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"Profiles of motor competence and its perception accuracy among children: Association with physical fitness and body fat"

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ABSTRACT

The main goals of this study were to identify profiles in school-aged children based on actual Motor Competence (MC) and accuracy of Perceived Motor Competence (PMC) and to examine how children with different profiles differ in terms of Physical Fitness (PF) and Body Fat percentage (BF%). The MC of a total of 287 children (51.6% boys, aged between 6 and 10 years-old) was assessed using the Motor Competence Assessment (MCA) instrument, and the accuracy of the PMC was measured using motor tasks (standing long jump, throwing, kicking, and walking backwards). PF and BF% were assessed using the 20m shuttle run test and TANITA, respectively. Cluster (C) analysis revealed four profiles, two of which were aligned – high MC-accurate PMC (C4) and low-inaccurate (C2), and two that were non-aligned – high-inaccurate (C1) and low-accurate (C3). Children in C4 performed better on PF and had less BF% than children in C3 and C2.

1. Introduction

High levels of both Motor Competence (MC) and Perceived Motor Competence (PMC) may be a driving force for engaging children in different physical activities and sports, and are both associated with various health-related behaviors (De Meester et al., 2020). MC can be defined as the person's ability to execute a variety of motor tasks in a proficient manner, including coordination quality of gross and fine movement skills that are needed to manage everyday tasks (D'Hondt, Deforche, De Bourdeaudhuij, & Lenoir, 2009; Robinson et al., 2015). MC and physical fitness (PF) are considered as crucial factors for promoting positive trajectories of health-related fitness (HRF) and physical activity (PA) over time (Robinson et al., 2015; Stodden et al., 2008; Utesch, Bardid, Büsch, & Strauss, 2019). PF is a determinant in the healthy development of children as it is related to various health outcomes (Utesch, Dreiskämper, Strauss, & Naul, 2017). Regarding the weight status in particular, children with normal-weight have been shown to have an advantage in the PF levels (Pepera, Hadjiandrea, Iliadis, Sandercock, & Batalik, 2022). In addition, the relationship between MC and PF is moderate to large and strengthens across age (Utesch et al., 2019), and both are important predictors of children's PA participation (Kaioglou, Dania, Kambas, & Venetsanou, 2022; Lopes, Rodrigues, Maia, & Malina, 2011).

Stodden and colleagues (Stodden et al., 2008) proposed a conceptual model to explain the reciprocal and developmentally dynamic relationship between MC, PA, HRF and PMC. According to this model, MC is a central factor that drives the PA levels, as higher levels of MC during middle and late childhood offer greater opportunities for children to engage in different physical activities and sports (contrarily, it is the PA that drives MC in early childhood). MC has a role on promoting a positive spiral of engagement (or a negative of disengagement) in PA and weight status. PMC is also relevant for a health-related lifestyle in childhood, which has a key role in this theoretical model as mediating variable. In other words, if low-skilled children perceive themselves as

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having low MC, they will probably choose not to engage in PA and sports, and ultimately will be at greater risk of being obese and sedentary during adolescence and adulthood. Consequently, they will not further develop aspects of HRF (Stodden et al., 2008). Stodden's model also suggests that HRF mediates the relationship between MC and PA, based on the argument that several aspects of neuromotor development are common to both MC and PF development, namely in muscular strength (*e.g.* the ability to effectively recruit motor units, the ability to increase motor-unit firing rates, and a decreased level of coactivation of muscle agonists and antagonists) (Stodden et al., 2008). De Meester et al. (2020), reviewed the relationship between MC and PMC, and concluded that the strength of the association between MC and PMC/physical self-perception is low to moderate, in youth, and does not differ according to sex. Additionally, less aligned measurements, in terms of MC and PMC, had no impact in the association between these variables, when compared to better aligned measurements. Barnett and collaborators (Barnett, Webster, et al., 2022) analyzed and systematically compiled mediation, longitudinal and experimental evidence for all variables presented in the conceptual model developed by Stodden et al. (2008). Studies that analyzed the mediation hypothesis are limited, and the results are inconclusive or with no enough evidence (Barnett, Webster, et al., 2022). Notably, evidence concerning MC and PMC, in both directions, is insufficient and inconsistent. The most reliable result was that MC is negatively associated, in both directions, with weight status (Barnett, Webster, et al., 2022). In a study not included in the review, it was found that the PMC is negatively associated with weight status (Trecroci, Invernizzi, Monacis, & Colella, 2021). Returning to the systematic review of longitudinal evidence, it is mentioned that there is indeterminate evidence for the HRF to MC but positive evidence for the reverse. Regarding MC and PA, there is indeterminate evidence, and no evidence for the reverse (Barnett, Webster, et al., 2022). Furthermore, Lopes and Rodrigues (Lopes & Rodrigues, 2021) have found that perfect mediation seems to exist in girls but not in boys. In boys, the relationship between MC and PA seems conditioned by the PF levels, and it has been well documented that boys outperformed girls on PF tests (*e.g.,* Colley et al., 2019; Emini, Saiti, Gontarev, Baftiu, & Cemena, 2022). Moreover, and particularly during the teenage years, PF was shown to improve at a faster level in boys than in girls (Tomkinson, Lang, Blanchard, Léger, & Tremblay, 2018). However, it is not just at PF that boys are better than girls. A systematic review and meta-analysis conducted by Barnett and coworkers (Barnett, Lai, et al., 2016) has shown that boys score higher than girls on MC. Specifically, boys were found to be more proficient in object control skills (Barnett, Lai, et al., 2016; Famelia, Tsuda, Bakhtiar, & Goodway, 2018). It has also been reported that there are differences in the body composition of both sexes, with girls consistently having a greater percentage of BF than boys in childhood and adolescence (Kirchengast, 2010; Malina, Bouchard, & Bar-or, 2014). While sex differences in MC are unquestionable, the findings concerning sex differences in the PMC are contradictory, with some studies revealing no differences (Morano, Bortoli, Ruiz, Campanozzi, & Robazza, 2020), others showing higher PMC for boys than girls (Duncan, Jones, O'Brien, Barnett, & Eyre, 2018).

