics committee and by the school board of the participating schools. Six elementary schools were solicited and agreed to participate. Participants were eligible for a draw to three $30 gift certificates. Parents or legal representatives of children were informed of the study through a letter sent by the schools. Those manifesting an interest to participate were then solicited to sign an informed consent form and to complete a questionnaire about their child. Once parental/legal representative consent was obtained, children were met at school by members of the research team. During this meeting the objectives and procedures of the study and the consent form were presented. Children who volunteered to participate were asked to sign (by writing their first name) an informed consent form before completing the PMSC.

Members of the research team administered the questionnaire individually at school. A booklet including the figures, the sentences, and the answer scales was used. The instructions and items of the PMSC were read aloud by the interviewer. Children were asked whether they had already done or not the action illustrated in the figures. Children who had never done the action were asked to imagine themselves doing it. Additionally, a physical demonstration of the skill illustrated in the figures was proposed when the child had never done this action or had difficulties to understand or recognize the action. Although this happened a few times, this remained a relatively rare occurrence that was not specific to any of the skills covered in the PMSC. Finally, for each skill, children were asked to point-out their response following the procedure described in the introduction. Responses were then reported by the interviewer on a separate scoring sheet. Children generally took less than 10 minutes to complete the PMSC.

Data Analysis

Given the ordered categorical nature of the data (Finney & DiStefano, 2013), analyses were conducted using Mplus 8.4's (Muthén & Muthén, 2019) robust weighted least squares (WLSMV). To account for the few missing responses at the item level (0.46% to 2.28%; M = 0.95%), models were estimated based using algorithms implemented in Mplus in conjunction with the WLSMV estimator (Asparouhov & Muthén, 2010). First, the adequacy of the *a priori* two-factor model (i.e., 7 items measuring ball skills, and 6 items measuring locomotor skills) was verified using confirmatory factor analyses (CFA). The goodness-of-fit of this model was examined using (e.g., Hu & Bentler, 1999; Marsh et al., 2005; Yu, 2002): The comparative fit index (CFI ≥ .90 and >. 95 reflect "acceptable" and "excellent" fit, respectively), the Tucker-Lewis index (TLI; same thresholds as for the CFI), and the root mean square error of approximation (RMSEA ≤.08 and ≤. 06 represent an "acceptable" and "excellent" fit, respectively). The composite reliability of the PMSC factors was estimated using the omega (ω) coefficient (McDonald, 1970).

In a second step, the measurement invariance of the PMSC factors was tested as a function of sex as following (Morin et al., 2011): (i) configural invariance; (ii) weak invariance (loadings); (iii) strong invariance (thresholds); (iv) strict invariance (uniquenesses); (v) invariance of the latent variances/covariances; and (vi) latent means invariance. Comparisons between these sequences were based on changes (Δ) in CFI, TLI and RMSEA. Invariance was supported when ΔCFI and ΔTLI were ≤ .01 and ΔRMSEAs ≤. 015 (Chen, 2007; Cheung & Rensvold, 2002). As recommended (e.g., Hu & Bentler, 1999; Marsh et al., 2005), the WLSMV chi-square test of exact fit (Wχ^2) and changes in its values (ΔWχ^2 estimated using the Mplus DIFFTEST function) will only be reported, but not interpreted given their known oversensitivity to sample size and minor misspecifications.

Tests of measurement invariance are harder to conduct, or less appropriate, when the variable considered is continuous (i.e., age and BMI) or involves small groups (i.e., few children were not involved in physical activity/sport). Thus, the presence of measurement bias in relation to age, BMI, and involvement in physical activity/sport was examined relying on tests of DIF and latent mean differences conducted within a multiple indicators multiple causes (MIMIC) CFA model. These MIMIC tests of DIF were performed separately for age, BMI and physical activity/sport involvement in the following sequence (Marsh et al., 2013; Morin et al., 2013): (a) null effects model (paths from the predictors to the latent factors and item responses were constrained to be zero); (b) saturated model (paths from the predictors to the item responses were freely estimated, while paths from the predictors to the latent factors were constrained to be zero); (c) factors only model (paths from the predictors to the latent factors were freely estimated, while paths from the predictors to the item responses were constrained to be zero). Improvement in fit (ΔCFI and ΔTLI ≥ .01 and ΔRMSEA ≥. 015) between the factors only model and the saturated model relative to the null effects model revealed the presence of associations between predictors and item responses. Moreover, improvement in model fit for the saturated model relative to the factors only model revealed a DIF.

