Socioeconomic and gender-based disparities in the motor competence of school-age children

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Title

Socioeconomic and gender-based disparities in the motor competence of school-age children

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Abstract

This study examined socioeconomic and gender-based disparities in motor competence (MC) amongst 6-12-year-old children (N = 2654). Validated product-oriented tests assessing agility, balance and coordination were used to measure MC and raw scores were normalized and standardized (z-score). School-level socioeconomic status (low, middle, high) was used to assess socioeconomic disparities. Analysis of covariance (ANCOVA) were conducted and odds ratios were calculated for the likelihood of having low MC by gender and socioeconomic status (SES). Girls displayed lower MC than boys for agility and coordination involving object-control ($P< 0.001$) while boys scored lower than girls for balance and hand-foot coordination ($P< 0.001$). Children in high SES schools displayed the highest level of MC for agility, balance and coordination ($P< 0.001$). Compared to the children in high SES schools ($P< 0.01$), odds of having low competence in balance was higher for the children in low SES schools ($P< 0.001$) and odds of having low competence in agility and coordination were higher for the children in both low and middle SES schools. Newell's model of constraints (1986) and Bourdieu's concept of habitus (1978; 1984) were used to consider potential explanations of the observed disparities. To level up inequalities in children's MC, resources invested in school-based interventions should be proportionate to the school SES.

Keywords

motor competence; social inequalities; gender-based inequalities; child health; socioeconomic factors

Introduction

Motor competence (MC) can be defined as the "mastery of physical skills and movement patterns that enable enjoyable participation in physical activities" (Goodway et al., 2019). It can be assessed from a process- or product-oriented perspective (Hulteen et al., 2019). Process-oriented assessments focus on form, *i.e.* the quality of movement (*e.g.* how does a child throw a ball) and usually assess MC in terms of movement patterns such as running, throwing or jumping (Logan et al., 2018). Product-oriented assessment measure movement outcomes such as speed, distance or precision (*e.g.* does the ball reach a target) and usually assess MC in terms of physical skills such as balance, speed, agility and coordination (Deitz et al., 2007; Wrotniak et al., 2006). Weak to strong correlations between process- and product-oriented assessments have been found (Hulteen et al., 2019; Logan et al., 2016). Therefore, both perspectives may provide a distinctive and complementary understanding of MC across developmental time.

Poor MC during childhood is likely a barrier to subsequent PA practices (De Meester et al., 2018; Seefeldt, 1980; Stodden et al., 2008; Stodden et al., 2013). Children who fail to acquire a proficient level of motor skills are more likely to drop out of organized sport during adolescence (Woods et al., 2010) and longitudinal data have shown that children with better MC are more likely to adopt an active lifestyle (Barnett et al., 2008; Lloyd et al., 2014; Lopes et al., 2011). Disparities in children's MC could therefore contribute to inequalities in PA practices later in life, such as the gender gap observed in PA during adolescence (Hallal et al., 2012) and the social gradient in leisure PA practices observed in adulthood (O'Donoughue et al., 2018). Given that the benefits of PA on health and wellbeing have now been widely demonstrated (Bouchard et al., 2011; WHO, 2018), addressing these inequalities are crucial. To do so, we need to improve our understanding of MC disparities in children.

Motor development is influenced by various factors, including individual (*e.g.* maturation), environmental (*e.g.* physical and sociocultural characteristics related to the world around us) and task (*e.g.* instructions, feedbacks, goals or rules) factors (Goodway et al., 2019; Haywood and Getchell, 2020; Newell, 1986). Socioeconomic status (SES) and gender can therefore both have a profound effect on motor development, which can potentially lead to disparities in MC (Goodway et al., 2019; Haywood and Getchell, 2020). Research that examined these issues from a process-oriented perspective have identified two specific populations at risk to delays in their motor development during early childhood: children from low SES backgrounds and girls (Goodway et al., 2019; Goodway et al., 2010). Lack of learning and environmental opportunities might contribute to the developmental delay found in the disadvantaged communities (Goodway et al.,2019; Goodway & Branta, 2003) while sociocultural influences have likely contributed to boys often outperforming girls in manipulative skills (Garcia, 1994). Research examining SES and gender-based disparities has also been conducted among school-aged children from a product-oriented perspective. Among these studies, it has also been observed that children from low SES environments usually demonstrate poorer MC than children from high SES environments (de Waal et al., 2020; Ferreira et al., 2018; Ghosh et al., 2016; Morley et al., 2015; McPhillips et al., 2007). Given that low SES schools consistently report more barriers and fewer enablers to PA than their high SES counterparts (Peralta et al., 2019), children attending low SES schools might have reduced opportunities to learn and practice motor skills. As for gender, some studies found that boys demonstrated superior gross MC than girls (Wrotniak et al., 2006; Morley et al., 2015) but another study reported no gender difference in MC (Ferreira et al., 2018). An important point about the research examining SES disparities among school-aged children is that even though social gradient in leisure PA practices observed in adulthood are distributed across the whole spectrum of SES (O'Donoughue et al., 2018), very few studies (Ferreira et al., 2018; Morley et al., 2015) examined the MC of middle-SES students. Additionally, to our knowledge, disparities in school-children's MC have not been examined from a product-oriented perspective in North America.

Leveling up disparities in children's MC is important because it involves supporting, for all children, the development of the underlying skills needed to enjoy and engage in various PA, sports, and games throughout life. In that sense, it supports children's capabilities to adopt an active lifestyle and could contribute to level up inequalities in PA practices and health later in life. Motor skill intervention in elementary schools are an effective strategy to improve MC in children (Morgan et al., 2013). However, it remains unclear for which social group school-based motor skills interventions should be developed as little is known about the MC of middle-class students and, from a product-oriented perspective, no consensus has emerged yet concerning the gender-based disparities. It also remains unclear which factors of MC should be targeted. Therefore, the purpose of this study is to examine the presence (or absence) of socioeconomic and gender-based disparities in children's MC in Quebec, a Canadian province, using a product-oriented perspective. Children from low, middle and high SES schools were included in the study.

