*Original Research Article*

# Associations Between Sedentary Behavior and Motor Coordination in Children

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**Objectives:** This study was conducted to evaluate the relationship between objectively measured sedentary behavior (SB) and motor coordination (MC) in Portuguese children, accounting for physical activity (PA), accelerometer wear time, waist-to-height ratio, and mother's education level.

**Methods:** A cross-sectional school-based study was conducted on 213 children (110 girls and 103 boys) aged 9–10 in the north of Portugal during the spring of 2010. Accelerometers were used to obtain detailed objective information about daily PA and SB over five consecutive days. MC was measured with a body coordination test (Körperkoordination Test für Kinder). Waist and height were measured by standardized protocols and the waist-to-height ratio (WHtR) was calculated. A questionnaire was used to assess mothers' educational levels. Receiver-operating characteristic (ROC) and logistic regressions were used.

**Results:** ROC analysis showed that sedentary time significantly discriminated between children with low MC and high MC, with a best trade off between sensitivity and specificity being achieved at $\geq$77.29% and $\geq$76.48% for girls and boys, respectively ($P < 0.05$ for both). In both genders, the low sedentary group had significantly higher odds of having good MC than the higher sedentary group, independent of PA, accelerometer wear time, WHtR, and mother's education level ($P < 0.05$ for both).

**Conclusions:** Our findings suggested that PA levels *per se* may not overcome the deleterious influence of high levels of SB on MC. Our data stress the importance of discouraging SB among children to improve MC. Am. J. Hum. Biol. 24:746–752, 2012. 

The importance of promoting active lifestyles from a young age is widely recognized and the health benefits of regular physical activity (PA) are extensively acknowledged (Strong et al., 2005). The incorporation of PA into daily life and the achievement of recommended health-related levels of PA are major public health challenges. Many children and adolescents do not meet the current PA recommendations (Jago et al., 2005; Riddoch et al., 2007; Strong et al., 2005). Moreover, previous research has shown a decline in PA from childhood to adolescence (Goran et al., 1998; Lopes et al., 2007), with the end of elementary school (9–11 years old) being a critical period of change (Goran et al., 1998; Nader et al., 2008).

The importance of promoting the development of motor coordination (MC) at younger ages relies on the evidence that there are current and future benefits associated with the acquisition and the maintenance of motor proficiency (Lubans et al., 2010). It has been suggested that an appropriate acquisition of gross MC contributes to children's physical, cognitive, and social development (Lopes et al., 2011b; Payne and Isaacs, 1995). A proper MC level is essential for strong general development, as well as for health, psychosocial development, and well-being (Haga, 2008; Piek et al., 2006). Although a rudimentary form of movement pattern may naturally be develop, a mature form of motor proficiency is more likely to be achieved with appropriate practice, encouragement, feedback, and instruction (Gallahue and Ozmun, 2006; Logan et al., 2011). Likewise, these skills need to be learned, practiced, and reinforced through developmentally appropriate movement programs (Logan et al., 2011). The early childhood years are a critical time for the development of these skills, which are considered the building blocks of more complex movements (Clark and Metcalfe, 2002).

Lately, there has been increasing interest in the relationships between MC and health-related behaviors and outcomes. Indeed, a recent review (Lubans et al., 2010) of the relationship between MC and health benefits in children and adolescents indicated that MC levels are inversely correlated with weight status, but positively correlated with PA, cardiorespiratory fitness, and perceived physical competence in cross-sectional and longitudinal data. In another systematic review of the literature conducted to synthesize the recent available data on fitness and PA in children with developmental coordination disorder (a neurodevelopmental condition characterized by poor motor proficiency that interferes with a child's activities of daily living). Body composition, cardiorespiratory fitness, muscle strength and endurance, anaerobic capacity, power, and PA have all been negatively associated, to various degrees, with poor motor proficiency (Rivilis et al., 2011).

Current efforts to increase youth's PA have had limited success, with effective changes achieved only in smaller

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subgroups or in the short term (Kipping et al., 2008; van Sluijs et al., 2007). One reason for this relative lack of success could be that most of the public health efforts to promote active lifestyles have focused mainly on PA and have paid little attention to the growing evidence that indicates that sedentary behavior (SB) is a distinct health-related behavior (Tremblay et al., 2011b). Additionally, neither interventions in PA or SB target improvements in MC (Salmon et al., 2005), and indicators of MC have not been systematically included in studies that consider correlates of PA (Lopes et al., 2011a) or SB.

SB is defined as any activity that does not increase energy expenditure substantially above the resting level (less than 1.5 METs), such as sleeping, sitting, lying down, or watching television, or other forms of screen-based entertainment (Pate et al., 2008). In light of recent research, lack of PA is only one part of the public health problem, because various types of SB may operate through different behavioral mechanisms (Owen et al., 2000), have different determinants (Gordon-Larsen et al., 2000), track differentially (Gordon-Larsen et al., 2004), and have a distinct range of potentially adverse health consequences (Tremblay et al., 2007) independently of PA. Additionally, SB shows moderate stability during childhood and adolescence (Janz et al., 2005).