Results

Factor Validity and Composite Reliability

As shown in the top row of Table 1, the a priori two-factor solution (model 1-1) resulted in an excellent level of fit to the data. Standardized parameter estimates from this solution are reported in Table 2. They generally reveal acceptable factor loadings (λ = .381 to .675), with the exception of the galloping item (λ = .190) which appeared to be more weakly related to its a priori factor. The composite reliability of the ball skills factor was acceptable (ω = .768), whereas that of the locomotor skills was slightly lower than desirable (ω = .697). This slightly lower level of composite reliability can be attributed to the problematic galloping item. Indeed, removing this item results in a composite reliability coefficient of ω = .745 for the locomotor skills factor.

Measurement Invariance and Differential Item Functioning

Measurement invariance across sex. The model fit results from the sequential tests of measurement invariance are reported in the second section of Table 1 (models 2-1 to 2-8). These results support the weak (model 2-2) invariance of this solution, but not its strong (model 2-3) or strict (model

2-5) invariance. Examination of the parameter estimates from these different solutions and of the modification indices associated with the failed strong and strict invariance solutions suggested that invariance constraints had to be relaxed on: (a) three response thresholds (out of a total of 39 response thresholds per sample) associated with the hitting a ball and galloping items across sex; and (b) two uniqueness (out of a total of 13 per sample) associated with the catching and galloping items across sex. The resulting model of partial strong (model 2-4) and partial strict (model 2-6) invariance were supported by the data. It is important to note that the majority of these non-invariant parameters can be attributed to the problematic galloping item. Finally, the last two steps also supported the invariance of latent variances/covariances (model 2-7), but revealed the presence of latent means differences (model 2-8) across sex. More precisely, boys tended to score significantly higher (.854, $p < .001$) than girls on the ball skills latent factor.

DIF across age, BMI and physical activity/sport involvement. The results from the MIMIC models are presented in the bottom section of Table 1. For age, the results showed that both the saturated (model 3-2) and factors only models (model 3-3) resulted in a substantial improvement in model fit relative to the null effects model (model 3-1). These results support the idea that age is significantly associated with PMSC responses. However, the factors only model resulted in substantially lower model fit than the saturated model ($\Delta W\chi^2 = 51.21$, df = 11, $p < .001$, ΔCFI = -.052, ΔTLI = -.059, ΔRMSEA = +.022), thus suggesting the presence of DIF as a function of age. Examination of the parameter estimates from the saturated model and of the modification indices associated with the factors only model suggested that direct effects of age on the sliding and kicking items needed to be added to the factors only model. Therefore, a fourth model of partial DIF was estimated (model 3-4) by adding direct paths between age and these two items to the factors only model. This partial DIF model was found to present a level of fit comparable to that of the saturated model (ΔCFI and ΔTLI ≤ .01 and ΔRMSEA ≤. 015). Results from this model showed that older children tended to score significantly lower on the locomotor (-.323, $p < .001$) factor relative to younger children. Older children also tended to score significantly higher on the sliding item (.306, $p < .001$) and lower on the kicking item (-.380, $p < .001$) relative to younger children.

In relation to BMI and to physical activity/sport involvement, the results showed that both the saturated (models 4-2 and 5-2) and factors only (models 4-3 and 5-3) models did not result in a substantial improvement in model fit when compared to the null effects model (models 4-1 and 5-1). These results suggested thus a lack of DIF, and do not support the idea that BMI and physical activity/sport involvement are significantly associated with responses of the PMSC latent factors.