The construct of perceived competence emerges from Harter's competence motivation theory that underlies the construction of the perceived competence in different domains, i.e., physical, social, and cognitive (Harter, 1978, 1982). Perceived competence is defined as the motivation to participate in an activity, based on how capable the individual is in that activity (Harter, 1978), and develops together with cognitive development (Harter, 1999). The perception of physical competence in elementary school children focuses on sports and outdoor activities (Harter & Pike, 1984), that is, it reflects believes in self capabilities in goal-directed fundamental movement skills (Estevan & Barnett, 2018), such as running, skipping, or hopping. Estevan and Barnett (2018) highlight that perceived motor competence can be differentiated into perceived stability, object control and locomotor competence.

Young children have limited accuracy in perceiving their physical competence, and generally their levels of perceived competence are higher than their actual competence (Harter, 1999; Harter & Pike, 1984). Children perceive themselves as highly competent but, in fact, they often have low levels of motor competence. The tendency of young children to overestimate their abilities is developmentally normal and might serve to motivate them towards greater levels of persistence, attempts and engagement in physical activities which is important to promote mastery of movement skills (Harter, 1982, 1999; Harter & Pike, 1984). On the other hand, if children perceive themselves as low competent at an activity or skill, they probably will not persist, which might be negative for their engagement in physical activities, leading to a sedentary lifestyle and ultimately increasing their risk of obesity (Stodden et al., 2008).

Over the past few decades, several studies have investigated the MC and PMC of children (Capio & Eguia, 2021; Lopes, Barnett, & Rodrigues, 2016; Spessato, Gabbard, Robinson, & Valentini, 2013; Ulrich, 1987), or their perceived physical literacy (Barnett, Mazzoli, et al., 2022), using self-reported measures of perceived competence based on how well children believe they can perform certain motor tasks (Barnett, Webster, et al., 2022; Harter & Pike, 1984). However, it should be noted that within Harter's framework, studies have not matched the measure of PMC with the performance of the same motor task. Regarding this weakness, Ulrich (1987) pointed out that the methodology "*should include assessment of demonstrated motor competence and a match between motor competence tasks and perceived competence items*" (p.66). The lack of alignment in the instrumentation used to assess actual MC and PMC can lead to an interpretation error on these variables (Estevan & Barnett, 2018; Robinson et al., 2015). To address Ulrich's concerns, Rudisill and colleagues (Rudisill, Mahar, & Meaney, 1993) developed, a few years later, a scale to measure the accuracy with which children perceive their MC. Other scales have been developed more recently to integrate PMC with matching motor tasks (Barnett, Vazou, et al., 2016; Tietjens et al., 2018), coined as aligned product-oriented measure of PMC (Coppens et al., 2021). The need for aligned instruments of MC and PMC has been further highlighted by Estevan and Barnett (2018). Nevertheless, all mentioned scales measure PMC based on a psychological construct, which solely allows to differentiate children with low and high-perceived competence.

Although PMC is an important psychological construct that represents a general psychological measure, it may not have a direct relation with the ability of children to perceive their MC in task-specific activities. Therefore, there is a great need for investigating the accuracy of children's perceptions "*tied to context-specific measures of perceived abilities in relation to the specificity of the task*" (pp. 157) (Gabbard, Caçola, & Cordova, 2009). These context-specific measures can be linked to Gibson's concept of affordances (Gibson, 1977, 1979). Considering Gibson's ecological framework, affordances are possibilities for action offered to the individual by the environment, expressing the match between individual characteristics and specific environmental features (Gibson, 1977, 1979). When children have an accurate perception of affordances on a certain task, the estimation of their performance matches their actual performance on that same task. A few studies (Almeida, Luz, Martins, & Cordovil, 2016, 2017) have previously explored the relationship between PMC and MC using context-specific measures based on Gibson's ecological approach to perception and action (Gibson, 1977, 1979). These have shown that, in general, children tend to overestimate their skills and that children with greater MC tend to be more accurate in the perception of their affordances (Almeida, Luz, Martins, & Cordovil, 2017). Recently, the relationship between PMC and actual MC in children has been explored using a person-centered approach, that is, using cluster analysis, with PMC measure aligned with actual MC (Coppens et al., 2021; Estevan, García-Massó, Molina García, & Barnett, 2019, 2021; Niemistö et al., 2022). Weiss and Amorose (2005) originally developed this methodology to analyze whether children estimated their MC accurately/inaccurately. The studies also analyzed whether children or adolescents with different profiles of actual and perceived MC (*e.g.*, low MC-high PMC) differ in PA and body mass index (De Meester, Stodden, et al., 2016; Estevan et al., 2019), autonomous motivation (Bardid et al., 2016; De Meester, Maes, et al., 2016), sport participation (Coppens et al., 2021), and PF (Estevan et al., 2019). Studies in this area have used mixed variables and methodological approaches that may influence their findings, such as: (i) using different instruments to measure PMC, (ii) defining the construct of PMC in different ways, (iii) using different samples, with different levels of MC and PMC, which influence "*the relative nature of whether actual or perceived motor competence is considered high or low*" (Estevan & Barnett, 2018, p. 2692); (iv) using product vs. process measures to assess MC (i.e., focus on the outcome or on the process of the movement, respectively) (De Meester et al., 2020).

Despite all advances, the relationship between the different types of children's profiles based on actual MC and PMC, in which the PMC is evaluated using context specific measures (accurate/inaccurate as opposed to high/low PMC), with PF and health-related variables remains to be explored. These are gaps in the literature that the present study aims to address. Thus, the current cross-sectional study had three aims. The first aim was to explored sex differences with respect to MC, accuracy of PMC, PF, and BF%. Concerning PF, we expected that boys displayed a higher level of PF than girls (Pinto, Cruz, Pinho, & Marques, 2020), and expected no differences for the other variables.