In a recent review, the relationship between MC and SB was classified as uncertain due to an inadequate number of studies (only two were available). The review of associations (Lubans et al., 2010) between MC and aspects of physical and psychological attributes provides indirect evidence that MC may be an important antecedent/consequent mechanism for promoting healthier lifestyle-related behaviors (Lubans et al., 2010). Most studies assume that MC is the cause rather than the consequence of PA, although it is also reasonable to expect that greater PA opportunities might also provide the context to improve MC (Cliff et al., 2009). Nevertheless, the literature has paid little attention to the relationship between SB and MC (two studies reported no association; Cliff et al., 2009; Graf et al., 2004), while the other two reported a negative association (Williams et al., 2008; Wrotniak et al., 2006), leaving the following questions unanswered: (i) does SB predict MC and, if so, (ii) does this predictive relationship remain after considering the levels of PA that children undertake.

In this context, the purpose of this study was to evaluate the relationship between objectively measured SB and MC in Portuguese children aged 9–10 years, accounting for PA levels, accelerometer wear time, waist-to-height ratio (WHtR), and mother's education level. We also examined the association between the amount of time spent on SBs and low MC development.

## METHODS

### *Study design and sampling*

Data for this study are derived from the Bracara Study aimed to evaluate the relations between MC, PA, physical fitness, body composition, academic achievement, and health behaviors among elementary school children. The Bracara Study was conducted in a middle city located in the north of Portugal during the 2009/2010 academic year.

All 21 public elementary schools in the city that qualified as urban (according to the Municipal Administration Registry) were considered and invited to participate in this study, corresponding to 846 children enrolling in the fourth grade; two schools decided not to take part in this study, corresponding to 90 children; six schools could not be evaluated on time to take part in this study, corresponding to 130 children; 30 children who failed the inclusion criteria (having a mental and/or physical disability or a health condition that did not allow them to participate in physical education classes) or had missing information on the variables of interest were excluded from this analysis. The final sample of Bracara Study accounts for 596 participants (281 girls); due to temporal and material restrictions (accelerometers available) 383 children did not wear the accelerometer. However, drop out analysis showed that the 383 missing children had a similar mean values for height, waist circumference, WHtR, and mother's education (data not showed). Therefore, the study included 13 urban public elementary schools, and 213 participants (110 girls) aged 9–10 years old.

The schools' directors and children's parents/guardians received verbal and written description of the study and signed a written informed consent form. The protocol and procedures employed followed the Helsinki Declaration for Investigation in Human Subjects and were approved by the Curricular Development and Innovation Division (Portuguese Ministry of Education) and by the University's Ethics Committee.

Data were collected during regularly scheduled physical education classes by two assessors in full time. Assessors were physical education graduates and received specific training, and had already participated in previous Körperkoordination Test für Kinder (KTK) and accelerometry data collection. The assessors were helped by the physical education teachers.

### *Measures*

Anthropometry. Height was measured to the nearest millimeter in bare or stocking feet with the children standing upright against a stadiometer (*Seca 220*). Waist circumference measurements were taken as described by Lohman et al. (1991).The waist and height were used to compute the WHtR. Previous analyses (data not showed) showed that WHtR explain better MC than body mass index, fat mass percentage, or waist circumference ($R^2$ = 0.22 for girls and $R^2 = 0.20$ for boys).

PA and sedentary time. The accelerometer GT1M Actigraph (ActiGraph, Pensacola, Florida) was used to obtain detailed and objectively information about daily PA and SB over five consecutive days. This lightweight, biaxial monitor was the latest model available by the manufacturer at the time of data collection, and studies have demonstrated that it is a technically reliable instrument, both within and across monitors (Rothney et al., 2008). The accelerometer was attached tightly in the hip, on the right side, with the notch faced upwards, and participants were instructed to use the accelerometer during waking hours and remove it during water-based activities; according to established procedures (Ward et al., 2005). The epoch length was set to 15 seconds to allow a more detailed estimate of PA intensity (Ward et al., 2005).

Accelerometer data were analyzed by an automated data reduction program (MAHUffe; see www.mrc-epid.cam.ac.uk) that provided options for screening the data and computing outcomes. Data files from individual participants were screened by detecting blocks of consecutive zeros. Periods with 60 minutes of consecutive zeros were detected and flagged as times in which the monitor was not worn (Troiano et al., 2008). Participants had to have at least 10 hours of data to count as a valid day and to have at least three valid days to be included (two weekdays and one weekend day). The screening procedures were consistent with current accelerometry studies and also similar to the screening used in national health and nutrition examination survey (NHANES) (Colley et al., 2010; Troiano et al., 2008). After screening was completed, the raw activity "counts" were processed for determination of time spent in the different PA intensities. Activity levels were expressed in mean counts $min^{-1}$ and also in estimates of the time spent in moderate-to-vigorous physical activity (MVPA). The established accelerometer cut-points proposed by Freedson and published by Trost et al., (2002) were used to determine PA intensities. SB was identified using a cut-point of <100 counts $min^{-1}$, as this cutoff was shown to have an excellent classification accuracy (Trost et al., 2011).

