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Full Length Article

The mediating role of cognitive ability on the relationship between motor proficiency and early academic achievement in children☆

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A R T I C L E I N F O

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A B S T R A C T

The aim of this study was to examine the relationship between motor proficiency and academic achievement in 7 years-old children. A mediating model in which the relation between motor proficiency and academic achievement is mediated by cognitive ability was tested. Participants included 152 children from the longitudinal study *Jeunes enfants et leurs milieux de vie (Young Children and their Environments)*. Motor proficiency was evaluated with the Bruininks-Oseretsky Test of Motor Proficiency (BOT2), cognitive ability with the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) and academic achievement with the Wechsler Individual Achievement Test II (WIAT II). Results showed that motor proficiency, cognitive ability and academic achievement were positively correlated with each other. A structural equation modeling analysis revealed that motor proficiency had a positive effect on academic achievement through an indirect path via cognitive ability. These results highlight the fundamental importance of motor skills in children's academic achievement in early school years.

1. Introduction

Research on the development of motor behavior has shown that body actions play a critical role in children's cognition (Needham & Libertus, 2011). Since Piaget's theory (1954), according to which infants, toddlers and children construct their understanding of the physical world through their own actions, numerous evidence have shown that movements contribute to children perception, provide them the means to acquire knowledge and to interact with people (Adolph & Franchak, 2017). During development, the child's repertoire of coordinated and skillful movements broadens and enriches his interaction with the world. For example, control of the sitting posture facilitates bimanual object exploration, such as fingering, transferring and rotating, which in turn facilitates learning about three-dimensionality of objects (Soska, Adolph, & Johnson, 2010). As proposed by Adolph and Franchak (2017), improved

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motor proficiency provides new or enhanced opportunities for learning and doing.

In recent years, there has been a renewed interest on the role of motor proficiency in children's academic achievement (Davies, Janus, Duku, & Gaskin, 2016; Diamond, 2010). Several studies showed that motor proficiency was related to academic achievement (Da Silva Pacheco, Gabbard, Kittel Ries, & Godoy Bobbio, 2016; Ericsson & Karlsson, 2014; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010). For example, it has been found that children with motor coordination disorders or motor insufficiency had a higher probability of low academic achievement in comparison with children without motor difficulties (Lopes, Santos, Pereira, & Lopes, 2013; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011). At the opposite, a better motor performance during infancy or early childhood has been related to better academic achievement later in school. For instance, an evaluation of data sets from three longitudinal studies found that fine motor skills in kindergarten children were a strong predictor of later reading and math achievement in fifth grade (Grissmer et al., 2010). In a longitudinal study lasting 14 years and beginning when participants were infants, Bornstein, Hahn, and Suwalsky (2013) showed that infants who had better motor control and who explored their environment more actively at 5 months obtained higher cognitive scores at 4 and 10 years, and performed also higher on academic achievement tests at 10 and 14 years. There were indirect effects of motor maturity and exploratory activity at 5 months on 14-year academic achievement through cognitive abilities at 4 and 10 years. As proposed by Bornstein et al. (2013), motor-exploratory competence appeared to serve as a foundation for cognitive functioning in childhood and academic achievement in adolescence.

The influence of motor proficiency on academic achievement does not seem to be limited to long term effects in adolescence but also concerns short-term effects that can be visible as children enter in formal schooling (Kulp, 1999; Pitchford, Papini, Outhwaite, & Gulliford, 2016; Son & Meisels, 2006). In a cross sectional study, Pienaar, Barhorst, and Twisk (2013) observed that visuo motor integration, motor coordination and motor proficiency were related to academic achievement in South African first graders. Recently, Kim, Duran, Cameron, and Grissmer (2017) examined the relationships between three processes (visuo motor integration, attention, and fine motor coordination) and mathematics skills in 5-year-olds (kindergarteners) and 6-year-olds (first graders) that were followed over the course of 2 school years. Fine motor coordination measured when children were at the beginning of kindergarten, contributed significantly to visuo motor integration at the end of kindergarten which was, in turn related to mathematics skills at the end of first grade. These findings suggest that motor proficiency contributes to academic achievement as soon as children begin formal reading and maths learning.