Method

Participants

This present study was conducted under the framework of an elementary school-based program aiming at assessing and following the evolution of motor skills in children in Quebec, a Canadian province (http://rseq.ca/viesaine/iso-actif/en-forme-au-primaire/). The test battery used for the program, called UQAC–UQAM, was built in 2011 (Leone et al., 2014) and a pilot project involving 300 children was conducted in 2011 to confirm its feasibility in a school environment. The data collected during the pilot project were used to calculate the sample size needed to produce normative standards by age (6 – 12) and gender. Based on Cohen's d power analysis, a sample size of 1450 was required to obtain a power of $1-\beta = 0.80$ for $\alpha = 0.05$ and an effect size $d = 0.50$ which corresponds to a medium effect. A sample of 2654 children (6-12-year-olds) from 10 elementary schools in Quebec have been tested between 2012 and 2016. The schools were randomly selected from 200 schools that expressed an interest in participating in the study. Parental and school consents were obtained prior to data collection. The University Ethics Committee granted ethical approval.

Data collection

Testing protocol

The UQAC-UQAM battery is composed of 14 product-oriented tests assessing limb speed, agility, balance, reaction time, coordination and cardiorespiratory fitness. The tests in the battery were selected based on the following criteria: valid and reliable; short in duration; easy to understand by children; easy to administer; require a minimum amount of equipment; require a minimum amount of space; low cost.

The validity and reliability of these tests have been reported by other authors (Leone et al., 2014, Barrow and McGee, 1971; Fleishman, 1964; Strand and Wilson, 1993). Reliability was established either by a test-retest procedure or by intra/inter raters, with overall correlation values above 0.70, and validity was examined through construct validation (factor analysis). Construct validation is still commonly used to validate motor competence assessment in children (Hulteen et al., 2020). In this study, we analyzed three of the six battery's components: agility, balance and coordination. A total of 10 tests are therefore included in the study (Figure 1).

Students were tested in the school gym in their class group for two 45-minute periods. The children were free to withdraw themselves from the study at any time without any consequence. Data were collected by a trained team of four physical educators and kinesiologists. The participants were divided into four groups and assigned to one of the four testing stations. Participants moved to the next station until all stations had been completed. The detailed procedures for data collection are described in Leone et al. (2010). Additionally, anthropometric measurements were taken, and a sociodemographic questionnaire was used to collect data on the child's age, gender, and school attended.

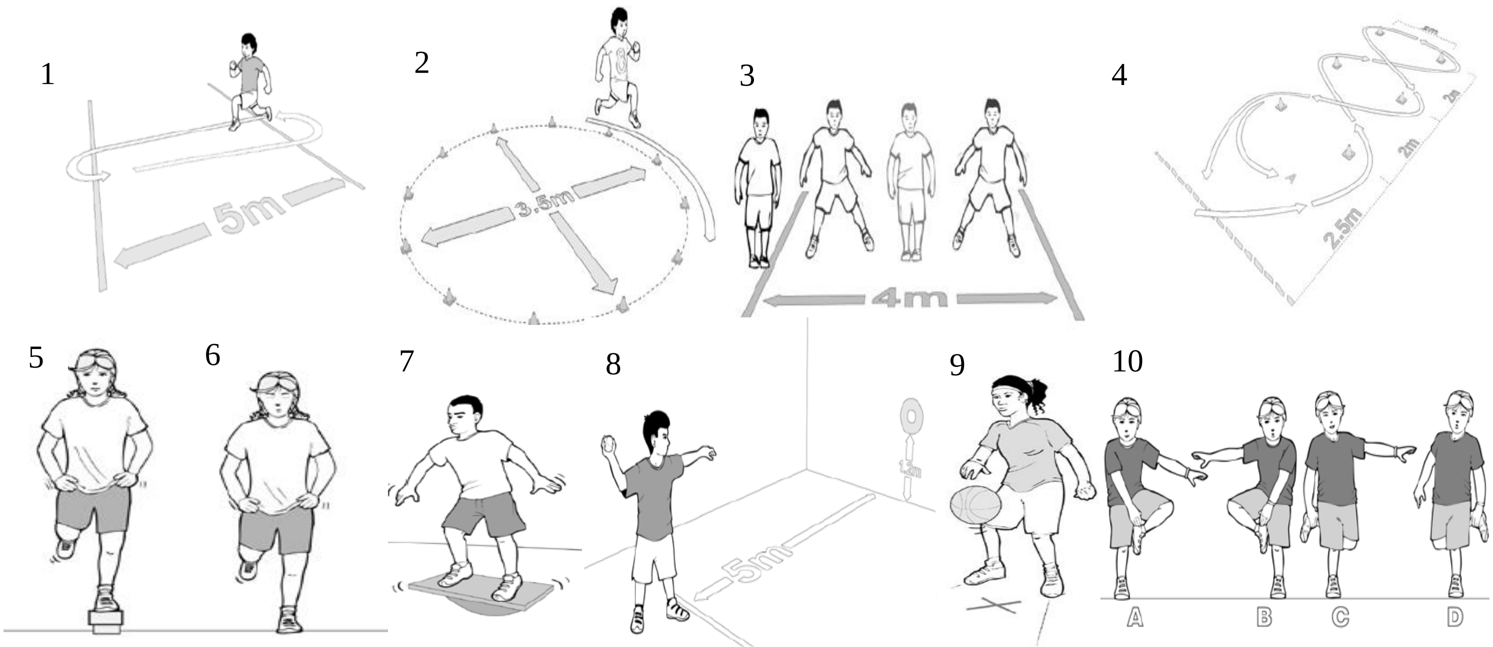

Figure 1. The 10 tests assessing agility, balance and coordination ***Agility:*** *1. 5m shuttle run 2. Circle run 3. Sidestep run 4. Slalom run* ***Balance:*** *5. One-foot beam lengthwise eyes open 6. One-foot balance on the ground eyes closed 7. Board balance test* ***Coordination:*** *8. Eye-hand coordination: target ball toss 9. Eye-hand dribbling coordination 10. Hand-foot coordination*