Discussion

This study sought to verify the psychometric properties of the French adaptation of the PMSC among a sample of French-Canadian children. Our results supported a French version of the 13-item updated version of the PMSC encompassing measures of perceived ball skill competence and locomotor skills competence (model 1-1). The composite reliability of both factors was acceptable, and aligned with reliability estimates found in recent cross-linguistic investigations of this version of the PMSC (Diao et al., 2018; Estevan et al., 2019; Venetsanou et al., 2018). Nevertheless, one item from the locomotor skills factor (galloping) was suboptimal in our a priori model (model 1-1). This item was also reported in previous studies to be not as well recognized by children as the other skills (Barnett et al., 2015, Diao et al., 2018; Estevan et al., 2018; Lopes et al., 2016; Venetsanou et al., 2018), potentially due to the skill not being a well-known or practiced skill. As such, our results reflect and confirm the results reported from other cultural and linguistic samples, and suggest that this skill might be targeted for re-examination in future studies.

To our knowledge, the current study was the first to examine the measurement invariance of the PMSC factor structure, and to test for evidence of DIF and latent mean differences in PMSC responses, as a function of a variety of children's characteristics. First, our results generally supported the measurement invariance of the PMSC factors as a function of sex, but suggested that the response thresholds (model 2-4) associated with the hitting a ball and galloping items tended to differ as a function of sex. This result suggests that it might be prudent, at this time, to avoid using these items in studies seeking to more specifically compare boys and girls on the basis of manifest (i.e., non-latent) scores. Alternatively, studies seeking to compare boys and girls using latent variables would benefit from accounting for this slight non-invariance as part of their analyses. Additional results (i.e., the comparison of models 2-7 and 2-8) also revealed that boys displayed significantly higher levels of perceived ball skill competence than girls. This result is consistent with those from previous cross-linguistic studies (e.g., Barnett et al., 2016a; Estevan et al., 2018, 2019; Morano et al., 2020) and also reflects actual motor competence (Barnett et al., 2016b).

Second, the present results showed older children displayed significantly lower levels of perceived locomotor skills competence relative to younger children (model 3-4), supporting theoretical notions that self-perceptions might be inflated in younger children because they have not yet become aware of how they perform relative to peers (Harter, 2003). In this study, additional results revealed some evidence of DIF as a function of children's age (model 3-4). More specifically, they showed that one item measuring ball skills tended to be scored lower (i.e., kicking) and one item measuring locomotor skills (i.e., sliding) tended to be scored higher, as a function of age. This observation thus suggests that these items should be excluded from analyses seeking to assess the effects of age using manifest (non-latent variables), or that this type of DIF would have to be controlled for as part of latent analyses.

Third, our results supported a lack of DIF in PMSC responses as a function of children's BMI (models 4-1 to 4-3) and physical activity/sport involvement (models 5-1 to 5-3). These results indicate that observed and latent scores on any of the PMSC factors can be confidently used to compare children as a function of their BMI and involvement in physical activities and sports. Nevertheless, no latent means differences were observed as a function of children's BMI and physical activity/sport involvement. In contrast, BMI was positively associated with locomotor perceptions (using the same version of the PMSC as in the current study) in Finnish children (Niemistö et al., 2019). However, Niemistö et al. (2019) noted that, as only 3.4% of their sample were classified as obese, this result could be better explained by a perception of a possible link between size and strength among overweight children. Alternatively, this result could also reflect the possible role played by muscular structure in increasing BMI among youth located at the lower range of the overweight continuum.