The second aim of this study was to develop profiles in school-aged children based on actual MC and PMC, using, for the first time to our knowledge, context-specific measures to determine PMC profiles. Considering the theoretical model of Stodden and collegues (2008) and the results of previous studies (Bardid et al., 2016; De Meester, Maes, et al., 2016), we expected to find four different profiles characterized by different combinations in levels of actual MC and PMC (i.e., high-accurate, low-inaccurate, low-accurate and high-inaccurate), with the majority of the children having a high-accurate level of MC and PMC, and a minority of the children possessing a low-inaccurate level. The third aim of this study was to analyze differences in Physical Fitness (PF) and Body fat percentage (BF%) between children with different MC and PMC-based profiles. It was hypothesized that children with profiles characterized by high level of actual MC and accuracy in PMC would display the highest level of PF and the lowest BF% (Estevan et al., 2019), while children with low levels of actual MC and not accurate in PMC were expected to display the lowest level of PF and the highest BF% (De Meester, Stodden, et al., 2016).

2. Method

2.1. Procedure

Ethics approval was obtained from Ethics Committee of the Faculty of Human Kinetics, University of Lisbon (Portugal), and Ministry of Education, and was carried out in agreement with the Declaration of Helsinki. A convenience sample of children from public primary schools in Lisbon was used. The parents of the children gave written consent, and the participating children provided their verbal assent. Each child was assessed for MC, PMC, PF, and BF%. Assessments were completed over a period of approximately one month. Two physical education teachers previously trained collected all the data for this study during regularly scheduled classes in a school gymnasium. All in all, the assessment of each child took about 60 min.

2.2. Participants

Participants were 287 children (148 boys and 139 girls) aged between 6.48 and 10.93 years-old (M = 8.63; SD = 1.15 years), selected from public primary schools in Lisbon. None of the children presented neurodevelopmental difficulties, significant hearing loss, visual impairment, or major physical disability, and all attended age-appropriate classes.

2.3. Measures

Motor competence (MC). Motor Competence was assessed with the Motor Competence Assessment (MCA) instrument (Luz, Rodrigues, Almeida, & Cordovil, 2016). The MCA is a quantitative (product-oriented) instrument for assessing MC throughout the lifespan (Rodrigues et al., 2019). The MCA instrument assesses the three theoretical categories through six motor tasks: (1) stability (i. jumping sideways and ii. shifting platforms), (2) locomotor (iii. standing long jump and iv. shuttle run) and (3) manipulative skills (v. ball kicking velocity and vi. ball throwing velocity) (Luz et al., 2016). All tasks were carried out according to description issued by Luz et al. (2016). The construct validity and normative values for the MCA have been established from early childhood to young adulthood (Rodrigues et al., 2019, 2021). The total MCA score is calculated through the average of the three MCA categories that in turn are obtained by the average of the two respective task percentiles. The results for the six tasks were computed into age and gender related percentiles using the normative values of the MCA battery (Rodrigues et al., 2019). Children performed all tasks, in the same order, in small groups (about four-five children for each task) and the assessment took approximately 10 min per child (Luz et al., 2016).

Accuracy of Perceived motor competence (PMC). Four motor tasks were used to assess the children's accuracy of PMC: (1) standing long jump, (2) throwing, and (3) kicking a ball into to the mini soccer goal (120 cm × 80 cm; a size 4 soccer ball), and (4) walking backwards on a balance beam (3 cm wide, 3 cm high, and 3 m long). The PMC for locomotor, manipulative, and balance tasks matched the real skills assessed. PMC assessment occurred individually in an isolated setting, and away from distractions, to avoid the learning bias effect. All the perceived tasks were performed prior to the MC assessment. Firstly, children were asked to estimate their maximum ability for each of the four motor tasks, and secondly, they were asked to perform those same tasks, as described in previous studies (Almeida et al., 2016, 2017). The procedure was conducted after the explanation of the evaluator and once the child indicated he/she understood the procedure. For the standing long jump, the children were asked to estimate their maximum jumping distance while standing behind a line. During the estimation the evaluator unraveled a measuring tape, starting from the line, until the child told the evaluator to stop, which was taken as the perceived maximum jumping distance. The jump was executed, starting from the line, in the opposite direction as the measured estimate. For the throwing and kicking apparatus, each child was asked to stand at the maximum distance he/she estimated to allow for a successful throw/kick of the ball into to the mini soccer goal. For the walking backwards task the evaluator asked the children to estimate the farthest distance they could walk backwards without stepping off the beam. The estimation task was performed from the starting position in the standing front upright posture, after which the child turned and performed the action backwards. For the standing long jump and walking backwards, the child was allowed to make fine adjustments after the order to stop if he/she found it necessary, using verbal instructions to move the tape (i.e., more or less; forward or backward), until he/she was satisfied with the distance. The perceived judgment was registered as the child's estimation. The estimation tasks were followed by the real performance tasks in the following order: standing long jump (measured in cm), throwing, and kicking the ball into the mini soccer ball (measured in m), and walking backwards along a balance beam (measured in cm). No feedback from the evaluator regarding the perceived judgment or the outcome of the real performance was given to the child. The assessment of PMC took approximately 10 min per child.

Absolute Percent Error (APE (|1 – estimation/real performance)| × 100) (cf., Almeida et al., 2017); was calculated for each task. APE quantifies the error of judgment expressed as percentage of the actual performance. After computing the four APE values, z-scores for each

APE were calculated to obtain a composite error measure, which is the average of the four z-scores. Since the error has an inverse relationship with an accurate perception (*i.e.*, greater errors indicate less accurate PMC), the composite error z-score of the PMC variable was multiplied by −1, so that a positive value is used to indicate a more accurate estimation, and a negative score indicates a less accurate estimation. Finally, percentiles for accuracy PMC were computed based on the composite error z-score.