However, despite the above evidence, the nature of the relationship between motor proficiency and early academic achievement is still unclear and the precise mechanisms that link them are debated (Cameron, Cottone, Murrah, & Grissmer, 2016). In most of the studies, the strength of the relationship between motor proficiency and academic achievement has been evaluated with correlational methods but these methods do not indicate if the relationship is direct or indirect or mediated by others factors like cognitive abilities (Cameron et al., 2016; Libertus & Hauf, 2017). Therefore, the main objective of the current study was to obtain a deeper understanding of the relationship between motor proficiency and academic achievement in children. A causal model was tested based on the assumption that motor proficiency influence academic achievement possibly by influencing cognitive ability (Bornstein et al., 2013; Rigoli, Piek, Kane, & Oosterlaan, 2012).

Motor proficiency is a broad concept that refers to the ability to perform various motor skills in a consistent and proficient manner (Bardid, Rudd, Lenoir, Polman, & Barnett, 2015; Rudd et al., 2015). As specified by Adolph and Franchak (2017), it depends on generating, controlling, and exploiting physical forces but also on core psychological functions for adaptive control of movement for goal directed actions. From the actual literature, it is difficult to disentangle which aspects of motor proficiency are more or less related to cognitive abilities at school age. Libertus and Hauf (2017) proposed that connections between motor experiences and cognitive development may exist beyond infancy but are limited to specific domains of cognition, such as spatial cognition for example. In a review aimed to give an overview of studies providing evidence for a relationship between motor and cognitive skills in 4–16 year old typically developing children, van der Fels et al. (2015) found that some categories of motor skills like fine motor skills, bilateral motor coordination and timed performance were more strongly related to cognitive skills like fluid intelligence, short term memory, visual processing compared to balance and agility skills. In contrast, Frick and Möhring (2016) found that balance skills in 6 year-olds were related with spatial and reasoning skills in mathematics one year later. In a large sample of 423 children aged between 8 and 10 years, Geertsen et al. (2016) found that specific motor skills were associated with different cognitive functions. More specifically, visuo motor tracking capacity (fine motor skills) and body coordination (gross motor skills) were associated with spatial working memory, wordlist memory, sustained attention, reaction time, the ability to learn paired associates, and performance in mathematics and reading.

Furthermore, in most of these studies, the level of children's physical activity was not considered while positive relations between physical activity levels and specific cognitive functions such as working memory and selective attention have been shown (Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014; Geertsen et al. 2016). There is also evidence that motor proficiency and physical activity levels are related (Cliff, Okely, Smith, & McKeen, 2009). For example, preschool children with better motor proficiency tend to be engaged more frequently in physical activity (O'Neill et al., 2014) and to have a better physical fitness (Sigmundsson & Haga, 2016). Cognitive abilities in children might be influenced by this combined effect of motor proficiency and physical fitness.

Therefore, in the current study, instead of considering a unique cognitive function as potential mediator of the relationship between motor proficiency and academic achievement, it was decided to examine the influence of three functions taken from the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) (Wechsler, 2003) that are perceptual reasoning, working memory and processing speed. These functions were chosen because they have been previously related to motor skills (Piek et al., 2004; Wechsler, 2004).

Thus, in order to examine the relationship between motor proficiency and academic achievement in first graders and verify if this relationship is mediated by cognitive ability, a mediating model was constructed and tested (Fig. 1). To construct this model, it was

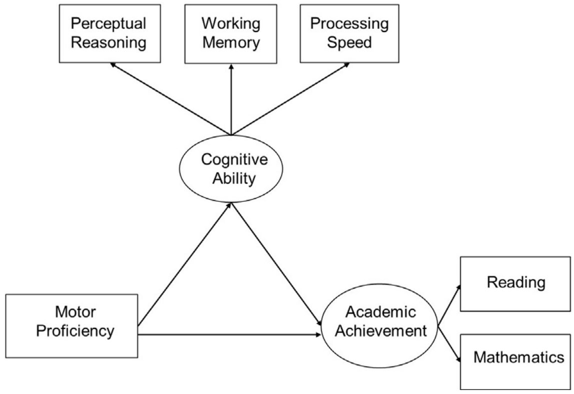

Fig. 1. Diagrammatic representation of the proposed mediating model.

