Perceptual and Motor Skills
2021, Vol. 128(3) 1002–1016

DOI: 10.1177/00315125211000862
journals.sagepub.com/home/pms

# Psychometric Properties of a French Version of the Perceived Motor Competence in Childhood Questionnaire

**Christophe Maïano[1,2,*], Alexandre J. S. Morin[2,*], Johanne April[3], Maike Tietjens[4], Charlaine St-Jean[5], Cynthia Gagnon[6], Dennis Dreiskämper[4], and Annie Aimé[6]**

## Abstract

In this study, we examined the psychometric properties of a French version of the Perceived Motor Competence in Childhood (PMC-C) questionnaire. The participants

[1]Cyberpsychology Laboratory, Department of Psychoeducation and Psychology, Université du Québec en Outaouais, Saint-Jérôme, Canada
[2]Substantive-Methodological Synergy Research Laboratory, Department of Psychology, Concordia University, Montreal, Canada
[3]Department of Education Sciences, Université du Québec en Outaouais (UQO|Campus de Saint-Jérôme), Saint-Jérôme, Canada
[4]University of Münster, Institute of Sport and Exercise Sciences, Department of Sport and Exercise Psychology, Germany
[5]Department of Education Sciences, Université du Québec à Rimouski, Canada
[6]Department of Psychoeducation and Psychology, Université du Québec en Outaouais (UQO|Campus de Saint-Jérôme), Saint-Jérôme, Canada

*The order of appearance of the first and second authors (C. M. and A. J. S. M.) was determined at random: Both C. M. and A. J. S. M. should be considered first authors

**Corresponding Author:**
Christophe Maïano, Département de Psychoéducation et de Psychologie, Université du Québec en Outaouais, Campus de Saint-Jérôme, 5 rue Saint-Joseph, Saint-Jérôme, Québec J7Z 0B7, Canada.
Email: christophe.maiano@uqo.ca

were 219 French-speaking children (aged 5-12 years), recruited from elementary schools in the Canadian Province of Quebec. Results supported the validity and reliability of a second-order confirmatory factor analytic (CFA) model, including one higher-order factor. Additional analyses supported the complete measurement invariance of the first- and second-order factor structure across sex and indicated no differential item functioning or latent mean differences in PMC-C factors as a function of selected predictors (i.e., age, body mass-index and physical activity/sport involvement). Thus, this French version of the PMC-C has satisfactory psychometric properties (i.e., factor validity and reliability, measurement invariance and differential item functioning) and can be used to assess French-speaking children's perceived motor competence.

**Keywords**
age, body mass-index, children, physical activity, perceived motor competence, sex, sport

## Introduction

In a seminal publication, Stodden et al. (2008) proposed a conceptual model to investigate the potential role of motor skills in the "initiation, maintenance, or decline of physical activity" across early to late childhood (p. 290). In this model, the authors hypothesized that the developmental relations between motor skills and physical activity would be mediated by children's perceptions of their motor competence. Although several studies have since examined these associations, most have relied on questionnaires measuring physical self-perceptions rather than perceived motor competence (Robinson et al., 2015). This observation led to the development of newer self-report questionnaires specifically designed to measure children's perceived motor competencies. For instance, Barnett et al. (2015) developed a pictorial instrument based on differentiation of locomotor and object control among fundamental movement skills. This instrument was especially designed for children with low literacy levels and for researchers using one-on-one interviews.

Building upon this instrument, Dreiskämper et al. (2018) developed the Perceived Motor Competence in Childhood (PMC-C) questionnaire, suitable for older children and group interviews. The PMC-C includes 24 items measuring eight motor competence dimensions (i.e., three items per dimension) in line with items from the third version of the Test of Gross Motor Development (TGMD; Ulrich, 2019): (a) running, (b) jumping, (c) hopping, (d) leaping, (e) throwing, (f) catching, (g) bouncing, and (h) kicking. Children answer each PMC-C item using a four point Likert-type scale represented by different smiley faces, with response options ranging from "1" strongly disagree (with a very sad face) to "4" strongly agree (with a very happy face).

Dreiskämper et al. (2018) examined the psychometric properties of the PMC-C among a German sample of 197 children aged between 7–13 years. Confirmatory factor analysis (CFA) supported a higher order factor structure including the eight *a priori* first-order factors and two second-order factors (locomotion: formed of the running, jumping, hopping and leaping factors; and object control: formed of the throwing, catching, bouncing, and kicking factor). Subsequent analyses revealed acceptable scale score reliability for all subscales ($\alpha = .79–.91$), as well as significant positive relations between the PMC-C subscales, and ratings of physical activity and sport enjoyment. Finally, their results also revealed that: (a) boys presented significantly higher scores in object control than girls; and (b) there were no significant mean differences between age groups.