Reliability analyses were computed using Intra- and Inter-Class Correlation (ICC) techniques for test-retest reliability and interrater reliability, respectively. An ICC <0.50, 0.50-0.75, 0.75-0.90, and >0.90 are indicative of poor, moderate, good, and excellent agreement, respectively (Koo & Li, 2016).

Twelve children aged between 6 and 10 years-old (M = 8.49, SD = 1.72) performed the PMC tasks twice under similar conditions, with a 7-day interval, and were assessed by the same rater. A moderate degree of reliability with an ICC of 0.59 and a confidence interval (CI) = 0.04 to 0.86 with 95% of confidence was obtained for the standing long jump. Concerning the manipulative tasks, a good reliability with an ICC of 0.80 (95% CI 0.42 to 0.94) and a moderate reliability with an CI 0.57 (95% 24 to 0.91) were obtained for throwing and kicking, respectively. A moderate degree of reliability with an ICC of 0.71 and an CI = 0.24 to 0.91 with 95% of confidence was obtained for the walking backwards. The ICC for inter-rater reliability between the two raters was 0.95 (95% IC 70 to 0.87) for the standing long jump and .97 (95% CI 0.94 to 0.99) for the walking backwards.

Physical fitness (PF). For the assessment of progressive cardiorespiratory fitness, children performed the 20m shuttle run test (20m SRT) (Léger, Lambert, Goulet, Rowan, & Dinelle, 1984), also named PACER. The 20m SRT is positively associated with aspects of physiological and physical health in school-aged children, among others, and could be a tool to screen children at risk of poor health and in need of increasing of PF levels (Lang et al., 2018). The 20m SRT comprises of 1-min levels of continuous, incremental speed running. Children are required to run back and forth between two lines 20m apart, while keeping pace with audio signals. The test finishes when the child fails to reach the end lines of two consecutive 20 m laps in time with the audio signal, or when he/she stops due to fatigue. The number of shuttles is recorded. A group of 4–5 children was tested simultaneously.

Body fat percentage. Percent body fat (BF%) was estimated using Tanita's programmed height (measured with a standard stadiometer), weight (measured by the Tanita scale function), age and gender, and BF % were measured.

2.4. Data analysis

All data were analyzed using IBM SPSS Statistics 26. Statistical significance was set at $p < .05$.

As mentioned above, the first aim of the current study was to examine the differences between boys and girls (considering the overall sample) in terms of MC, PMC, PF, and BF%. The mean, standard deviation, minimum, and maximum values of the data were calculated for each variable. The relationship between all studied variables was examined by Pearson correlation. A Multivariate data analysis, controlled for age and sex, since both variables have been found to be significantly associated with PF (Emini et al., 2022) and BF% (Costa-Urrutia et al., 2019), was performed to examine the differences between boys and girls for the mentioned variables.

The second aim of this study was to analyze whether different profiles based on MC and accuracy of PMC could be identified. Ward's hierarchical cluster (squared Euclidean distance method) analysis were computed. Firstly, the scores of the MC (assessed by MCA) and accuracy of PMC (assessed by the four motor tasks) of the children were standardized. Secondly, the standardized scores of MC and accuracy of PMC (conversion into z-scores) were checked first for univariate outliers (absolute z-score of more than three) and then for multivariate (Mahalanobis distance measure). As a consequence of this procedure, five univariate outliers were removed (absolute z-score of more than three), additionally no multivariate outliers were found resulting in a final sample of 287 children. The results indicate the existence of 3 cluster solutions, namely solutions with 3, 4 and 5 clusters, however after examining the explained variance, the agglomeration Schedule coefficients graph, and the frequency (number of children per cluster) it was decided to use the 4-cluster solution. More specifically, the solution with 3 clusters did not show an explanation of variance greater than 50% and was therefore not considered. The 5 and 4 solutions showed similar results with an explained variance above 50%. However, analyzing the agglomeration Schedule coefficients graph, the 4-cluster solution represented a better solution.

A chi-square test was conducted to explore whether boys and girls were equally distributed across clusters. Univariate analysis was conducted to analyses age-related differences among clusters, and Bonferroni post hoc test was performed to determine significant differences.

The third aim of this study was to examine whether the clusters differed on PF, and BF% using multivariate data analysis (using the same output obtained in the analysis performed for aim 1). Bonferroni adjusted post hoc analyses were used to detect significant subgroup differences.

3. Results

3.1. Descriptive statistics

Means, standards deviations, minimum and maximum values, and correlations of the variables are presented in Table 1. Children had medium overall levels of MC and accuracy of PMC with a mean percentile of 57.68 (SD = 18.18) and 53.73 (SD = 26.67), respectively.

Regarding to MC (boys: $M_{percentile} = 59.56$, SD = 17.48; girls: $M_{percentile} = 55.67$, SD = 18.75; $F(1)=.57$, $p = .45$) and PMC (boys: $M_{percentile} = 52.58$, SD = 27.00; girls: $M_{percentile} = 54.98$, SD = 26.35; $F(1)=.05$, $p = .82$), no significant differences between boys and girls were found. Concerning to PF, boys performed (M = 34.63, SD = 13.69), on average, a larger number of laps than girls (M = 26.74, SD = 10.87) ($F(1)=14.96$, $p < .001$). The BF% of boys (M = 18.31, SD = 6.86) did not significantly differ from that of girls (M = 19.97, SD = 7.77) $F(1)=.22$, $p = .64$).

Pearson's correlation results indicated that MC was positively and significantly associated with PMC (r = 0.13, $p = .03$) and PF (r = 0.46, $p < .001$), and negatively and significantly associated with BF% (r = −0.33, $p < .001$) and age (r = −0.17, $p = .004$). The accuracy of PMC was positively and significantly associated with age (r = 0.29, $p < .001$) and PF (r = 0.19, $p = 001$). PF is negatively and significantly associated with BF% (r = −0.36, $p < .001$), and positively and significantly associated with age (r = 0.33, $p < .001$). BF% was positively and significantly associated with age (r = 0.16, $p = .005$).