In relation to children's involvement in physical activity/sport practice outside of the school context, the current study remains limited by the imprecise (i.e., binary) nature of our measure (i.e., involved vs. not involved). Indeed, a number of previous studies conducted among Australian children have rather relied on objective continuous measures of physical activity with mixed results. For example, in Australian children, using the first version of the PMSC, moderate to vigorous physical activity (MVPA) at 3.5 years predicted perceived total skills at 5 years (Barnett et al., 2016c). In another sample, perceived object control skills in 6-7 years old predicted MVPA one year later (Barnett et al., 2016c). Yet, in two other cross-sectional samples, no association was found between PMSC and MVPA among 6 years old (Slykerman et al., 2016) or 8-11 years old children (Barnett et al., 2018). These mixed results could be explained by a variety of methodological differences making it hard to clearly compare results across studies (Robinson et al., 2015). Indeed, in the motor competence literature, physical activity is often assessed in many different ways (Robinson et al., 2015). Therefore, it is important that further research could seek to more fully understand the relation between physical activity and PMSC, and how it may differ according to the way physical activity is measured and children's age.

The current study has four main limitations that should be considered when interpreting the results. First, this adapted two-factor structure of the French version of the PMSC was only validated on a small convenience sample of children with a wide age range. Moreover, 60.1% of the children involved in the present study were of normal weight, and 82.9% of them were involved in physical activity/sport outside of the school. Therefore, the extent to which these results would generalize to other French-speaking populations, to other linguistic groups, or to larger and more representative samples of French-Canadian children, remains unknown. Second, children's height and weight were obtained via parental reports rather than objectively measured. As a result, the BMI scores used in this study might have been lower than if objective measurement had been performed (Ghosh-Dastidar et al., 2016). Therefore, the extent to which our results would generalize to other studies relying on objective measures of BMI remains to be verified in future research.

Third, the cross-cultural and linguistic invariance of the PMSC was not tested in the current study. Therefore, it is currently unknown whether the factor structure of the current version of the PMSC would be invariant among samples of: (a) French-speaking children from different cultures (e.g., North-American, European and North-African); and (b) children speaking other languages (i.e., English, Dutch, Greek, Portuguese, Spanish, etc.). Finally, no evidence of the test-retest reliability, longitudinal invariance, responsiveness to change, concurrent validity, or predictive validity of the French version of the PMSC was proposed in the present study. These psychometric properties should thus be more thoroughly examined in future longitudinal research in combination with other self-report measures of perceived movement or motor skills competence and more objective measures such as the TGMD-3 (Ulrich, 2019). More importantly, although our results suggested age-related changes in children's locomotor skills levels, these results remain cross-sectional in nature and cannot be directly interpreted as reflecting a developmental effect. Future longitudinal studies will be needed to better understand this effect, and the developmental mechanisms at play.

In conclusion, results from the present study confirmed that the psychometric properties (factor validity, composite reliability, and measurement invariance/DIF) of the French adaptation of the PMSC are promising. This questionnaire can be used in the context of group-based comparisons based on latent variable models (but not necessarily observed scores yet) as a function of age, BMI, physical activity/sport involvement and sex. However, practitioners or researchers seeking to rely on manifest scores to conduct age- and sex-based comparisons should do so carefully by considering the evidence of measurement non-invariance and DIF associated with a subset of items. Finally, based on the aforementioned limitations it is presently premature to recommend its use in cross-linguistic/cultural and longitudinal studies.

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Table 1
Goodness-of-Fit Statistics of Confirmatory Factor Analyses (CFA) for the PMSC