## PMC-C's Limited Validation in Other Languages and Cultures

To our knowledge, the PMC-C has solely been validated in German, which considerably limits its applicability for research with participants who speak other languages and come from other countries. Thus, in the present study, we attempted to validate a French version of this instrument. This effort is particularly important, given an absence of any validated self-report questionnaire for investigating perceived motor competence among French-speaking children. Practically speaking, the availability of a French version of the PMC-C will greatly facilitate comparing children across various European (e.g., France, Belgium, Switzerland, Luxembourg), North-American (Canada) and North-African (e.g., Algeria, Morocco, Tunisia) countries in which French is the first or second spoken language.

## PMC-C Measurement Invariance and Latent Means Differences

An important issue in the investigation of the PMC-C's psychometric properties is whether it can be used to compare observed or latent mean scores across different subpopulations, such as younger versus older children, or boys versus girls (Millsap, 2011). Indeed, measurement bias may occur when the factor structure of a questionnaire (also named configural invariance) differs across distinct subpopulations from the main population of interest (e.g., Maïano et al, 2015, 2021). Such measurement biases may also occur across subpopulations (Maïano et al., 2015, 2021) in relation to: (a) associations between test items and latent factors (factor loadings); (b) average patterns of item responses (intercepts or thresholds); and (c) item-level measurement error (uniquenesses or residuals). Importantly, any finding of factor loading non-invariance between certain groups precludes any group-based comparisons, whereas findings of items intercepts or response thresholds only preclude group-based mean comparisons. Finally, findings non-invariance of item uniquenesses precludes group-based comparisons that rely on observed scale scores, but not those based on latent factors. Although the previous taxonomy of invariance tests applies well to the consideration of categorical grouping of variables, it cannot be directly transposed to the investigation of measurement biased (or differential item functioning – DIF) as a function of continuous characteristics. For such characteristics, an alternative approach, relying on multiple causes multiple indicators (MIMIC) analyses is required to more directly assess the presence of DIF in item responses to a questionnaire as a function of continuous characteristics (e.g., Morin et al., 2013).

Unfortunately, despite their report of analyses focused on the identification of an age or sex difference in PMC-C scores, Dreiskämper et al. (2018) did not report evidence of measurement invariance or lack of DIF of children's responses to the PMC-C as a function of these two characteristics. More generally, although the role of a variety of common attributes or characteristics (e.g., age, body mass-index or BMI, physical activity/sport involvement and sex) are frequently assessed in studies examining children's perceived motor competence (e.g., Carcamo-Oyarzun et al., 2020; Clark et al., 2018; Estevan et al., 2018; Morano et al., 2020), there is no current evidence that the PMC-C can reliably (i.e., without biases) investigate associations between perceived motor competencies and these characteristics. Previous research has reported mean differences in perceived motor competence as a function of: (a) age (i.e., older children tended to present significantly higher scores than younger children; e.g., Estevan et al., 2018; Morano et al., 2020); (b) BMI (i.e., children having higher BMI tended to present lower scores than those with a lower BMI; e.g., Carcamo-Oyarzun et al., 2020); (c) physical activity/sport involvement (i.e., physically active children tended to score higher than inactive children; e.g., Famelia et al., 2018); and (d) sex (i.e., boys tended to present significantly higher scores than girls; e.g., Carcamo-Oyarzun et al., 2020; Clark et al., 2018; Estevan et al., 2018; Morano et al., 2020). However, pending a demonstration that perceived motor competence measures perform equivalently irrespective of children's levels on these various personal characteristics, group invariance cannot be assumed.

## Present Study Objectives

The main objective of this study was to examine the psychometric properties (i.e., factor validity and reliability, measurement invariance and DIF) of the French version of the PMC-C among a sample of French-speaking Canadian children. First, the PMC-C was translated into the French language. Second, the factor validity and reliability of PMC-C responses were examined using a higher-order CFA approach. Third, we measured PMC-C response invariance as a function of children's sex. Finally, we examined the presence of DIF in responses to the PMC-C as a function of children's age, BMI and physical activity/sport involvement.

# Method

## Participants and Procedures

We recruited a sample of 219 French-speaking, 5-12 year old children ($M = 8.00$, $SD = 1.74$) from six elementary schools located in the Canadian Province of Quebec. Among these, 49.3% were boys and 82.9% were involved in physical activity/sport outside of school. Potential participants were not included in the study if they presented a characteristic likely to bias their PMC-C responses or limit their ability to complete the instrument. More precisely they were excluded if they: (a) needed assistance to move, (b) had sensory or physical disabilities, (c) had a neurological disorder, and/or (d) had a developmental delay.