hypothesized that motor proficiency (as a composite measure of fine motor control, manual coordination, body coordination, strength and agility) would have a positive effect on academic achievement (as measured by reading and mathematics skills). It was also hypothesized that motor proficiency would have a positive direct effect on cognitive ability (as measured by perceptual reasoning, working memory and processing speed) through a direct path; that cognitive ability would have a positive direct effect on academic achievement, and motor proficiency would have a positive effect on academic achievement through an indirect path with cognitive ability mediating this relation.

2. Method

2.1. Participants

Participants of the current study came from a sample of the longitudinal research project Jeune enfant et ses milieux de vie (*Young Children and their Environments*) conducted in Québec (Canada) following children at the ages of 4, 5 and 7 years (Bigras, Lemay, Bouchard, & Eryasa, 2016). The recruitment of the original sample took place between October 2009 and September 2010. Letters were sent to 4575 families from a list provided by the *Régie de l'assurance maladie du Québec (Québec Health Insurance)* and phone contact was established with 3000 families. Of these, 1425 children met the participation criteria with regards to childcare attendance (home-based or center-based with > 20 h per week), health (Apgar > 7, weight > 2500 g at birth and pregnancy over 37 weeks), mother tongue (French), and typical overall development. At the end, 255 families agreed to participate and this study concerns 152 children (55% girls) who were followed from the age of 4 until 7-years-old. Eighty percent of parents reported family income conforming to the medium category, according to Statistics Canada (Les lignes de faible revenu, 2010 à 2011, Statistics Canada). Eighty-eight percent of children were from two-adults families and 73% of mothers had completed a university degree. This study was approved by the ethics committee of the University of Quebec in Montreal and parents provided written consent to participate.

2.2. Procedures

Measures were taken during home visits at the end of the school year (April–June) when children were 7-years-old. During these visits, trained evaluators assessed children motor proficiency, cognitive ability and academic achievement with validated tests that were respectively the *Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition* (BOT-2 SF) (Bruininks & Bruininks, 2005); the *Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV) (Wechsler, 2003) and the *Wechsler Individual Achievement Test II* (WIAT-II) (Wechsler, 2005). Evaluators were research assistants that were trained by two psychologists. For the WISC-IV and the WIAT-II, they received a theoretical training with exercises (including a video demonstration) and for the BOT-II they received a theoretical and practical training. Then, for each test, the psychologist accompanied each research assistant for her first two assessments followed by feedback. In both of these evaluations, an 85% interrater agreement was sought. If the research assistant did not reach an 85% agreement score for two consecutive assessments, she was accompanied by the psychologist until she reached this threshold.

Two visits were required to administer the three tests. The WISC-IV was administered at the first visit. The WIAT-II and BOT-II were administered at the second visit in the same order. In general, the WISC-IV administration lasted for approximately 45 min-1 h and a pause was proposed in the middle of the test, or if signs of fatigue were present in the child. The selected subtests of the WIAT-II lasted for 45 min-1 h. Then a pause was taken, followed by the BOT-II administration that lasted for 20 min.

A second evaluator was present for 15% of the visits and interrater reliability was evaluated for each test.