Scoring protocol

For nine of the 10 tests (exception being the target ball toss), students had two attempts and only their best attempt was considered for the score. For the 5m shuttle run, the circle run and the sidestep run, the score was the time required to complete five rounds (to the nearest 0.1 second). For the slalom run, it was the time required to complete two rounds. For the three balance tests, the score was the length of time during which the participant held their balance (maximum of 60 seconds, recorded to the nearest 0.1 second). For the hand-foot coordination test, the time required to complete four consecutive cycles was recorded to the nearest 0.1 second. For the target ball toss, one point was given when the target was hit, and one bonus point was given if the throw hit the target's center. Finally, for the eye-hand dribbling coordination test, the score was the number of dribbles made in 20 seconds.

Anthropometric Measurements

Height was measured using a portable stadiometer (Seca, model 214 portable stadiometer, Hanover, MD) to the nearest 0.1 cm. Body mass was recorded using a portable calibrated mechanical scale (Seca, model 760 body mass scale, Hanover, MD) to the nearest 0.5 kg. Body mass index (BMI) was calculated using the following formula: Body mass (kg)/Height^2 (m^2).

Socioeconomic status

A school-level SES indicator was used as an indicator of SES. It has been developed specifically for Quebec schools and is calculated by the Ministère de l'Éducation et de l'Enseignement Supérieur du Québec (MEES) for each primary school of the province. The school-level SES corresponds to the proportion of families with children whose income is near or below the low-income cut-off. It varies between 1 and 10, 1 being the highest SES (MEES, 2020). Children from SES 1, 3, 4, 5, 9 and 10 were included in the study. The following groupings were made: High SES = 1-2; Middle SES = 3-6 and Low SES = 9, 10.

Statistical analysis

Data were analyzed using SPSS version 25 and statistical significance was set at $p < 0.05$.

To facilitate comparisons across motor tests, raw scores were normalized and standardized (z-score). A higher score indicates better MC. We created composite scores for each category (agility, balance and coordination) by averaging the standardized scores of all tests within each category, for all participants.

We conducted analyses of covariance (ANCOVA) to examine differences in MC for all 10 tests as well as for the 3 composite scores according to gender and SES (High, Middle, Low) while controlling for age and BMI. First, gender was used to estimate mean test z-score and 95%CI while controlling for age, SES and BMI. Interactions were formally tested, and no significant interaction were found. Afterwards, SES was used to estimate mean test z-score and 95% confidence intervals (95%CI) while controlling for age, gender and BMI. Significant gender interactions were found for 5 out of the 13 scores: sidestep run, 5m-shuttle run, composite agility score, dynamic balance and hand-foot coordination. For these, we studied the relationship between SES and MC separately for boys and girls. Estimated means with pair-wise comparisons with Bonferroni adjustments were used to identify differences between SES groups. For all models, effect sizes using partial eta squared (η^2) were calculated and interpreted as 0.01 = small, 0.06 = medium and 0.14 = large (Cohen, 1988).

We performed binary logistic regression to further examine the associations between MC, gender and SES while controlling for age and BMI. Specifically, we looked at the odds ratio (OR) and 95%CI of having low scores by gender (boys, girls) and SES category (low, middle, high). Scores for each test were used as dependent variables, coded as binary variables (1 = low and 0 = others). To be classified as low, a score needed to be below the first quintile (≤ 20^{th} percentile) of the distribution. The 20^{th} percentile has previously been used to classify low scores (Merino-De Haro et al., 2018; Ortega et al., 2018). Because significant gender interactions were found with sidestep run, 5m-shuttle run, composite agility score, dynamic balance and hand-foot coordination, the relationship between SES and MC was studied separately for boys and girls for these scores.

Results

Participant information

The descriptive characteristics of the children (N = 2654) are shown in Table 1. Children in the low SES group were significantly younger than children in the other SES groups (*P< 0.001*) and there were significantly fewer girls (*P< 0.001*) in the middle SES group. Boy's in the low SES group showed higher mean BMI than boy's in the two other groups.