Parents or legal representatives of children enrolled in the participating schools (corresponding, approximatively, to a potential sample of 400) received an information letter about the study, and those who expressed interest in the study were contacted to sign an informed consent form, and to subsequently complete a questionnaire about their child. Children for whom parental/legal consent was obtained were met at school by four members of the research team who explained the study's objectives and procedures and invited interested children to sign a separate consent form and respond to the PMC-C. The study protocol was approved by the research ethics committee of the first author's University, and by the school board of the participating elementary schools.

We administered the PMC-C individually, at school. Four members of the research team read aloud the instructions for the PMC-C and all its items. For each item, children were asked to point out their answers on a cardboard display of the PMC-C answer array. The interviewer then recorded each answer onto a separate response sheet. Participating children were eligible for a drawing for three $30 gift certificates.

## Measures

*Demographic and Anthropometric Characteristics.* Parents/legal representatives completed a questionnaire soliciting information regarding the children's age, sex, height, weight, and involvement in physical activity/sport practice outside of school (i.e., "*Does your child practice a physical activity or a sport outside of school?*"). Data about the children's height and weight were then used to estimate each child's BMI [Weight/(Height*Height)]. In the present study, BMI values ranged between 11.29 and 31.86 $kg/m^2$ ($M = 16.64$, $SD = 3.01$).

*Perceived Motor Competence in Childhood.* The PMC-C was adapted into French using standardized translation and back-translation techniques (Hambleton, 2005) by two independent professional bilingual translators. Discrepancies between the original and back-translated versions were resolved by a committee comprised of members of the research team and the translators. The final French items and response scale of the PMC-C are reported in Table S1 of the Online Supplements and can be used freely by researchers.

## Data Analysis

Analyses were conducted using Mplus 8.2's (Muthén & Muthén, 2017) robust weighted least squares (WLSMV) estimator to account for the ordered categorical nature of the data (Finney & DiStefano, 2013). To account for the few missing responses at the item level (0.46% to 1.83%; $M = 0.74$), models were estimated based on algorithms implemented in Mplus in conjunction with the WLSMV estimator (Asparouhov & Muthén, 2010), allowing us to retain all participants.

In a first stage, the aforementioned *a priori* higher order factor structure of the PMC-C was examined using a CFA approach. The composite reliability of the PMC-C factors was estimated using McDonald's (1970) omega ($\omega$). The goodness-of-fit of the original factor structure of the PMC-C was assessed using a variety of fit indices (e.g., Hu & Bentler, 1999; Marsh et al., 2005; Yu, 2002): the comparative fit index (CFI), Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). CFI and TLI values $\geq .90$ suggested an acceptable level of fit to the data, whereas values $> .95$ suggested an excellent level of fit. For the RMSEA, values $\leq .08$ and $\leq .06$ respectively suggested an acceptable and excellent fit, respectively.

Second, the measurement invariance of the retained CFA model was examined between boys and girls. As recommended by Morin et al. (2011), the invariance of the first-order factor structure was first examined without including the second-order factor structure in the following sequence: (a) configural invariance; (b) weak invariance (invariance of loadings); (c) strong invariance (invariance of thresholds); (d) strict invariance (invariance of item uniquenesses); (e) invariance of the latent variances/covariances; and (f) invariance of latent mean factors. Then, the invariance of the second order factor structure was examined (starting from the measurement invariance model retained for the first-order factor structure, up to strict invariance) in the following sequence (Morin et al., 2011): (a) configural invariance; (b) invariance of second-order loadings (weak invariance); (c) invariance of second-order intercepts (strong invariance); (d) invariance of second-order disturbances (strict invariance); (e) invariance of the second-order latent variances/covariances; and (f) invariance of the second-order latent means. Invariance was supported when ΔCFIs/ΔTLIs were $\leq .01$ and ΔRMSEAs $\leq$. 015 between a model and the previous one (Chen, 2007;

Cheung & Rensvold, 2002). Due to their known oversensitivity to sample size and minor misspecifications, the WLSMV chi-square test of exact fit ($W\chi^2$) and changes in its values ($\Delta W\chi^2$ estimated using the Mplus DIFFTEST function) will only be reported, but not interpreted (e.g., Hu & Bentler, 1999; Marsh et al., 2005).