2.3. Measures

2.3.1. Motor proficiency

Motor proficiency was assessed using the short form of the *Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition* (BOT-2 SF) (Bruininks & Bruininks, 2005). This test is a norm-referenced standardized motor assessment for participants aged between 4 and 21 years-old. It was selected for its suitability to assess children with and without motor problems and because it has been shown to have strong test-retest reliability (Yoon, Scott, & Hill, 2006). The BOT-2 SF includes 12 items, which are categorised into four composite motor domains each containing two motor sub-tests i.e. 1. Fine motor control: fine motor precision (drawing lines through paths, folding paper); fine motor integration (copying a square, copying a star); 2. Manual coordination: manual dexterity (transferring pennies); upper-limb coordination (dropping and catching a ball, dribbling a ball); 3. Body coordination: bilateral coordination (jumping in place, tapping feet and fingers); balance (walking forward on a line); 4. Strength and agility: running speed and agility (one-legged stationary hop); and strength (push-ups). The strength subtest had two options for performing the «push up» test and for this study the «knee push-up» option was chosen because it was easier for children. Children's performance on each of the 12 items provided raw scores, which were then converted to corresponding point scores. The scores were converted to standardized scores, adjusted for age based on US normative data (Bruininks & Bruininks, 2005). Standard scores were classified as > 70 = well above average; 60–69 = above average; 41–59 = average; 31–40 = below average, and < 30 = well below average according to the descriptive categories provided by the BOT-2. The scores obtained with the BOT-2 have excellent psychometric properties ($\alpha = 0.92$) (Wuang & Su, 2009). Interrater reliability was calculated at 84% for this study.

2.3.2. Cognitive ability

Cognitive ability was assessed with *The Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV) (Wechsler, 2003), that is an individually administrated instrument for the assessment of children's measures cognitive ability for children aged 6–16 years. The WISC-IV contains 15 subtests divided into 10 scores and 5 supplemental subtests that provide four composites scores with a mean of 100 and a standard deviation of 15: verbal comprehension, perceptual reasoning, working memory and processing speed. In the present study, three of these composites were retained: perceptual reasoning assessing visual information processing and non-verbal reasoning, working memory evaluating elements regarding to attention and concentration and processing speed measuring the speed of mental processing in given tasks. The verbal comprehension composite was not used because the relationship between motor proficiency with verbal knowledge and understanding obtained through both informal and formal education is still debated (Libertus & Hauf, 2017). The WISC-IV has excellent internal consistency ($\alpha = 0.80$–0.90), test-retest reliability ($r = 0.80$–0.90), criterion validity, and construct validity (Wechsler, 2003). Interrater reliability was calculated at 97.4% for this study.

2.3.3. Academic achievement

Academic achievement was assessed with *The Wechsler Individual Achievement Test II* (WIAT-II) (Wechsler, 2005) that is an individually administered test of achievement in individuals aged between 4 and 29 years-old. The WIAT-II is composed of 9 subtests, assessing academic skills in the domains of reading, writing, mathematics and oral language (mean of 100, standard deviation of 15). In the present study, two of these composites were retained: reading and mathematics. The WIAT-II has excellent internal consistency ($\alpha > 0.90$), test-retest reliability ($r > 0.80$) and has been empirically linked with the WISC-IV in its validation (Wechsler, 2005). Interrater reliability was calculated at 96.6% for this study.

2.4. Analyses

For motor proficiency, the total score (max = 75) obtained with the BOT-2 SF was converted to standard scores for each child, using the norms provided (Bruininks & Bruininks, 2005).

The analysis of the relationships was conducted in two steps. First, correlations between BOT-2 SF, WISC-IV and WIAT-II scores were calculated in SPSS. Then, structural equation modeling, with maximum likehood estimation, was used to determine the degree to which cognitive ability mediate the relationship between motor proficiency and academic achievement. The analysis was conducted with MPlus (Version 7.31; Muthén & Muthén, 1998). The assumption of normality was met.

3. Results

3.1. Descriptive statistics and correlations

The means, standard deviations, and ranges for the variables measuring motor proficiency, cognitive ability and academic achievement are presented in Table 1.

The distribution of BOT-2 SF variables was verified and did not deviate substantially from the normal distribution. *T* tests were conducted to examine gender effects and there was no difference between boys and girls for BOT-2 SF scores ($F = 1.54$; $p = .217$). Consequently, results from boys and girls were merged in the same group for the analysis. The mean BOT-2 SF standard score was 49.04 (± 7.19) classifying the participants as having average motor skills. On an individual level, most of the participants were classified in this category.