Table 1. Descriptive characteristics of the sample

	SES						
	Low (9-10)		Middle (3-6)		High (1-2)		Total
Schools (N)	2		4		4		10
Children (N)	524		848		1282		2654
Girls (%)	56		45***		52		51
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	
Chidren (N)	251	273	469	379	569	713	2654
Age	9.1 (1.7) ***	9.2 (1.7) ***	9.6 (1.8)	9.6 (1.8)	9.7 (1.6)	9.7 (1.7)	9.6 (1.7)
BMI	17.7 (3.8)	17.5 (3.6)	16.7 (3.2)***	17.2 (3.7)	17.3 (3.8)	17.2 (3.6)	17.2 (3.4)
Height (cm)	134.3 (11.4)	134.4 (12.0)	136.6 (12.0)	137.4 (12.9)	139.9 (11.0)	140.5 (12.7)	137.9 (12.3)
Weight (kg)	32.6 (11.2)	32.4 (10.8)	31.8 (10.4)	33.4 (12.0)	34.5 (9.8)	34.7 (10.8)	33.5 (10.8)
Agility - raw scores (seconds)							
5m shuttle run	11.3 (1.5)	11.8 (1.8)	11.9 (1.7)	11.9 (1.2)	11.0 (1.2)	11.3 (1.4)	11.5 (1.5)
Circle run	22.3 (3.1)	23.0 (2.6)	23.1 (3.2)	23.5 (2.7)	21.5 (2.6)	22.0 (2.3)	22.4 (2.8)
Sidestep run	12.1 (1.9)	12.7 (2.3)	11.5 (2.3)	11.6 (2.1)	11.2 (2.5)	11.5 (1.9)	11.6 (2.2)
Slalom run	21.3 (4.5)	21.6 (4.2)	19.9 (3.8)	20.2 (3.2)	19.3 (3.4)	19.7 (2.8)	20.1 (3.6)
Balance - raw scores (seconds)							
Static balance eyes open	22.2 (18.4)	26.9 (20.3)	23.1 (18.5)	27.6 (20.3)	22.1 (18.1)	27.0 (20.4)	24.8 (19.5)
Static balance eyes closed	13.9 (13.8)	16.6 (15.7)	20.6 (17.8)	23.2 (18.5)	19.5 (16.5)	21.9 (17.9)	20.0 (17.2)
Dynamic balance	4.3 (6.4)	5.7 (8.5)	12.0 (15.2)	12.1 (15.5)	16.8 (19.4)	22.9 (23.2)	14.6 (18.7)
Coordination - raw scores							
Target ball toss *(points)*	4.25 (2.7)	3.00 (2.4)	4.9 (2.9)	3.3 (2.4)	4.8 (3.0)	3.2 (2.4)	3.9 (2.8)
Eye-hand dribbling coordination *(dribbles)*	36.0 (8.3)	34.2 (7.5)	37.8 (9.2)	34.7 (9.1)	39.5 (8.4)	36.8 (8.0)	36.9 (8.6)
Hand-foot coordination *(seconds)*	16.5 (9.3)	15.1 (7.9)	15.7 (8.3)	13.2 (7.4)	12.8 (6.3)	11.2 (5.3)	13.5 (7.3)

*The values are mean (SD) unless otherwise indicated. SES = socioeconomic status, N = number of participants, SD = standard deviation, BMI = Body Mass Index. *** indicates a significant difference (P<0.001) between this SES group and the two other SES groups for Gender, Age and BMI*

Differences in agility, balance and coordination according to gender and SES

The results of ANCOVA comparing mean z-scores by gender and SES are presented in Tables 2 and 3.

Gender

Gender differences were statistically significant for all tests. For all agility tests and for both coordination tests involving object-control, girls displayed lower proficiency than boys (*P< 0.001*) whereas boys scored lower than girls for all balance tests and for the hand-foot coordination test (*P< 0.001*). All effect sizes are small except for the target ball toss (medium), which showed the highest gender-based difference (mean z-score of 0.29 for boys and -0.25 for girls, η^2 = 0.10). Regarding the composite scores, boys scored higher for agility (0.15 for boys and -0.09 for girls, *P < 0.001*) and coordination (0.15 for boys and -0.10 for girls, *P < 0.001*) while girls scored higher for balance (-0.11 for boys and 0.08 for girls, *P < 0.001*).

SES

Children in the high SES group presented the highest level of proficiency at all agility tests. Children in the middle SES group got the lowest scores for two of the four tests (5m shuttle run and circle run) and children in the low SES group got the poorest for the other two (slalom run and sidestep run). Overall, the composite agility score showed no significant difference between low and middle SES (*P>0.05*). Boys' agility was more affected than girls by SES (η^2= 0.05 for boys and 0.03 for girls), especially for the 5m shuttle run (η^2= 0.09 for boys and 0.04 for girls).

Regarding balance, SES differences were statistically significant *(P<0.001)* for dynamic balance and static balance with eyes closed, with children from low SES schools displaying the lowest scores. A large effect size was observed for dynamic balance (η^2= 0.13 for boys and 0.14 for girls). For this latter test, girls in the low SES group obtained a mean z-score of -0.6 (C.I. 95% -0.8, -0.5) compared to a mean z-score of 0.3 (C.I. 95% 0.2, 0.4) for girls in the high SES group, a difference equivalent to almost one SD between the two groups.

Regarding coordination, children from middle SES schools got the best scores for the target ball toss but the differences were not statistically significant. For the other coordination tests, children in the low and middle SES groups got statistically significant lower scores than children in the high SES group.

Overall, for all composite scores (agility, balance and coordination), children in the high SES group displayed the highest level of proficiency, and for all composite scores except for agility for boys, children in the low SES group displayed the lowest. Children in the middle SES group obtained poorer results than children in the high SES group for agility and coordination.