Third, MIMIC tests of DIF were conducted to verify the association between age, BMI, and physical activity/sport involvement and PMC-C responses. Although physical activity/sport involvement was a categorical variable, it was impossible to conduct the more extensive tests of measurement invariance applied to sex due to the low sample size of children not involved in physical activity/sport, leading to the decision to also rely on the MIMIC approach for this characteristic. These MIMIC tests of DIF were performed separately for each predictor in the following sequences (Morin et al., 2013): (a) null effects model (paths from the predictors to the PMC-C 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 latent factors were constrained to be zero); (c) first-order factors only model (paths from the predictors to the first-order latent factors were freely estimated, while paths from the predictors to the second-order latent factors and item responses were constrained to be zero); and (d) second-order factors only model (paths from the predictors to the second-order latent factors were freely estimated, while paths from the predictors to the first-order latent factors and item responses were are constrained to be zero). Improvement in fit ($\Delta$CFIs/TLIs $\geq$.01 and $\Delta$RMSEAs $\geq$.015) between the factors only models and the saturated models relative to the null effects model provided support for the presence of associations between predictors and item responses. Furthermore, improvement in model fit for the saturated model relative to the factors only models provided support for DIF.

## Results

### Factor Validity and Reliability

The goodness-of-fit statistics of the *a priori* higher-order CFA model (model 1-1) including two second-order factors (object control and locomotion) is reported in the top section of Table 1. This model resulted in an acceptable level of fit to the data. Parameter estimates from this model are reported in Table S2 of the Online Supplements, and they revealed that all first- and second-order factors are well defined through high factor loadings, and satisfactory estimates of composite reliability. However, the correlation between the two second-order factors was high enough to suggest conceptual overlap ($r = .928$), indicating that they might, in fact, have reflected a single second-order factor. This alternative model was thus estimated (model 1-2), and it

**Table 1.** Goodness-of-Fit Statistics of Confirmatory Factor Analyses (CFA) for the PMC-C.

| Models | No | Description | $W\chi^2$(df) | CFI | TLI | RMSEA | RMSEA 90% CI | CM | $\Delta W\chi^2$(df) | ΔCFI | ΔTLI | ΔRMSEA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CFA | 1-1 | Two 2nd order factor | 495.424(243)* | .957 | .951 | .069 | .060–.078 | — | — | — | — | — |
| | 1-2 | One 2nd order factor | 519.436(244)* | .953 | .947 | .072 | .063–.080 | — | — | — | — | — |
| MI-CFA 1st order factor: Sex | 2-1 | Configural invariance | 652.010(448)* | .969 | .962 | .064 | .053–.075 | — | — | — | — | — |
| | 2-2 | Weak invariance | 662.825(464)* | .970 | .964 | .063 | .051–.073 | 2–1 | 16.47(16) | +.001 | +.002 | −.001 |
| | 2-3 | Strong invariance | 698.236(504)* | .971 | .968 | .059 | .048–.070 | 2–2 | 44.15(40) | +.001 | +.004 | −.004 |
| | 2-4 | Strict invariance | 749.785(528)* | .967 | .965 | .062 | .051–.072 | 2–3 | 60.98(24)* | −.004 | −.003 | +.003 |
| | 2-5 | Latent variances-covariances invariance | 674.027(564)* | .983 | .984 | .042 | .028–.054 | 2–4 | 39.63(36) | +.016 | +.019 | −.020 |
| | 2-6 | Latent means invariance | 703.584(572)* | .980 | .981 | .046 | .033–.057 | 2–5 | 21.71(8)* | −.003 | −.003 | +.004 |
| MI-CFA 2nd order factor: Sex | 3-1 | Configural invariance | 822.995(568)* | .962 | .963 | .064 | .054–.073 | — | — | — | — | — |
| | 3-2 | Weak invariance | 843.604(575)* | .960 | .961 | .065 | .056–.075 | 3–1 | 22.06(7)* | −.002 | −.002 | +.001 |
| | 3-3 | Strong invariance | 861.691(582)* | .958 | .960 | .066 | .057–.075 | 3–2 | 25.92(7)* | −.002 | −.001 | +.001 |
| | 3-4 | Strict invariance | 879.695(590)* | .956 | .959 | .067 | .058–.076 | 3–3 | 23.71(8)* | −.002 | −.001 | +.001 |
| | 3-5 | Latent variance-covariance invariance | 733.969(591)* | .979 | .980 | .047 | .035–.058 | 3–4 | 0.23(1) | +.023 | +.021 | −.020 |
| | 3-6 | Latent mean invariance | 743.560(592)* | .977 | .979 | .048 | .036–.059 | 3–5 | 4.06(1) | −.002 | −.001 | +.001 |
| DIF: Age | 4-1 | Null effects | 495.077(268)* | .964 | .960 | .062 | .054–.071 | — | — | — | | — |
| | 4-2 | Saturated | 523.363(244)* | .954 | .946 | .072 | .064–.081 | 4–1 | 20.38(24) | −.010 | −.014 | +.010 |
| | 4-3 | Factors only—1st order factor | 537.246(260)* | .957 | .950 | .070 | .062–.078 | 4–1 | 5.95(8) | −.007 | −.010 | +.008 |
| | 4-4 | Factor only—2nd order factor | 538.412(267)* | .957 | .952 | .068 | .060–.077 | 4–1 | 0.17(1) | −.007 | −.008 | +.006 |
| DIF: Body mass-index | 5-1 | Null effects | 481.101(268)* | .962 | .958 | .064 | .055–.073 | — | — | — | | — |
| | 5-2 | Saturated | 508.631(244)* | .953 | .942 | .075 | .066–.084 | 5–1 | 19.56(24) | −.009 | −.016 | +.011 |
| | 5-3 | Factors only—1st order factor | 521.111(260)* | .954 | .947 | .072 | .063–.081 | 5–1 | 5.72(8) | −.008 | −.011 | +.008 |
| | 5-4 | Factor only—2nd order factor | 524.783(267)* | .954 | .949 | .071 | .062–.080 | 5–1 | 0.04(1) | −.008 | −.009 | +.007 |
| DIF: PA/Sport involvement | 6-1 | Null effects | 521.244(268)* | .958 | .953 | .066 | .058–.074 | — | — | — | | — |
| | 6-2 | Saturated | 517.961(244)* | .954 | .944 | .072 | .063–.081 | 6–1 | 31.75(24) | −.004 | −.009 | +.006 |
| | 6-3 | Factors only—1st order factor | 524.568(260)* | .956 | .949 | .068 | .060–.077 | 6–1 | 14.59(8) | −.002 | −.004 | +.002 |
| | 6-4 | Factor only—2nd order factor | 533.438(267)* | .955 | .950 | .068 | .059–.076 | 6–1 | 2.33(1) | −.003 | −.003 | +.002 |