3.2. Identifying clusters

As displayed in Fig. 1, four clusters were identified based on cluster analysis. The clusters were categorized based on relative scores for MC (high *vs* low) and PMC (accurate *vs* inaccurate), respectively. Children in Cluster 1 (C1, n = 51, 17.77%) showed high MC and inaccurate PMC, in comparison to children belonging to the other clusters. This cluster was labelled "high-inaccurate" cluster. Children in Cluster 2 (C2 n = 24, 8.36%) showed low MC and inaccurate PMC (low-inaccurate), compared to children belonging to the other clusters. This cluster was labelled "low-inaccurate" cluster. Children in Cluster 3 (C3, n = 90, 31.36%) showed low MC and accurate PMC, in comparison to children belonging to the other clusters. This cluster was labelled "low-accurate" cluster. Children in Cluster 4 (C4, n = 122, 42.51%) showed high MC and accurate PMC, in comparison to children belonging to the other clusters. This cluster was labelled "high-accurate" cluster. Chi-squared

Table 1
Descriptive statistics and correlations between variables.

	M	SD	Min	Max	1	2	3	4
1. Motor competence (percentile)	57.68	18.18	6.67	96.67	–			
2. Accuracy of perceived motor competence (percentile)	53.74	26.67	0.32	95.19	.13*	–		
3. Physical fitness (20m SRT; number of laps)	30.83	12.99	9	67	.46**	.19**	–	
4. Body fat Percentage	19.12	7.35	3.80	53.60	−.33**	.06	−.36**	–
5. Age (years)	8.63	1.15	6.48	10.93	−.17**	.29**	.33**.	16**

Note: n = 287 children, except for 20m SRT (n = 280)
*p < .05; **p < .01

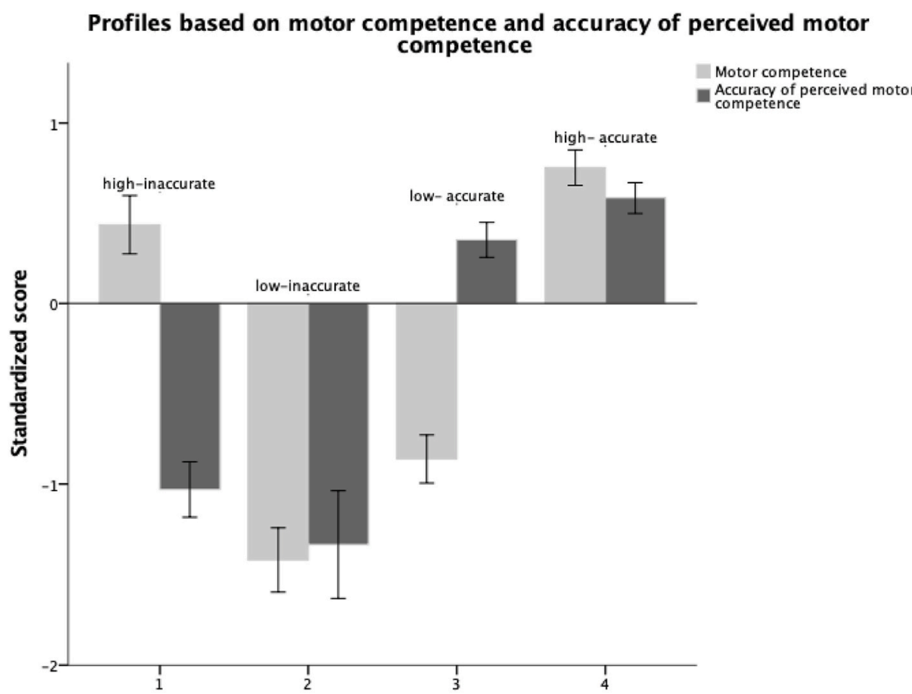

Fig. 1. Four cluster solution based on z-scores for motor competence and accuracy of perceived motor competence.

analysis showed boys and girls were equally distributed across clusters ($\chi^2(3) = 2.96$; $p = .40$). Regarding age-related differences between clusters, a significant age-effect was found ($F(3) = 7.63$; $p < .001$). Bonferroni post hoc tests revealed a significant difference in age between children in C1 (M = 7.99; SD = 1.05 years) and C3 (M = 8.91; SD = 1.11 years) ($p < .001$), and children in C1 and C4 (M = 8.70; SD = 1.16 years) ($p = .001$).

Concerning MC, significant differences were found between the four clusters ($F(3) = 191.06$; $p < .001$) (see Table 2). The high-accurate cluster (C4 $M_{percentile} = 71.18$, SD = 9.98) had the highest mean score,

Table 2
Mean scores and cluster comparison for the four cluster – real and perceived motor competence, body fat percentage (n = 287), physical fitness (n = 280).

Variable	Cluster				F	*eta*^{2}
	Cluster 1 (C1) high MC-inaccurate PMC (n = 51; 17,77%; 20 girls, 31 boys; M_{age} = 7.99, SD = 1.05)	Cluster 2 (C2) low MC-inaccurate PMC (n = 24; 8.36%; 13 girls, 11 boys; M_{age} = 8.62, SD = 1.04)	Cluster 3 (C3) low MC-accurate PMC (n = 90; 31.36%; 48 girls, 42 boys; M_{age} = 8.91, SD = 1.11)	Cluster 4 (C4) high MC-accurate PMC (n = 122; 42.51%; 58 girls, 64 boys; M_{age} = 8.70, SD = 1.16)		
Cluster dimension (raw scores)						
Motor competence (percentile) $^+$	65.44 (1.46)	31.76 (1.55)	41.89 (1.21)	71.18 (.90)	191.06 ***	.67
Accuracy of perceived motor competence (percentile)$^+$	18.19 (1.48)	13.73 (2.46)	62.37 (1.67)	70.10 (1.42)	202.08***	.69
Physical fitness (number of laps) $^+$	31.82 (1.65)	20.00 (1.67)	25.31 (1.04)	36.55 (1.22)	33.22***	.27
Body fat Percentage$^+$	17.64 (.96)	23.24 (1.82)	21.54 (.86)	17.13 (.51)	9.28***	.09
Cluster dimension (z-scores)						
Motor competence$^+$	.43 (.08)	−1.42 (.09)	−.86 (.07)	.75 (.05)	191.06***	.67
Accuracy of perceived motor competence$^+$	−1.03 (.077)	−1.33 (.14)	.35 (.05)	.58 (.04)	202.08***	.69