Table 2. Mean agility, balance and coordination z-scores by gender

	Boys	**Girls**	***Overall p-value***	η^2
Agility				
5m shuttle run (N = 1211; 1246)	0.12 (0.07, 0.16)	-0.06 (-0.11, -0.02)	*< 0.001*	0.01
Circle run (N = 1223; 1266)	0.14 (0.09, 0.19)	-0.06 (-0.11, -0.01)	*< 0.001*	0.01
Sidestep run (N = 1207; 1243)	0.16 (0.11, 0.21)	-0.07 (-0.11, -0.02)	*< 0.001*	0.02
Slalom run (N = 1201; 1240)	0.08 (0.03, 0.13)	-0.08 (-0.12, -0.03)	*< 0.001*	0.01
Composite agility score (N = 1174; 1200)	0.15 (0.11, 0.20)	-0.09 (-0.13, -0.04)	*< 0.001*	0.02
Balance				
Static balance eyes open (N = 1201; 1225)	-0.09 (-0.14, -0.04)	0.12 (0.06, 0.17)	*< 0.001*	0.01
Static balance eyes closed (N = 1178; 1202)	-0.04 (-0.10, 0.10)	0.06 (0.00, 0.11)	*0.010*	0.00
Dynamic balance (N = 1168; 1208)	-0.11 (-0.16, -0.06)	0.01 (-0.06, 0.04)	*0.009*	0.00
Composite balance score (N = 1143; 1164)	-0.11 (-0.16, -0.06)	0.08 (0.03, 0.13)	*< 0.001*	0.01
Coordination				
Target ball toss (N = 1203, 1248)	0.29 (0.25, 0.34)	-0.25 (-0.30, -0.21)	*< 0.001*	0.10
Eye-hand dribbling coordination (N = 1197; 1238)	0.14 (0.10, 0.19)	-0.16 (-0.21, -0.12)	*< 0.001*	0.03
Hand-foot coordination test (N = 1151, 1210)	-0.12 (-0.17, -0.07)	0.19 (0.14, 0.24)	*< 0.001*	0.04
Composite coordination score (N = 1128; 1182)	0.15 (0.11, 0.19)	-0.10 (-0.14, -0.06)	*< 0.001*	0.03

The values are adjusted z-score means (95% CI) with a Bonferroni adjustment. The analysis of covariance (ANCOVA) was adjusted for age, SES and BMI. Effect sizes (η^2) were interpreted as 0.01 = small, 0.06 = medium and 0.14 = large (Cohen, 1988).

Table 3. Mean agility, balance and coordination z-scores by SES

	SES - High	SES - Middle	SES - Low	*Overall P-value*	η^2	Difference
Agility						
5m shuttle run* Boys (n = 508; 453; 250)	0.32 (0.24, 0.40)	-0.24 (-0.33, -0.16)	0.32 (-0.06, 0.43)	*< 0.001*	0.09	M < L, H
Girls (n = 617; 357; 272)	0.06 (-0.03, 0.12)	-0.29 (-0.37, -0.21)	0.02 (-0.05, 0.07)	*< 0.001*	0.04	M < L, H
Sidestep run* Boys (n = 503; 454; 250)	0.31 (0.23, 0.38)	0.11 (0.03, 0.19)	-0.10 (-0.21, -0.01)	*< 0.001*	0.03	L < M < H
Girls (n = 611; 359; 273)	0.04 (-0.03, 0.10)	0.04 (-0.04, 0.13)	-0.40 (-0.49, -0.30)	*< 0.001*	0.05	L < M, H
Circle run All (n = 1136; 830; 523)	0.25 (0.20, 0.30)	-0.26 (-0.32, -0.20)	0.06 (-0.02, 0.13)	*< 0.001*	0.06	M < L < H
Slalom run All (n = 1123; 800; 518)	0.11 (0.06, 0.16)	0.01 (-0.05, 0.06)	-0.24 (-0.31, -0.16)	*< 0.001*	0.02	L < M < H
Composite agility score* Boys (n = 497; 431; 246)	0.36 (0.28, 0.43)	-0.06 (-0.15, 0.02)	0.07 (-0.04, 0.18)	*< 0.001*	0.05	L, M < H
Girls (n = 596; 333; 271)	0.06 (0.00, 0.12)	-0.18 (-0.26, -0.11)	-0.23 (-0.32, -0.15)	*< 0.001*	0.03	L, M < H
Balance						
Static balance eyes open All (n = 1113; 790; 523)	-0.02 (-0.08, 0.04)	0.01 (-0.06, 0.08)	0.10 (0.01, 0.18)	*0.079*	0.00	L, M, H
Static balance eyes closed All (n = 1097; 761; 522)	0.06 (0.00, 0.11)	0.12 (0.05, 0.18)	-0.26 (-0.34, -0.17)	*< 0.001*	0.02	L < M, H
Dynamic balance* Boys (n = 497; 423; 248)	0.09 (0.02, 0.16)	-0.01 (-0.09, 0.07)	-0.74 (-0.85, -0.64)	*< 0.001*	0.13	L < M, H
Girls (n = 604; 337; 267)	0.30 (0.23, 0.38)	-0.02 (-0.12, 0.07)	-0.64 (-0.75, -0.53)	*< 0.001*	0.14	L < M < H
Composite balance score (n = 1074; 719; 514)	0.10 (0.05, 0.16)	0.06 (0.00, 0.13)	-0.37 (-0.45, -0.29)	*< 0.001*	0.04	L < M, H
Coordination						
Target ball toss (n= 1118; 810; 523)	-0.02 (-0.07, -0.03)	0.06 (0.00, 0.12)	0.02 (-0.06, 0.09)	*0.170*	0.00	L, M, H
Eye-hand dribbling coordination (n = 1091; 821; 523)	0.11 (0.06, 0.16)	-0.09 (-0.15, -0.03)	-0.13 (-0.20, -0.06)	*< 0.001*	0.02	L, M < H
Hand-foot coordination test* Boys (n = 484; 418; 249)	0.09 (0.02, 0.17)	-0.34 (-0.41, -0.26)	-0.22 (-0.32, -0.12)	*< 0.001*	0.06	L, M < H
Girls (n = 595; 342; 273)	0.38 (-0.03, 0.45)	0.10 (-0.04, 0.19)	-0.06 (-0.16, 0.03)	*< 0.001*	0.05	L < M < H
Composite coordination score (n = 1054; 734; 522)	0.15 (0.10, 0.19)	-0.06 (-0.12, -0.01)	-0.12 (-0.18, -0.06)	*< 0.001*	0.03	L, M < H