*Notes*. $W\chi^2$ = robust weighed least square chi-square; Δ = change from previous model; $\Delta W\chi^2$ = chi square difference test (calculated with the Mplus DIFFTEST function); CFI = comparative fit index; CM = comparison model; df = degrees of freedom; DIF = differential item functioning; MI = measurement invariance; PA = physical activity; PMC-C = Perceived Motor Competence in Childhood Questionnaire; RMSEA = root mean square error of approximation; 90% CI = 90% confidence interval; TLI = Tucker-Lewis index. $W\chi^2$values are not exact, but "estimated" as the closest integer necessary to obtain a correct *p* value so that $W\chi^2$ and the resulting CFI values can be non-monotonic with model complexity. $^*p < .01$.

resulted in a satisfactory level of fit to the data that did not meaningfully differ from the fit of the *a priori* factor structure, despite its greater parsimony. Parameter estimates form this alternative model are reported in Table 2, and they revealed that all first- and second order factors are well defined through high factor loadings, and satisfactory estimates of composite reliability. This model was retained for further analyses.

## *Measurement Invariance and DIF*

*Measurement Invariance Across Sex.* The goodness-of-fit statistics of measurement invariance of models are presented in the second and third sections of Table 1. These results supported the complete invariance (weak, strong, strict, variances/covariances, and latent means) of the first-order factor structure across sex (models 2-1 to 2-6). Furthermore, results also supported the complete invariance (weak, strong, strict, variances/covariances, and latent mean) of the second-order factor across sex (models 3-1 to 3-6). Given that sex differences in latent means were of substantive interest and that the $\Delta W\chi^2$(df) difference was significant at this step, latent mean differences across sex were examined. Results showed that boys tended to have significantly higher latent means than girls in throwing (.666, $p \leq .01$), catching (.352, $p \leq .05$), kicking (.552, $p \leq .01$), and on the higher-order motor competence factor (.310, $p \leq .05$).

*DIF Across Age, BMI and Physical Activity/Sport Involvement.* The goodness-of-fit statistics of the MIMIC models estimated for all three predictors are reported in the bottom three sections of Table 1. These results showed that the saturated (models 4-2, 5-2, 6-2), first-order factor-only (models 4-3, 5-3, 6-3) and second-order factor-only (models 4-4, 5-4, 6-4) models did not result in a substantial improvement in model fit when compared to the null effects model (models 4-1, 5-1, 6-1). Thus, these results suggested a lack of DIF, and failed to support significant associations between BMI[1] or physical activity/sport involvement with responses on the PMC-C scales.