According to the mean WISC-IV and WIAT-II scores, participants were in the average category for cognitive ability and academic achievement.

Table 1
Means, standard deviations (SD), and ranges (Minimum-Maximum) of scores.

	Mean	SD	Range
Motor proficiency	49.04	7.19	27–76
Cognitive ability			
Perceptual Reasoning	105.97	13.58	70–134
Working Memory	103.98	14.58	68–139
Processing Speed	102.96	12.76	59–136
Academic Achievement			
Reading	115.45	18.51	64–157
Mathematics	104.44	12.02	72–135

Correlations are presented in Table 2. As shown, 14 out of a total of 15 correlations reached statistical significance.

3.2. Structural equation modeling

Fit indices providing an indication of the overall fit of the model can be found in Table 3. The fit statistics for this model suggest an acceptable fit to the data: $\chi 2(7) = 11.453$; $p = .120$; a non-significant $\chi 2$ value ($p \geq 0.05$; Kline, 2005); the Comparative Fit Index (CFI) is > 0.9 (Kline, 2005); and the Standardized Root Mean Square Residual (SRMR) is < 0.10 (Kline, 2005). The Root Square Mean Square Error of Approximation (RMSEA) for the saturated and the mediator models were above the desired 0.05 level but below the 0.08 level indicating an acceptable data-model fit.

In both the saturated model and the mediator models, illustrated in Figs. 2 and 3 respectively, the indirect path (Motor proficiency → Cognitive ability → Academic achievement) was significant. The standardized effects were respectively 0.327 ($p = .006$) IC 95% bootstrap [0.180, 1.194] and 0.342 ($p < .001$) IC 95% bootstrap [0.279, 1.064]. This indirect path indicates that motor proficiency had an indirect effect on academic achievement through cognitive ability. Among the functions included in cognitive ability, working memory was the most important indicator (0.744) followed by perceptual reasoning (0.671). This indirect effect was shared on reading and mathematics.

In the saturated model, the direct path (Motor proficiency → Academic achievement) was nonsignificant. The standardized effect was 0.027 ($p = .780$) IC 95% bootstrap [−0.355, 0.401].

4. Discussion

The aim of this study was to examine the relationship between motor proficiency and academic achievement in first grade children. The results showed that although there were positive correlations between motor proficiency and academic achievement, the relation between both was not direct but could be best understood through an indirect impact via cognitive ability. These findings support a mediating model in which the relation between motor proficiency and academic achievement is mediated by cognitive ability, and in which working memory and perceptual reasoning processes have the most important mediating influence. These results are in agreement with previous mediating models in which motor coordination influenced indirectly academic achievement through working memory processes in adolescents (Rigoli et al., 2012) or in which fine motor coordination influenced indirectly mathematics skills through perceptual processes in 5 and 6 years old children (Kim et al., 2017).

In the current study, motor proficiency was a composite measure of fine motor precision and integration, manual dexterity, upper-limb coordination, bilateral coordination, balance, running speed, agility and strength (Bruininks & Bruininks, 2005). Therefore, the results indicate that motor proficiency as a whole had a positive effect on academic achievement in 7 years-old children. This finding corroborates those from Da Silva Pacheco et al. (2016) who found a significant relationship between motor performance, measured with the long version of the BOT2 and academic achievement in 8–11 year-olds. Interestingly, in a deeper analysis, these authors showed that among the different components of motor proficiency, bilateral coordination accounted for the highest impact on academic achievement (Da Silva Pacheco et al., 2016). This finding raises the question of the specificity of the motor effects. It has

Table 2
Correlation matrix.

	Motor Proficiency	Perceptual Reasoning	Working Memory	Processing Speed	Reading	Mathematics
Motor Proficiency	1.00					
Perceptual Reasoning	0.12	1.00				
Working Memory	0.30**	0.51**	1.00			
Processing Speed	0.24**	0.33**	0.33**	1.00		
Reading	0.28**	0.42**	0.54**	0.33**	1.00	
Mathematics	0.21*	0.50**	0.46**	0.28**	0.51**	1.00

Note: *$p < .05$; **$p < .01$.