*The values are adjusted z-score means (95% CI) with a Bonferroni adjustment. "Difference" indicates post-hoc statistically significant (P<0.05) differences between pairs. The analysis of covariance (ANCOVA) were adjusted for age, gender and BMI. Effect sizes (η^2) were interpreted as 0.01 = small, 0.06 = medium and 0.14 = large (Cohen, 1988).*Gender interactions were formally tested, and significant interactions (P<0.05) were found with the 5m shuttle run, the sidestep run, the composite agility score, the dynamic balance and the hand-foot coordination. For these tests, the relationship between SES and MC was studied separately for boys and girls. No significant interaction was found for all the other tests; consequently, the results are presented for boys and girls together.*

Odds of very poor proficiency in agility, balance and coordination by gender and SES

The results of logistic models to estimate the odds of obtaining low scores in agility, balance and coordination by gender and SES are summarized in figures 2 and 3. The full results for all 10 tests are presented in supplemental material.

Girls were more likely than boys to obtain a low score at all agility tests and both coordination tests involving object-control, with odds 1.4 and 1.8 times higher than boys for the composite agility and coordination scores, respectively. However, girls were 1.4 times less likely than boys to obtain a very low score for the composite balance score (Figure 2).

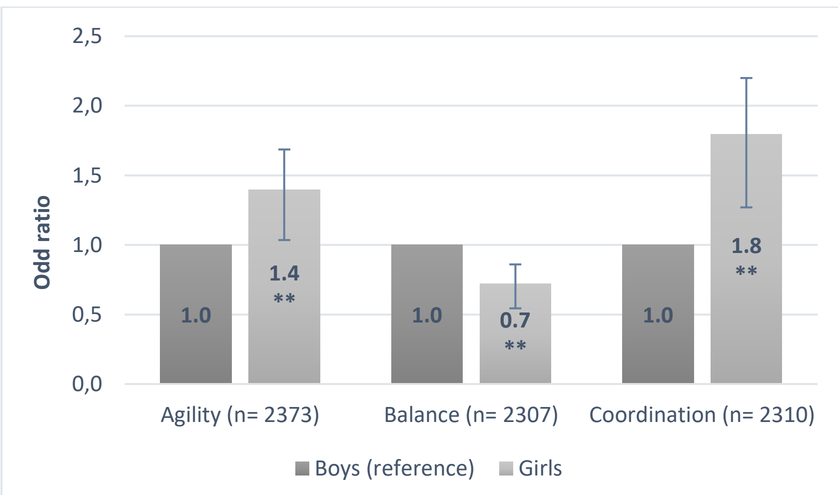

Figure 2. Odds ratio (95%CI) of low agility, balance and coordination composite scores by gender. *Low score is defined as < 20th percentile. The logistic regression models were adjusted for age, gender, SES and BMI. *: p-value <0.05 **: p-value <0.01 ***: p-value <0.001*

Children in both low and middle SES groups were more likely to obtain low scores when compared to high SES children for all agility tests, with odds 2.3 and 3.0 times higher, respectively, for the composite score for boys, and odds 2.7 and 2.1 times higher for girls (figure 3). Regarding balance, children in the low SES group were almost 3 times more likely than children in the high SES group to obtain a low composite balance score, and 4.7 times (95%CI = 3.7, 6.1) for the dynamic balance test. Finally, concerning coordination, children in both the low and middle SES groups were more likely to obtain low scores when compared to high SES children, with odds 1.9 and 1.5 times higher, respectively, for the composite score.

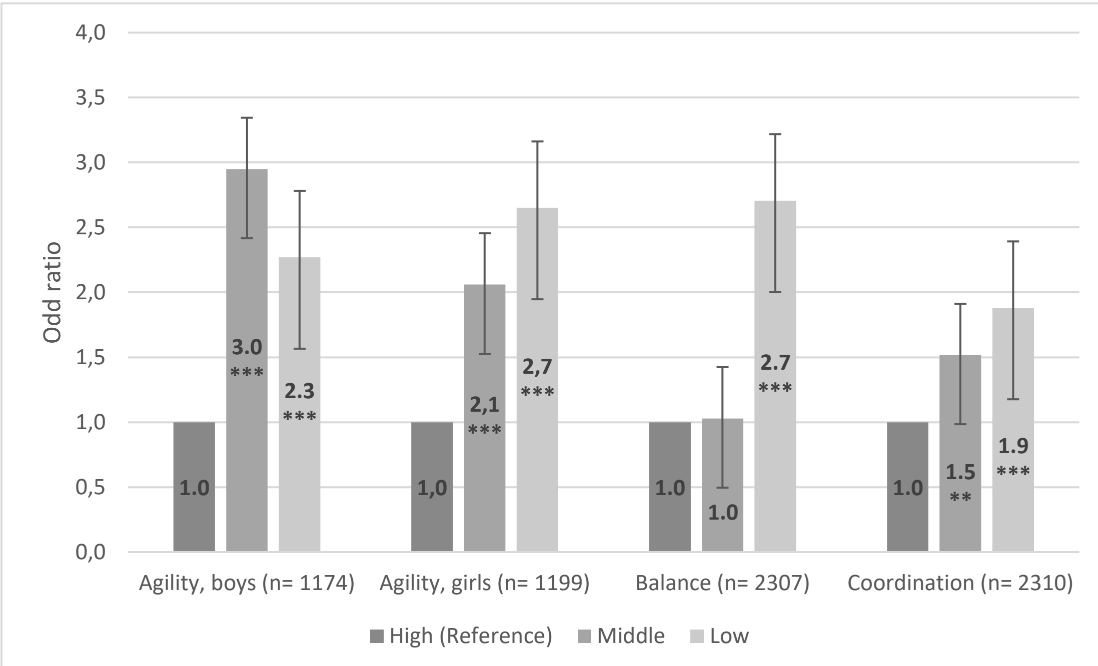

Figure 3. Odds ratio (95%CI) of low agility, balance and coordination composite scores by SES.
*Low score is defined as < 20th percentile. The logistic regression models were adjusted by age, gender, SES and BMI. Gender interactions were formally tested, and significant interactions (P<0.05) were found with the composite agility score; consequently, the relationship between SES and agility was studied separately for boys and girls. No significant interaction was found for the other composite scores; consequently, the results are presented for boys and girls together. *: p-value <0.05 **: p-value <0.01 ***: p-value <0.001*