# Discussion

This study sought to verify the psychometric properties (i.e., factor validity and reliability, measurement invariance and differential item functioning) of a newly developed French adaptation of the PMC-C among a sample of French-Canadian children. All analyses supported the *a priori* first-order factor structure of the PMC-C, systematically revealing eight well-defined and reliable factors reflecting running, jumping, hopping, leaping, throwing, catching, bouncing, and kicking. However, the analyses failed to support the presence of two well-differentiated second-order factors, rather suggesting that children's

**Table 2.** Standardized Parameters Estimates from the One Second Order Factor CFA of the PMC-C.

| Items | | Throwing ($\lambda$) | Running ($\lambda$) | Catching ($\lambda$) | Hopping ($\lambda$) | Kicking ($\lambda$) | Leaping ($\lambda$) | Bouncing ($\lambda$) | Jumping ($\lambda$) | $\delta$ |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | | .707 | | | | | | | | .500 |
| T2 | | .644 | | | | | | | | .586 |
| T3 | | .868 | | | | | | | | .247 |
| R1 | | | .908 | | | | | | | .176 |
| R2 | | | .889 | | | | | | | .210 |
| R3 | | | .964 | | | | | | | .071 |
| C1 | | | | .615 | | | | | | .622 |
| C2 | | | | .748 | | | | | | .441 |
| C3 | | | | .896 | | | | | | .197 |
| H1 | | | | | .802 | | | | | .357 |
| H2 | | | | | .936 | | | | | .149 |
| H3 | | | | | .551 | | | | | .697 |
| K1 | | | | | | .837 | | | | .300 |
| K2 | | | | | | .922 | | | | .149 |
| K3 | | | | | | .431 | | | | .814 |
| L1 | | | | | | | .788 | | | .379 |
| L2 | | | | | | | .955 | | | .087 |
| L3 | | | | | | | .755 | | | .430 |
| B1 | | | | | | | | .853 | | .273 |
| B2 | | | | | | | | .694 | | .519 |
| B3 | | | | | | | | .730 | | .467 |
| J1 | | | | | | | | | .796 | .367 |
| J2 | | | | | | | | | .828 | .314 |
| J3 | | | | | | | | | .908 | .175 |
| $\omega$ | | .787 | .943 | .802 | .813 | .792 | .874 | .805 | .882 | |
| 2nd order factor | | Throwing | Running | Catching | Hopping | Kicking | Leaping | Bouncing | Jumping | $\omega$ |
| | $\gamma$ | .986 | .866 | .832 | .807 | .853 | .978 | .919 | .879 | .969 |
| | $\zeta$ | .029 | .249 | .308 | .349 | .273 | .044 | .155 | .227 | |

*Notes.* $\lambda$ = factor loadings; $\gamma$ = 2nd order factor loading; $\delta$ = uniquenesses; $\zeta$ = 2nd order measurement error; $\omega$ = McDonald's omega coefficient of composite reliability; B = Bouncing; C = Catching; CFA = confirmatory factor analyses; K = kicking; H = hopping; J = jumping L = leaping; PMC-C = Perceived Motor Competence in Childhood Questionnaire; R = running; T = throwing.

responses to the PMC-C reflected a single (well-defined and reliable) higher-order motor competence factor.

Building upon limited prior knowledge regarding the assessment of children's perceptions of motor competence, this study was able to establish its first- and second- order measurement invariance as a function of sex, and we also reported a lack of DIF in PMC-C responses as a function of children's age, BMI, and physical activity/sport involvement. Thus, these results indicate that observed and latent mean scores on any of the PMC-C factors can confidently be used to compare French-speaking children as a function of their age, BMI, involvement in physical activities and sports, and sex.

In addition, and supporting results previously reported by Dreiskämper et al. (2018), and others (e.g., Carcamo-Oyarzun et al., 2020; Clark et al., 2018; Estevan et al., 2018; Morano et al., 2020), boys presented slightly higher scores than girls on the throwing, catching, kicking, and global motor competence factor. Likewise, and also supporting previous results (e.g., Dreiskämper et al., 2018) there were no age-related differences on any of the PMC-C factors. Furthermore, there were no significant differences on any of the PMC-C factors in relation to children's BMI, and involvement in physical activities and sports, generally contradicting previous research conducted with other types of measures (e.g., Carcamo-Oyarzunet al., 2020; Famelia et al., 2018). However, this lack of associations may be due in part to the limited number of children in this sample who were not involved in physical activities or sports outside of school, possibly resulting in a slight reduction in BMI variability among this sample. Nevertheless, because this is the first study to examine these latent mean differences in PMC-C factors, caution is required when generalizing these results, and further research will be needed.