Note: Values in parentheses are standard errors. n = 287 children, except for Physical fitness (n = 280, C1 n = 50; C2 n = 23; C3 n = 87; C4 n = 120); $^+$MANCOVA controlled for sex and age; ****p < .001* followed by the high-inaccurate (C1 $M_{percentile}$ = 65.44, SD = 10.42), the low-accurate (C3 $M_{percentile}$ = 41.89, SD = 11.52) and the low-inaccurate cluster (C2 $M_{percentile}$ = 31.76, SD = 7.61), respectively. Significant differences in accuracy of PMC ($F(3) = 202.08^{**}$; $p < .001$) were found between clusters, except between C1 and C2 (see Table 2). The high-accurate cluster (C4 $M_{percentile}$ = 70.01, SD = 15.70), had the highest mean score, followed by the low-accurate (C3 $M_{percentile}$ = 62.37, SD = 15.87), the high-inaccurate cluster (C1 $M_{percentile}$ = 18.19, SD = 10.57), and the low-inaccurate cluster (C2 $M_{percentile}$ = 13.73, SD = 12.07), respectively.

3.3. Differences between clusters in physical fitness and body fat percentage

Multivariate data analysis (controlled for age and gender) displayed significant differences between clusters for both PF($F(3) = 33.22$; $p < .001$) and BF% ($F(3) = 9.28$; $p < .001$) (see Table 2). The high-accurate cluster (C4) had the highest mean score for PF, followed by the high-inaccurate cluster (C1), the low-accurate (C3) and the low-inaccurate cluster (C2), respectively (see Fig. 2). Children in C4 (high-accurate), on average, performed significantly more laps in the 20m SRT (M = 36.55, SD = 13.45) than children in C3 (low-accurate) (M = 25.22, SD = 9.79) and in C2 (low-inaccurate) (M = 20.00; SD = 8.05). On average, children in C1 (high-inaccurate) performed more laps (M = 31.82, SD = 11.56) than children in C3 (low-accurate) and C2 (low-inaccurate). Children in C1 (high-inaccurate) did not significantly differ in PF from children in C4 (high-accurate). Children in C2 (low-inaccurate) and C3 (low-accurate) did not significantly differ in their PF.

Regarding the BF%, the high-accurate cluster (C4) had the lowest mean score, followed by the high-inaccurate cluster (C1), the low-accurate cluster (C3) and the low-inaccurate cluster (C2), respectively (see Fig. 3). Children in C1 (high-inaccurate) (M = 17.64, SD = 6.86) had significantly lower BF% than children in C2 (low-inaccurate) (M = 23.24, SD = 8.90). Children in C2 (low-inaccurate) and C3 (low-accurate) had significantly more BF% (M = 23.24, SD = 8.90; M = 21.54, SD = 8.15, respectively) than children in C4 (high-accurate) (M = 17.13, SD = 5.63). Children in C1 (high-inaccurate) did not significantly differ in their BF% from children in C4 (high-accurate) and C3 (low-accurate). C2 (low-inaccurate) did not significantly differ from C3 (low-accurate) in terms of BF%.

4. Discussion

This study aimed to explore sex differences with respect to MC, accuracy of PMC, PF, and BF% (aim 1), to identify profiles in school-aged children according to actual MC and accuracy of PMC (aim 2), and to analyze how children with different types of profiles (based on actual MC and accuracy of PMC) differ in terms of PF and BF% (aim 3).

The present study complements and extends previous research on the analysis of perceived and actual MC, by obtaining the children's accuracy of PMC through a direct measure of performance using the same motor task. Following Gabbard et al.'s (2009) suggestion, PMC was assessed using context-specific measures (*c.f.*, Almeida et al., 2016, 2017) instead of relying on the self-confidence of the children and on how good they think they are in performing various motor skills (Barnett, Vazou, et al., 2016; Coppens et al., 2021; Harter & Pike, 1984). To our knowledge, this is the first study that aims to develop profiles of school-aged children according to their actual MC and accuracy of PMC, using context-specific measures to assess PMC, on which the child must estimate his/her maximum ability in different MC tasks (jumping, throwing, kicking, and walking backwards). Since the methodology used in this study was different from other studies, as the PMC was measured in terms of accuracy vs. inaccuracy instead of high vs. low PMC, it is challenging to directly compare the results of our analysis to others in the literature. As such the conclusions should be taken with caution.