Discussion

The aim of this study was to examine the presence (or absence) of socioeconomic and gender-based disparities in MC for Quebec children (6-12-year-olds). Overall, our results showed the presence of both socioeconomic and gender-based disparities. The main contributions of our study include the identification of a specific aspect of MC for which low SES children are more affected (dynamic balance), boy's relatively low hand foot coordination proficiency and a need for motor skills interventions in middle SES schools. In that sense, our results are useful to guide policy on where best to invest resources to improve MC among youth.

Socioeconomic disparities

Regarding socioeconomic disparities, for every aspect of MC assessed in the current study, *e.g.* agility, coordination and balance, children in the high SES group showed the highest level of proficiency, and, except for boys' agility, children in the low SES group, the lowest. Children in the low SES group were also more likely than children in the high SES group to demonstrate low proficiency for all aspects of MC. Previous studies that used product-oriented tests to assess MC in school-aged children also observed that low SES is associated with poorer MC (Morley et al., 2015; McPhillips & Jordan-Black, 2007; Ghosh et al., 2006; Ferreira et al., 2018; Vandendriessche et al, 2012; Lingham et al., 2009). Newell (1986) suggested that motor development is a dynamic process, influenced by individual, environmental and task constraints. Disadvantaged children may face barriers associated with these three types of constraints, such as less sports equipment at home, reduced parental support and fewer financial resources for organized sport, which might negatively impact their motor skills development (Barnett et al., 2016). One of the main contributions of this study is the identification of components of MC for which low SES children are more affected, dynamic balance being the most important. Balance is a perceptual-motor ability, influenced by visual, tactile-kinesthetic and vestibular stimulation (Goodway et al., 2019; Haywood and Getchell, 2020). Given the number of perceptual systems involved and the broad range of environmental and task constraints involved in performing a balance task, the interaction of many constraints might be at play in creating these disparities. Although various constraints might be at play, motor skill interventions targeting low SES children and physical education programs within low SES schools could consider incorporating more balance related equipment as well as developmentally appropriate games and activities to tailor to this specific skill (Goodway et al., 2019; Sherrill, 2004).

Another main contribution of the study regarding socioeconomic disparities relates to the MC of children in the middle SES group. Children in this group showed higher odds of low MC compared to children in high SES schools for coordination and agility. Regarding agility, they displayed the lowest level of proficiency (below children from both high and low SES schools) for two tests, and middle-SES boys presented the highest odd of obtaining a low agility score (higher than low-SES boys). Limited studies have examined the MC of children in middle SES. In the UK, Morley et al. (2015) found that children in high and middle SES significantly outperformed children in low SES for gross motor skills. More recently, Ferreira et al. (2018) studied children from high, middle and low SES in Brazil and reported that middle SES children displayed lower level of MC compared to high SES children. This latter study, as our current results, suggest that motor interventions are also needed in middle SES environments. However, none of these studies provide potential explanations for the results of middle-SES children's MC. It is possible that barriers to motor development usually associated with low SES environments, *e.g.* lack of safe places to play and be active in the community, limited activity role models for girls, limited sport equipment at home, reduced parental support and lack of access to motor skill programs (Barnett et al., 2016; Goodway & Branta, 2003; Goodway et al., 2003), are also present, partially or entirely, in middle SES environments. These factors are akin to the task and environmental constraints in Newell's model of constraints (1986). Another possible explanation might be that types of leisure PA vary between SES groups (Kantomaa et al., 2007; Wiltshire et al., 2019; Whigham et al., 2019) which may lead to differing motor skills between social class. To better understand why there might be social class differences in PA and sport practices, Wiltshire et al. (2019) and Whigham et al. (2019) fruitfully used Bourdieu's (1978) concept of habitus. The notion of habitus allows a better understanding of the preferences in practices, including sports and PA preferences, as being social, rather than the result of a natural disposition or psychological trait (Laberge & Kay, 2002). The habitus represents a system of embodied inclinations and appreciation that guide an individual's thoughts, feelings and behaviors. For Bourdieu (1984), different social conditions produce different habitus because individuals in different conditions of existence are exposed to different socio-economic relations, which generate different needs, priorities, values, lifestyles and preferences. For example, in our results, even though middle-class boys displayed the lowest level of proficiency in agility, they showed the highest proficiency at the target ball toss. This may suggest a preference for a type of PA in these environments (*e.g.* games like dodgeball or sports like baseball), which may influence the type of activities performed during free play, and, accordingly, their performance on different aspects of MC. Within Newell's model of constraints, preferences are part of the individual functional constraints (Newell, 1986). We therefore argue that SES may impact children's motor development through all three constraints of the Newell's model: task (*e.g.* differences in equipment), environmental (*e.g.* differences in access to motor skill programs) and individual (*e.g.* differences in preferences). As there is very little research on this subject, future studies could further examine how PA preferences vary between SES for both gender and their potential impact on motor development.