Table 3
Fit indices for saturated and mediator models.

	χ2	p value	RMSEA	CFI	SRMR
Saturated model	11.453	.120	0.065	0.978	0.033
Mediator model	11.544	.173	0.054	0.983	0.033

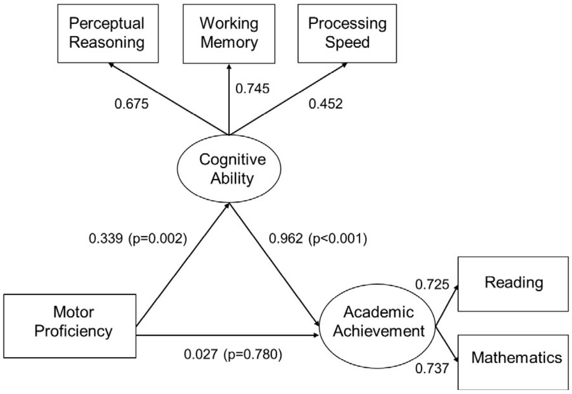

Fig. 2. Saturated model.

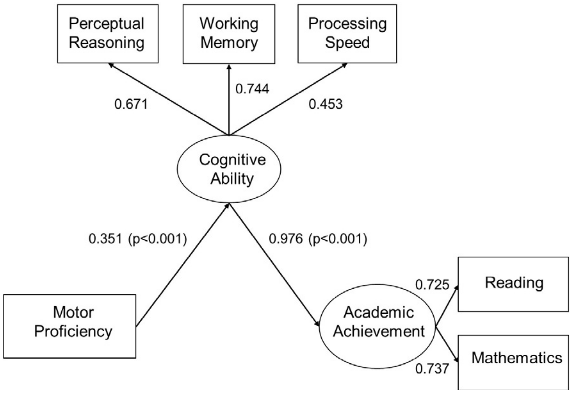

Fig. 3. Mediator model.

been argued that motor skills that influence positively cognitive abilities and school achievement must have some motor specificity (Da Silva Pacheco et al., 2016). For example, Fernandes et al. (2016) found that more rapid hand-eye coordination was associated with higher academic achievement and higher scores in perceptual reasoning and processing speed in 8–14 year-olds. In contrast, in the same study, agility tested with a «running back and forth» test was not associated with academic achievement and cognitive skills. However, at the opposite, it has also been proposed that balance skills would help children to explore their environment and to build a more solid understanding of spatial relationships necessary for mathematics skills (Frick & Möhring, 2016). Thus, the question whether some motor skills would have a stronger influence than others on academic achievement remains a complex question that needs further research.

The current mediating model suggests that motor proficiency influenced children's academic achievement through an impact on cognitive ability. Several studies have shown that motor proficiency can have a positive effect on cognitive ability (Geertsen et al., 2016). However, as proposed by Wassenberg et al. (2005), the tasks used to assess both cognitive ability and motor proficiency can influence their relationship. For example, Wassenberg et al. (2005) found association between cognitive and motor functions in 5- to 6-year-old children when cognitive functions included motor skills such as drawing or pointing but did not find association when cognitive functions were devoid of motor skills such as verbal recalling of digits or naming. In the present study, some components of the WISC-IV and the BOT2 shared some similarities. For example, in the cubes task for perceptual reasoning, participants had to manipulate cubes to produce geometric models whereas in the BOT2 children had to manipulate pennies to transfer them from one box to the other. In both situations, the main motor behavior was a manipulation with spatial precision. For processing speed, children had to draw different shapes they had perceived whereas in the BOT2 participants had to draw a square or a star. Again, in both cases, the required motor behavior was handwriting. These similarities may have influenced the relation between motor proficiency and cognitive ability but can't explain the entire relationship because several other components were distinct in both tests as bilateral coordination.