The first aim of this study was to explored sex differences with respect to MC, accuracy of PMC, PF, and BF%. Considering the overall sample, our results show that MC and accuracy of PMC are positively and significantly associated, but the strength of the association is weak ($r = .13$, $p = .03$), which is in line with previous studies. More specifically, a meta-analysis including data from 69 papers (De Meester et al., 2020), has shown that the strength of the relationship between MC and PMC/physical self-perception in children, adolescents and young adults, was low to moderate, and does not differ by age, sex and alignment between measurement instruments. A positive association between MC and PF and a negative association between MC and BF% was found in this study. Previous research has also shown that PF is positively associated with MC (Kolunsarka, Gråsten, Huhtiniemi, & Jaakkola, 2021), and PF is inversely associated with BF% (Mota et al., 2002). Further, an excessive BF% was found to unfavorably affect 20m SRT test performance (Stigman et al., 2009; Tomkinson et al., 2018). A positive correlation was found in this study between accuracy of PMC and age. This may indicate that the accuracy of children's perception improves with age and cognitive development, with the children being gradually more capable of making realistic judgments about their competences during elementary years (Harter, 1982, 1999). Accuracy of PMC is also found to be positively related with PF. Previous research has demonstrated the positive association between 20m SRT and PMC (Huhtiniemi, Sääkslahti, Tolvanen, Watt, & Jaakkola, 2022), although the quality of

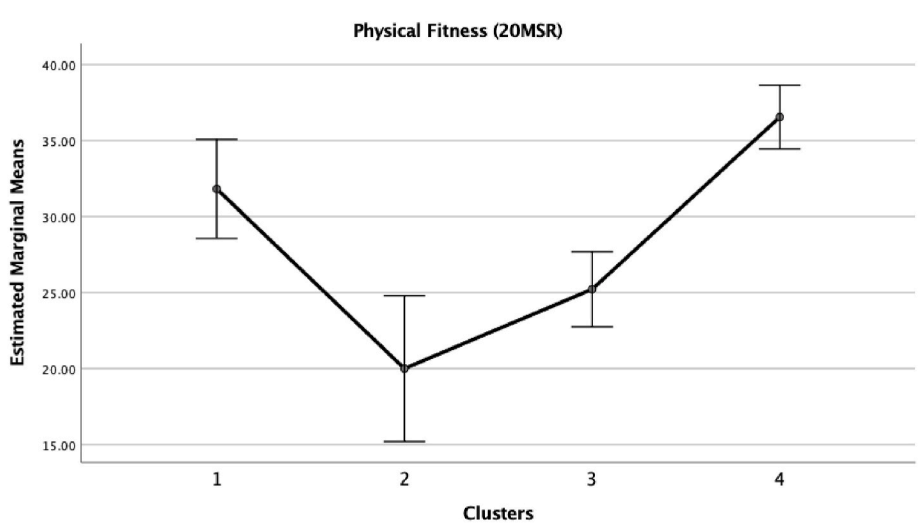

Fig. 2. Estimated marginal means and confidence intervals (95%) by clusters for physical fitness.

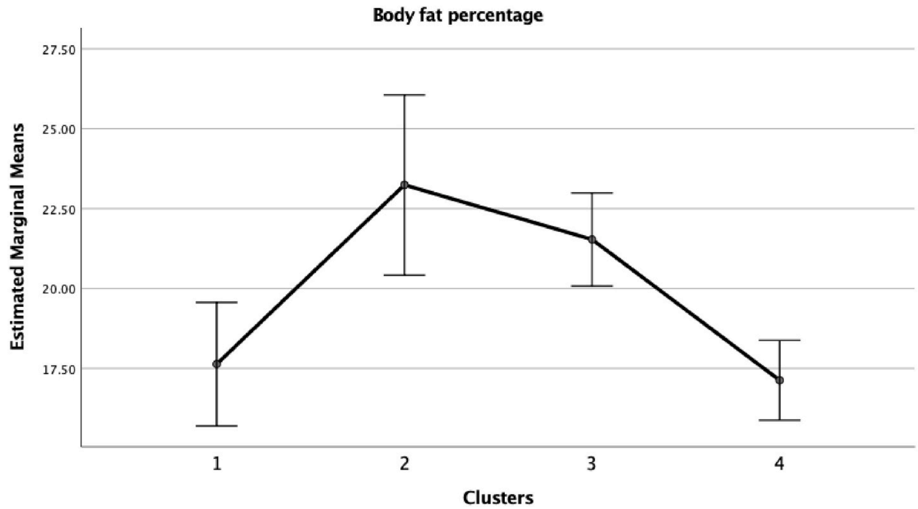

Fig. 3. Estimated marginal means and confidence intervals (95%) by clusters for body fat percentage.

the evidence was very low (Lang et al., 2018). PF was also found to be associated with age, which is attributed to somatic and biological maturation, and thus it is expected that aging increases the PF performance (that is, number of laps) (Tomkinson et al., 2018). Finally, and looking at sex difference, our study found differences concerning PF, where boys outperform girls. This finding was expected and is also aligned with previous studies (Lanza et al., 2015; Pinto et al., 2020; Tomkinson et al., 2018).

The second aim of this study was to identify profiles based on children's MC and accuracy of PMC. The cluster analysis revealed four distinct and substantially sized groups, in agreement with our hypothesis. Two profiles were characterized by corresponding levels of actual MC and PMC (50.77%), with 42.51% of all children having a relatively high level of actual MC and being accurate in PMC (high-accurate), and only 8.26% having a relatively low level of actual MC and being inaccurate in PMC (low-inaccurate). The other two profiles identified children with non-corresponding levels (49.13%) of actual MC and accuracy of PMC: 17.77% of children had relatively high level of MC but are inaccurate in their PMC (high-inaccurate), and 31.36% exhibited a combination of relatively low level of MC and accurate PMC (low-accurate).