### Limitations and Directions for Future Research

Three main limitations should be considered when interpreting these results. First, we examined the psychometric properties of the French version of the PMC-C in a single sample of French-Canadian children, possibly limiting generalizability of these results to other French-speaking populations, or to other linguistic groups. More precisely, while we proposed no evidence of the cross-linguistic invariance of the French version of the PMC-C, it would be interesting to examine the measurement invariance of the French version of the PMC-C with (a) French-speaking samples of children from North-America (Canada), Europe (Belgium, France, Switzerland, Luxembourg) and North-Africa (Algeria, Morocco, Tunisia); and (b) other linguistic samples. Second, the present study did not examine the test-retest reliability and longitudinal invariance of the French version of the PMC-C. These psychometric properties should thus be more thoroughly examined in future research. Third, we proposed no evidence of the convergent validity of the French version of the PMC-C, meaning that additional research is needed to determine how this instrument relates to other questionnaires measuring perceived motor competence or movement skills, and to results from objective assessments of fundamental movement or motor skills.

## Conclusion

In conclusion, the current study supported the psychometric properties (i.e., factor validity and reliability, measurement invariance and differential item functioning) of a newly developed French version of the PMC-C. This French version can be used to reliably and validly assess perceived motor competence in samples of French-speaking children with similar characteristics and in the context of group-based comparisons related to age, BMI, physical activity/sport involvement and sex. However, given the limitations of this study, the use of the French version of the PMC-C in cross-linguistic and longitudinal studies remains premature.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

### ORCID iD

Christophe Maïano https://orcid.org/0000-0002-4764-2209

### Supplemental material

Supplemental material for this article is available online.

### Note

1. We thank one of the reviewers for suggesting the use of BMI percentile values rather than actual BMI values in our analyses. As this new set of analyses provided results that were virtually identical to initial analyses, we retained our initial analyses for the main article and presented the results from the alternative analyses in sections S1 and Table S3 of the Online Supplements.

### References

Asparouhov, T., & Muthén, B. (2010). *Weighted least squares estimation with missing data*. Mplus Technical Appendix. Muthén & Muthén.

Barnett, L. M., Ridgers, N., Zask, A., & Salmon, J. (2015). Face validity and reliability of a pictorial instrument for assessing fundamental movement skill perceived competence in young children. *Journal of Science and Medicine in Sport*, *18*(1), 98–102. https://doi.org/10.1016/j.jsams.2013.12.004.

Carcamo-Oyarzun, J., Estevan, I., & Herrmann, C. (2020). Association between actual and perceived motor competence in school children. *International Journal of Environmental Research and Public Health*, *17*(10), 3408. https://doi.org/10.3390/ijerph17103408

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

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5

Clark, C. C., Moran, J., Drury, B., Venetsanou, F., & Fernandes, J. F. (2018). Actual vs. perceived motor competence in children (8–10 years): An issue of non-veridicality. *Journal of Functional Morphology and Kinesiology*, *3*(2), 20. https://doi.org/10.3390/jfmk3020020

Dreiskaemper, D., Utesch, T., & Tietjens, M. (2018). The perceived motor competence questionnaire in childhood (PMC-C). *Journal of Motor Learning and Development*, *6*(s2), S264–S280. https://doi.org/10.1123/jmld.2016-0080

Estevan, I., Molina-García, J., Abbott, G., Bowe, S. J., Castillo, I., & Barnett, L. M. (2018). Evidence of reliability and validity for the pictorial scale of perceived movement skill competence in Spanish children. *Journal of Motor Learning and Development*, *6*(s2), S205–S222. https://doi.org/10.1123/jmld.2016-0065

Famelia, R., Tsuda, E., Bakhtiar, S., & Goodway, J. D. (2018). Relationships among perceived and actual motor skill competence and physical activity in Indonesian preschoolers. *Journal of Motor Learning and Development*, *6*(s2), S403–S423. https://doi.org/10.1123/jmld.2016-0072

Finney, S. J., & DiStefano, C. (2013). Non-normal and categorical data in structural equation modeling. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course* (2nd ed., pp. 439–492). IAP.

Hambleton, R. K. (2005). Issues, designs, and technical guidelines for adapting tests to languages and cultures. In R. K. Hambleton, P. Merenda, & C. Spielberger (Eds.), *Adapting educational and psychological tests for cross-cultural assessment* (pp. 3–38). Erlbaum.

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

Maïano, C., Morin, A. J. S., & Mascret, N. (2015). Psychometric properties of the short form of the physical self-description questionnaire in a French adolescent sample. *Body Image*, *12*, 89–97. https://doi.org/10.1016/j.bodyim.2014.10.005

Maïano, C., Morin, A. J. S., Aimé, A., Lepage, G., & Bouchard, S. (2021). Psychometric properties of the body checking questionnaire (BCQ) and of the body checking cognitions scale (BCCS): A bifactor-exploratory structural equation modeling approach. *Assessment*, *28*(2), 632–646. https://doi.org/10.1177/1073191119858411

Marsh, H. W., Hau, K.-T., & Grayson, D. (2005). Goodness of fit evaluation in structural equation modeling. In A. Maydeu-Olivares, & J. McArdle (Eds.), *Contemporary psychometrics* (pp. 275–340). Erlbaum.