As proposed by Hayes (2015), even if a mediation analysis is not a formal test of causality, it remains that a mediation is a causal process. A simple mediation model reflects a causal sequence in which X affects Y indirectly through mediator variable M. In this model, X is postulated to effect M, and this effect then propagates causally to Y. This indirect effect represents the mechanism by which X transmits it effect on Y (Hayes & Preacher, 2014). As such, the present findings indicate that motor proficiency had a positive effect on academic achievement in first graders, namely on maths and reading achievement and that this effect can be explained by a positive influence on working memory and perceptual processes.

These results are in agreement with theories emphasizing the critical role of body actions in cognition (Bushnell & Boudreau, 1993; Kiefer & Trumpp, 2012). During child development, learning and cognition are constrained and facilitated by the child's changing motor repertoire (Needham & Libertus, 2011). In some cases, controlling movements is a constraint for the child. For example, experiences in which reaching for objects was supported by Velcro-palmed mittens in infants revealed an increase interest in object and an earlier capacity to interpret other people's reaches as goal-directed compared to infants who didn't receive such mittens (Needham, Barrett, & Peterman, 2002). In other cases, a better control of movement can facilitate cognition and the present results are in agreement with this facilitating role. As proposed by Adolph and Franchak (2017), through their motor experiences, young children learned how their body moves in various postures and on various surfaces. They learn to learn. In school-aged children, controlled actions facilitate the perception of meaningful information from the environment such as spatial cues or variations of written lines like in handwriting (Nonaka, 2017).

In sum, the results of this study confirms the idea that child's motor skills are among the necessary abilities for academic achievement (Davies et al., 2016; Diamond, 2010; Pagani, Fitzpatrick, Archambault, & Janosz, 2010) and must receive complete attention from educators and teachers during the early school years. Sufficient effort must be made to support children in their motor development in first grade but also before their formal school entry. For instance, children who are less prepared or who have motor difficulties in kindergarten must be supported to develop their motor proficiency in order to be prepared for the first grade transition (Pagani & Messier, 2012). While it may be tempting in early intervention to focus on reading and maths skills to ensure academic achievement, our results highlight the relevance of targeting both motor and cognitive abilities. As such, the many factors that have a profound influence on the child's motor proficiency might be considered. These factors are for example the parental support in the child's immediate surroundings (Barnett, Hinkley, Okely, & Salmon, 2013); the opportunities for play, sport and other forms of motor performance practice (Ericsson & Karlsson, 2014); the quality of educative practices in daycares and at school (Pate et al., 2016; Saunders et al., 2017; Soini et al., 2016). A few studies have demonstrated that specific motor interventions can help children to improve their motor skills, improving at the same time their cognitive abilities. For example, Alesi, Bianco, Luppina, Palma, and Pepi (2016) showed that after a 6 months football exercise program, 8 years children improved their coordinative skills but also their visuo spatial working memory, their attention, their inhibition and their planning abilities. Westendorp et al. (2014) showed that a 4 months ball skill intervention was an effective method to improve the ball skills of children with learning disorders. Moreover, improvement in ball skills performance was associated with improvement in problem solving. Thus, the quality and the quantity of interventions are crucial to support children's motor proficiency and cognitive abilities.

5. Strengths and limitations

This study had some limitations. The global measure of the BOT2 has to be considered with caution. The composite motor score gives a measure of overall motor proficiency that fails to discriminate between individual profiles of motor abilities. For example, an individual who has scored moderately across the board cannot be distinguished from an individual who has done poorly in some areas but especially well in others (MacCobb, Greene, Nugent, & O'Mahony, 2005). Given that the model was mostly tested with children coming from medium socioeconomic category, the results apply only to this category and further research should be conducted to assess more deeply the effects of the socioeconomic status on the relationship between motor proficiency and academic achievement. Nevertheless, the strength of this study was to use structural equation modeling that gives, in a causal framework, a more complete picture of the complexity of the relationship between motor proficiency and academic achievement in 7 years-old children.

6. Conclusion

The results of this study highlight the important role of motor proficiency in children academic achievement in first grade. By influencing positively cognitive functions such as working memory and reasoning processes, motor proficiency contributed to math and reading performance. Given the importance of first school years, these results show that children's motor proficiency must be strongly supported during these early years.

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