Gender-based disparities

Regarding gender-based differences, girls were more likely than boys to demonstrate low level of proficiency for agility and hand-eye coordination (dribble and target ball toss) while boys were more likely than girls to exhibit low MC for hand-foot coordination. Previous research also observed that boys are more likely than girls to master object-control skills (Morley et al., 2015; Wrotniak et al., 2006) and have better agility than girls (Wrotniak et al., 2006). However, to our knowledge, boys' poor motor proficiency at hand-foot coordination have not been observed before. A possible explanation for this absence is that hand-foot coordination is not part of the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), a commonly used product-oriented test battery to assess motor proficiency in children (Wrotniak et al., 2006; Burton & Miller, 1998). As for the gender-based difference observed in our results, given that pre-pubescent males and females are biologically similar, it is likely that the observed disparities are due to sociocultural factors (Garcia, 1994; Thomas & French, 1985). Object-control skills are required for ball sports commonly played by boys (Pelligrini et al., 2002) while hand-foot coordination might be potentially associated with activities such as dance and gymnastics in which girls are usually more engaged (Okely & Booth., 2004; Garcia, 1994). These gendered preferences in leisure PA might be partially explained as embodied gendered inclinations and appreciations, in accordance with Bourdieu's concept of habitus (Laberge, 1995). Under Newell's model of constraints, they would be part of the individual functional constraints, which influence motor development in interaction with task, environmental and other individual constraints.

We believe our findings could have important implication for interventions aiming at reducing social inequalities in health. We observed a large effect of SES on dynamic balance, and medium effects on hand-foot coordination as well as on two agility tests. Gender also showed a medium effect for the target ball toss. Even the small effect sizes observed might be meaningful and could have practical implications. For example, the difference in average hand-eye dribbling coordination adjusted raw scores is 35 dribbles for a child in low SES vs. 38 dribbles for a child in high SES, which represents a 8% difference proportionally to the average of the population studied (37 dribbles).

As poor MC is likely a barrier to subsequent PA patterns (Stodden et al., 2008), inequalities in children's MC might contribute to inequalities in PA practices, such as the gender gap observed in PA during adolescence (Hallal et al., 2012) and the social gradient in leisure PA practices observed in adulthood (O'Donoughue et al., 2018). Our findings revealed that children in low SES schools presented higher needs than children in both middle and high SES schools, and children in middle SES schools showed higher needs than those in high SES schools. Therefore, to level up social inequalities in MC, resources invested in school-based motor intervention and PA programs should be proportionate to the school SES. Additionally, higher object-control proficiency for boys might be a concern as there is growing evidence that this skill is a strong predictor of PA and fitness behavior during adolescence (Barnett et al., 2008; Cohen et al., 2014; Vlahov et al., 2014).

Developmentally appropriate motor skill interventions are an effective strategy to improve MC in children attending primary school (Morgan et al., 2013). Furthermore, given that MC may be linked to academic performance, it has been suggested that school policymakers should consider prioritizing, from school entry, students' acquisition of motor skills (de Waal et al., 2020; MacDonald et al., 2018). It is therefore important that our findings are translated into practice. High-quality physical education programs, as well as community sport provision, might allow children in low and middle SES schools to develop their different motor skills by offering opportunities of varied movement experiences. For example, developmentally appropriate activities targeting agility, coordination and especially dynamic balance in low SES environment could be added to physical education classes or existing motor interventions, while improving agility and hand-foot coordination through developmentally appropriate activities should be a concern in middle SES environment. Developing hand-foot coordination for boys within all SES should also be targeted. Finally, since games are essential to the development of object-control skills, they should be organized in a way that encourages all children, boys and girls, to engage with the activity.

Limitations

This study has several limitations. It was cross-sectional and cannot establish a causal effect. The SES indicator used in the study was a school-level SES, therefore it cannot reflect the variability in children's family background within schools, for which we did not have information. Furthermore, we did not have information about PA levels and ethnicity, two important confounders. Concerning PA levels, the expectation is that improving MC will facilitate higher levels of PA engagement. Measuring PA levels was also beyond the scope of this study and should be considered in future studies, as well as preferences in types of PA. Future studies should also consider documenting ethnicity. All children in our sample were not white, and ethnicity is a potential confounder when examining SES disparities. Finally, we had a relatively low number of schools even though we had a large, representative sample of schoolchildren across a broad age range. Future studies should include a larger amount of schools, which would allow the consideration of potential additional factors influencing children's MC in the school setting, *e.g.* number and type of sport facilities as well as geographical location. In the current study, all low SES schools were in an urban environment.

Conclusion

This study examined socioeconomic and gender-based disparities in agility, balance and coordination amongst Quebec children (6-12-year-olds) using product-oriented tests. Overall, boys were more likely than girls to demonstrate low MC for hand-foot coordination while girls showed lower levels of proficiency for agility and skills involving object-control. Children in low SES schools were more likely than children in high SES schools to demonstrate low levels of MC in agility, balance and coordination. The largest gap was observed for dynamic balance. Children in middle SES schools showed higher odds of low MC compared to children in high SES schools for agility and coordination. The use of Newell's model of constraints (1986) and Bourdieu's concept of habitus (1978; 1984) were useful to consider potential explanations of the profound causes of these disparities. To level up inequalities in MC, resources invested in school-level PA programs could be proportionate to the school SES and physical education classes should include varied developmentally appropriate activities targeting, from school entry, students' acquisition of all motor skills. Additionally, future research could benefit from using theoretical or sociological frameworks to better understand MC disparities and inform the development of efficient school-based interventions.

Disclosure of interest

The authors report no conflict of interest

Supplemental material

File 1. Odds of low motor proficiency for 10 tests assessing agility, balance and coordination by gender and SES

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