Curiously, our findings are in very good agreement with the study of Bardid et al. (2016) that found four profiles in children with a mean age of 8.82 years (mean age in our sample was 8.63 years), in which two groups were characterized by aligned levels of MC and PMC (52.90% of all children vs 50.77%) and two groups were characterized by not-aligned levels of MC and PMC (47.10% vs 49.13% in our study), even if the evaluation of the paradigm is different. Considering studies with other mean age groups, De Meester and colleagues (De Meester, Maes, et al., 2016) have also identified four clusters. Even though the study was carried out with adolescents (mean age 13.64 years), 50.98% of the sample showed corresponding levels of perceived and actual MC. Another study by De Meester and colleagues (De Meester, Stodden, et al., 2016) involving children (mean age 9.50 years) identified three clusters in which two had aligned levels of MC and PMC (67.96%). A recent study (Coppens et al., 2021) that aimed to identify profiles in children (mean age 10.83 years) based on MC, PMC and organized sports participations, identified 5 out of 6 profiles with aligned (high–average–low) levels of MC and PMC (83.92%), and only one profile showing non-aligned levels of MC and PMC. Furthermore, and since we have, in the present study, analyzed the accuracy of PMC and not the PMC scored as low or high, we were able to differentiate between accurate children (73.87%), from both non-aligned and aligned clusters (C3 and C4), and less accurate children (26.13%) from non-aligned and aligned clusters (C1 and C2). Our results indicate that the accuracy of perception of MC seems to be more related to age than to the actual level of children's MC. In fact, children in C1 (high-inaccurate) in our study, were significantly younger than children in both the accurate clusters (C3: low-accurate; and C4: high-accurate).

The third aim of this study was to analyze differences in PF and BF% between children with different MC and PMC-based profiles. Children in C4 (high-accurate) were found to show, in average, a better score in PF and lower BF% than children in C1 (though not statistically significant), C3, and C2 (both statistically significant). The profile who exhibited a combination of low MC and inaccurate PMC (C2) had the lowest level of PF and highest BF%. Previous studies that have assessed PA and BMI (De Meester, Stodden, et al., 2016; Estevan et al., 2019) have reported that the combination of both high MC and PMC is related with a higher level of PA and a lower weight status. Even though the mentioned studies used different variables than the ones used in this study, there is a known association between PA and PF measured by 20m SRT (Jaakkola et al., 2019; Kolunsarka et al., 2021) and between BMI and BF% (Costa-Urrutia et al., 2019). Our results, which show an association between higher MC and both better PF and lower BF%, are in line with the mentioned studies. Furthermore, our results suggest that high MC levels (C1 and C4) lead to a better PF and lower BF%, making the MC a more fundamental characteristic than the accuracy in the PMC (C3 and C4), independently if the PMC is high or low.

Our findings are supported by Stodden's conceptual model (Stodden et al., 2008), which describes the dynamic and reciprocal roles of MC, PMC, HRF, PA engagement and obesity in children. According to this model, MC has a potential role in promoting a positive trajectory of HRF and weight status, and PMC and HRF are mediating variables in this model for the engagement in sports and PA. Children that perceive themselves as having high level of MC are more likely to engage in PA, to become active and to have a healthy weight status, than children who perceive themselves as having low MC (Stodden et al., 2008). In other words, children in C4 (high-accurate), according to Stodden et al. (2008), are in the positive spiral of engagement in PA and are more likely to have a healthy weight status over time in adolescence. In childhood, MC could be considered both a precursor and a consequence of weight status (Robinson et al., 2015). The significant differences found in PF and BF% between children with high-accurate (C4) profile and children with low-inaccurate (C2) and low-accurate (C3) profiles highlight the importance of promoting opportunities, or even interventions to increase MC. More opportunities permit children to engage more frequently in physical and motor activities, which in turn offer more opportunities for improving MC and PMC that together can promote HRF later in life (Robinson et al., 2015; Stodden et al., 2008). Furthermore, interventions in early childhood should also aim to increase PF in order to promote positive trajectories of health (Utesch et al., 2019). Given the role of MC and PMC, both the assessment of PF, MC and PMC, and the relationship between these variables, should be considered in physical education classes and sport contexts. Regarding this topic, Estevan, Menescardi, García-Massó, Barnett, and Molina García (2021) suggest that the profile of the children, according to type of MC and PF assessment, should be identified prior to an intervention targeting actual MC, PMC and PF. The promotion of both MC and PMC, as well as their mediating variables, should be a goal for professionals in the field of human kinetic who are interested in a holistic view of children's development.

4.1. Strengths, limitations, and recommendations for future research

The strengths of this work are (i) the alignment of the MC and PMC assessments, and (ii) the fact that the assessment of the PMC of the children uses context-specific measures. For this motive, the results are difficult to compare to other studies that use a pictorial measure or a self-report questionnaire for assessing PMC, where children are differentiated based on low or high as opposed to accurate-inaccurate perceived competence. One limitation of this study is related with the reliability analyses and the small number of participants. As a rule of thumb, reliability studies should be conducted with at least 30 participants (Koo & Li, 2016). Another limitation of this study is that the relationship between MC and PMC and the role of PF and BF% were investigated using a cross-sectional methodology instead of longitudinal. Furthermore, the assessment of PMC focused on a relative narrow range of fundamental movement skills, although distributed by perceived competence in stability, locomotor, and manipulative skills, leaving out the assessment of perceived competence in active play skills (Estevan & Barnett, 2018). Future research could investigate the relation between MC and PMC using longitudinal methodologies to understand how this relation change to across the life span.

5. Conclusions

The present cross-sectional study revealed two profiles with aligned levels of MC and accuracy of PMC and two non-aligned profiles. Additionally, the findings suggest that a combination of relatively low MC and PMC (that is, inaccuracy) in school-aged children was related to a lower PF level and a higher BF%, in contrast with children with high levels of both MC and PMC (that is, accuracy), that had a higher PF level and a lower BF%. These results highlight that promoting children's MC and PMC might be essential to increase levels of PF and reduce BF%, resulting in the future adoption of active and healthier lifestyles. By assessing MC and PMC, teachers of physical education and specialists in the field of motor development, can identify children who are at risk of entering a negative spiral of disengagement that may have an unfavorable impact on their health. Matching the assessments of MC and PMC will help the professionals to understand these relationships.

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Authors' contributions

GA: conceptualization, study design, formal analysis, writing, review and editing critical revision, CL: study design, formal analysis, writing manuscript draft, critical revision, LPR: study design, manuscript drafting, critical revision, VL: study design, manuscript drafting, critical revision, RC: study conception and design, data analysis and interpretation, critical revision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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