McDonald, R. P. (1970). Theoretical foundations of principal factor analysis, canonical factor analysis, and alpha factor analysis. *British Journal of Mathematical and Statistical Psychology*, *23*(1), 1–21. https://doi.org/10.1111/j.2044-8317.1970.tb00432.x

Millsap, R. E. (2011). *Statistical approaches to measurement invariance*. Routledge.

Morano, M., Bortoli, L., Ruiz, M. C., Campanozzi, A., & Robazza, C. (2020). Actual and perceived motor competence: Are children accurate in their perceptions? *PLoS One*, *15*(5), e0233190. https://doi.org/10.1371/journal.pone.0233190

Morin, A. J. S., Moullec, G., Maïano, C., Layet, L., Just, J.-L., & Ninot, G. (2011). Psychometric properties of the center for epidemiologic studies depression scale (CES-D) in French clinical and nonclinical adults. *Revue D'epidemiologie et de Sante Publique*, *59*(5), 327–340. https://doi.org/10.1016/j.respe.2011.03.061

Morin, A. J. S., Marsh, H. W., & Nagengast, B. (2013). Exploratory structural equation modeling. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course* (2nd ed., pp. 395–438). Information Age.

Muthén, L. K., & Muthén, B. (2017). *Mplus user's guide* (8th ed.). Muthén & Muthén.

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine (Auckland, N.Z.)*, *45*(9), 1273–1284. https://doi.org/10.1007/s40279-015-0351-6

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*, *60*(2), 290–306. https://doi.org/10.1080/00336297.2008.10483582

Ulrich, D. A. (2019). *Test of gross motor development* (3rd ed.). Austin, Pro-ED.

Yu, C. Y. (2002). *Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes*. University of California.

## Author Biographies

**Christophe Maïano**, PhD, is full Professor in the Department of psychoeducation and psychology of the Université du Québec en Outaouais (UQO|Campus Saint-Jérôme), Canada. His expertise and research broadly covers physical and psychological well-being, sport, exercise, and adapted physical activity among youth with a typical development or special needs.

**Alexandre J. S. Morin** is full professor in the Department of Psychology (Concordia University, Canada). He defines himself as a lifespan developmental psychologist, with broad research interests anchored in the exploration of the social determinants of psychological well-being at various life stages and in various settings, such as schools and organisations. Many of his publications are anchored in a substantive-methodological synergy framework, and thus represent joint ventures in which new methodological developments (bifactor exploratory structural equation modeling, person-centered analyses, longitudinal analyses, and psychometric validation) are applied to substantively important issues. Consistent with the multidisciplinary focus of his research, he was identified as a "Highly Cited Researcher" by the Web of Science in 2019 and in 2020 in the cross-field category.

**Johanne April**, PhD, is full Professor in the Department of Education Sciences of the Université du Québec in Outaouais (UQO|Campus Saint-Jérôme), Canada. Her recent research interests include preschool teachers' practices, and psychomotor development and social interactions in early childhood. She is a regular research member of the team « Qualité des contextes éducatifs de la petite enfance » and has authored a book entitled « L'activité psychomotrice au préscolaire; des activités nécessaires au développement GLOBAL de l'enfant » published by Chenelière Education in 2015.

**Maike Tietjens**, PhD, is apl. professor for sport science and is currently vice rector at the University of Münster. She received her habilitation at the University of Münster and her doctorate at the University of Bielefeld, Germany. She works on physical self-concept and motor testing, and on their implication for physical education, sport club setting, and health.

**Charlaine St-Jean**, PhD, is a professor of education in the Department of Educational Sciences at the Université du Québec à Rimouski. Her research examines the different educational practices of those working in preschool education that allow children to have greater knowledge and curiosity in relation to the awakening to early mathematics.

**Cynthia Gagnon**, PhD, is a post-doctoral fellow at the Université du Québec en Outaouais (UQO| Campus Saint-Jérôme), Canada. Her research interests include eating disorders, self-perceptions, weight-related bullying, intellectual disabilities and diabetes.

**Dennis Dreiskämper**, PhD, is a Senior researcher at the Institute of Sport and Exercise Science, Department of Sport and Exercise Psychology at the University of Münster.

**Annie Aimé**, PhD, is an associate professor in the Department of psychoeducation and psychology of the Université du Québec en Outaouais (UQO|Campus Saint-Jérôme), Canada.