Models	N°	Description	Wχ² (df)	CFI	TLI	RMSEA	RMSEA 90% CI	CM	ΔWχ² (df)	ΔCFI	ΔTLI	ΔRMSEA
CFA	1-1	2-factor (7-6 items)	85.575(64)	.967	.960	.039	.010-.060		-	-	-	-
Measurement Invariance: Sex	2-1	Configural invariance	168.600(128)*	.936	.922	.054	.028-.075	-	-	-	-	-
	2-2	Weak invariance	175.118(139)	.943	.936	.049	.020-.070	2-1	10.80(11)	+.007	+.014	-.005
	2-3	Strong invariance	217.165(163)*	.915	.919	.055	.033-.074	2-2	53.91(24)*	-.028	-.017	+.006
	2-4	Partial strong invariance	198.567(160)	.940	.941	.047	.020-.067	2-2	27.77(21)	-.003	+.005	-.002
	2-5	Strict invariance	221.304(173)*	.924	.932	.050	.027-.069	2-4	24.31(13)	-.016	-.009	+.003
	2-6	Partial strict invariance	211.218(171)	.937	.942	.046	.020-.066	2-4	14.48(11)	-.003	+.001	-.001
	2-7	Latent variances-covariances invariance	205.575(174)	.951	.956	.041	.000-.061	2-6	0.94(3)	+.014	+.014	-.005
	2-8	Latent means invariance	264.352(176)*	.862	.877	.068	.050-.084	2-7	25.23(2)*	-.089	-.079	+.027
DIF: Age	3-1	Null effects	144.529(77)*	.898	.879	.063	.047-.079	-	-	-		-
	3-2	Saturated	79.197(64)	.977	.967	.033	.000-.055	3-1	55.32(13)*	+.079	+.088	-.030
	3-3	Factors only	124.743(75)*	.925	.908	.055	.037-.072	3-1	10.51(2)*	+.027	+.029	-.008
	3-4	Partial DIF	92.130(73)	.971	.964	.035	.000-.055	3-2	13.72(9)	-.006	-.003	+.002
DIF: Body mass-index	4-1	Null effects	96.363(77)	.968	.962	.036	.000-.057	-	-	-		-
	4-2	Saturated	88.241(64)	.959	.942	.044	.017-.066	4-1	11.61(13)	-.009	-.020	+.008
	4-3	Factors only	99.102(75)	.960	.951	.041	.012-.061	4-1	0.93(2)	-.008	-.011	+.005
DIF: PA/Sport involvement	5-1	Null effects	89.532(77)	.981	.978	.027	.000-.049	-	-	-		-
	5-2	Saturated	87.712(64)	.965	.950	.041	.015-.061	5-1	7.39(13)	-.016	-.028	+.014
	5-3	Factors only	95.115(75)	.970	.964	.035	.000-.055	5-1	0.41(2)	-.011	-.014	+.008

Notes. PMSC = pictorial scale of Perceived Movement Skill Competence for Young Children; Wχ² = robust weighed least square (WLSMV) chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; 90% CI = 90% confidence interval of the RMSEA; CM = comparison model; Δ = change from previous model; ΔWχ² = WLSMV chi square difference test (calculated with the Mplus DIFFTEST function); DIF = differential item functioning; PA = physical activity; The fact that Wχ² values are not exact, but "estimated" as the closest integer necessary to obtain a correct *p* value explains the fact that the Wχ² and the resulting CFI values can be non-monotonic with model complexity. *p <.01.

Table 2

Standardized Parameter Estimates from the 2-Factor Solution of the PMSC

Items	Ball Skills (λ)	Locomotor Skills(λ)	δ
Hitting a ball	.381		.855
Hitting a ball with one hand	.608		.630
Bouncing	.502		.748
Catching	.644		.585
Kicking	.600		.639
Throwing underhand	.642		.588
Throwing overhand	.571		.674
Running		.675	.544
Galloping		.190	.964
Hopping		.571	.674
Skipping		.639	.591
Jumping forwards		.550	.698
Sliding		.492	.758
Factor Correlation	.801		

Notes. All coefficients are statistically significant ($p \leq .05$); PMSC = pictorial scale of Perceived Movement Skill Competence for Young Children; λ = factor loadings; δ = uniquenesses.

Appendix - *French Items of the PMSC*

N°	Scales	Labels	Items	
1	LOC	Running	Ce garçon est plutôt bon pour courir. Es-tu : Vraiment bon OU Plutôt bon pour courir	Ce garçon n’est pas très bon pour courir. Es-tu : Un peu bon OU Pas trop bon pour courir
2	LOC	Galloping	Ce garçon n’est pas très bon pour galoper comme un cheval. Es-tu : Pas trop bon OU Un peu bon pour galoper comme un cheval	Ce garçon est plutôt bon pour galoper comme un cheval. Es-tu : Plutôt bon OU Vraiment bon pour galoper comme un cheval
3	LOC	Hopping	Ce garçon est plutôt bon pour sauter sur une jambe. Es-tu : Vraiment bon OU Plutôt bon pour sauter sur une jambe	Ce garçon n’est pas très bon pour sauter sur une jambe. Es-tu : Un peu bon OU Pas trop bon pour sauter sur une jambe
4	LOC	Skipping	Ce garçon n’est pas très bon pour se déplacer en sautillant[a]. Es-tu : Pas trop bon OU Un peu bon pour te déplacer en sautillant.	Ce garçon est plutôt bon pour se déplacer en sautillant. Es-tu : Plutôt bon OU Vraiment bon pour te déplacer en sautillant.
5	LOC	Jumping forwards	Ce garçon est plutôt bon pour sauter vers l’avant. Es-tu : Vraiment bon OU Plutôt bon pour sauter vers l’avant	Ce garçon n’est pas très bon pour sauter vers l’avant. Es-tu : Un peu bon OU Pas trop bon pour sauter vers l’avant
6	LOC	Sliding	Ce garçon n’est pas très bon pour se déplacer de côté. Es-tu : Pas trop bon OU Un peu bon pour te déplacer de côté	Ce garçon est plutôt bon pour se déplacer de côté. Es-tu : Plutôt bon OU Vraiment bon pour te déplacer de côté
7	BS	Hitting a ball	Ce garçon est plutôt bon pour frapper une balle. Es-tu : Vraiment bon OU Plutôt bon pour frapper une balle	Ce garçon n’est pas très bon pour frapper une balle. Es-tu : Un peu bon OU Pas trop bon pour frapper une balle
8	BS	Hitting a ball with one hand	Ce garçon n’est pas très bon pour frapper une balle d’une main. Es-tu : Pas trop bon OU Un peu bon pour frapper une balle d’une main	Ce garçon est plutôt bon pour frapper une balle d’une main. Es-tu : Plutôt bon OU Vraiment bon pour frapper une balle d’une main
9	BS	Bouncing	Ce garçon est plutôt bon pour faire rebondir un ballon. Es-tu : Vraiment bon OU Plutôt bon pour faire rebondir un ballon	Ce garçon n’est pas très bon pour faire rebondir un ballon. Es-tu : Un peu bon OU Pas trop bon pour faire rebondir un ballon
10	BS	Catching	Ce garçon n’est pas très bon pour attraper. Es-tu : Pas trop bon OU Un peu bon pour attraper	Ce garçon est plutôt bon pour attraper. Es-tu : Plutôt bon OU Vraiment bon pour attraper
11	BS	Kicking	Ce garçon est plutôt bon pour frapper un ballon avec le pied. Es-tu : Vraiment bon OU Plutôt bon pour frapper un ballon avec le pied	Ce garçon n’est pas très bon pour frapper un ballon avec le pied. Es-tu : Un peu bon OU Pas trop bon pour frapper un ballon avec le pied

N°	Scales	Labels	Items	
12	BS	Throwing underhand	Ce garçon n'est pas très bon pour lancer une balle par-dessous l'épaule. Es-tu : Pas trop bon OU Un peu bon pour lancer une balle par-dessous l'épaule	Ce garçon est plutôt bon pour lancer une balle par-dessous l'épaule. Es-tu : Plutôt bon OU Vraiment bon pour lancer une balle par-dessous l'épaule
13	BS	Throwing overhand	Ce garçon est plutôt bon pour lancer une balle par-dessus l'épaule. Es-tu : Vraiment bon OU Plutôt bon pour lancer une balle par-dessus l'épaule	Ce garçon n'est pas très bon pour lancer une balle par-dessus l'épaule. Es-tu : Un peu bon OU Pas trop bon pour lancer une balle par-dessus l'épaule

Notes. PMSC = Pictorial Scale of Perceived Movement Skill Competence for Young Children; LOC = Locomotor Skills; BS = Ball Skills; [a] the word "gambadant" can also be used and might be easier to understand by younger children.