MC. MC was evaluated with the body coordination test (KTK), developed for German children (aged 5–15 years). The KTK battery has four items:

*Balance.* The child walks backward on three balance beams each 3 m in length, 5 cm in height, but with decreasing widths of 6, 4.5, and 3 cm. The child has three attempts at each beam; the number of successful steps is recorded; a maximum of 24 steps (eight per trial) were counted for each balance beam, which comprises a maximum of 72 steps.

*Jumping laterally.* The child makes consecutive jumps from side to side over a small beam (60 cm × 4 cm × 2 cm) as quickly as possible for 15 seconds. The child is instructed to keep his/her feet together; the number of correct jumps in two trials was summed.

*Hopping on one leg over an obstacle.* The child was instructed to hop on one foot at a time over a stack of foam blocks after a short run-up. After a successful hop with each foot (the child clears the block without touching it and continues to hop on the same foot at least two times), the height was increased by adding a block (50 cm × 20 cm × 5 cm). The child had three attempts at each height and on each foot; three, two, or one point(s) was/were awarded for a successful performance on the first, second or third trial, respectively; a maximum of 39 points (12 stacks blocks) could be scored for each leg (maximum score 78).

*Shifting platforms.* The child begins by standing with both feet on one platform (25 cm × 25 cm × 2 cm) supported on four legs, 3.7 cm in height and holding a second identical platform in his/her hands; the child is then instructed to place the second platform alongside the first and to step on to it; the first box is then lifted and placed alongside the second and the child steps on to it; the sequence continues for 20 seconds. Each successful transfer from one platform to the next earns two points (one for shifting the platform, the other for transferring the body); the number of points in 20 seconds is recorded and summed for two trials. If the child falls off in the process, he/she simply gets back on to the platform and continues the test.

Although some of the items in the KTK appear to measure specific components of motor performance, e.g., dynamic balance, speed and agility, balance and power, the four tests are loaded toward a single factor when analyzed with other items. Hence, the authors utilized the four items together as a global indicator of MC, the "motor quotient." Each performance item was scored relative to gender- and age-specific reference values for the population upon which the KTK was established (Kiphard and Schiling, 1974). The sum of the standardized scores for the four items provides the motor quotient. Using the motor quotient children were then categorized as having: MC disorders (<70 motor quotient); MC insufficiency (71 ≤ motor quotient ≤ 85); normal MC (86 ≤ motor quotient ≤ 115); good MC (115 ≤ motor quotient ≤ 130); or very good MC (131 ≤ motor quotient ≤ 145). In this study participants were then categorized as having high MC if children has normal or good MC (86 ≤ motor quotient ≤ 130), because none of the children showed very good MC; or low MC if children were classified has having MC disorders or insufficiency (<85 motor quotient).

The psychometric characteristics of the KTK have been documented (Kiphard and Schiling, 1974). The test-retest reliability coefficient for the raw score on the total test battery was 0.97, while corresponding coefficients for individual tests ranged from 0.80 to 0.96. Factor analysis of the four individual tests resulted in a single factor labeled gross MC. The percentage of total variance in MC explained by the single factor varied from 81% at 6 years to 98% at 9 years (Kiphard and Schiling, 1974). Intercorrelations among the four tests varied from 0.60 to 0.81 for the reference sample of 1228 children. Both the factor analysis and intercorrelations thus indicated acceptable construct validity. Validity was further determined through differentiation of normal from disabled children. The KTK test differentiated 91% of children with brain damage from normal children.

Sociodemographics. A questionnaire was distributed to parents for assessing general child and parental health variables, divided in three sections: the first section collected information related to the child, the second section collected information to characterize the parents, and the third section addressed parental PA. The questionnaire asked about the mother's educational level, a variable used as a measure of socioeconomic status. Mothers were categorized according to the Portuguese Education Level: Low (mandatory education–9 school years); Medium (secondary education–12 school years); and High (college or university degree).

Statistical analysis. Descriptive data are presented as means and standard deviations, and two-sided $t$-tests were performed to assess gender differences for age, MC, WHtR, and accelerometer wear-time. Analysis of the covariance was performed to analyze the differences between genders for sedentary time (mean min/day), sedentary time (percentage), and MVPA (mean min/day) adjusted for accelerometer wear-time.

Receiver-operating characteristic (ROC) curves were used to calculate the optimal sedentary time cutoff points that best discriminate between the participants with high and low MC. The area under the ROC curve (AUC) represents the ability of the test to correctly classify the participants with high or low MC. The values of AUC range

*TABLE 1. Participants' characteristics (means ± standard deviation)*

| | All ($n$ = 213) | Girls ($n$ = 110) | Boys ($n$ = 103) | $P$ |
|---|---|---|---|---|
| Age (years) | 9.46 ± 0.43 | 9.45 ± 0.37 | 9.48 ± 0.50 | 0.612[a] |
| WHtR | 0.48 ± 0.05 | 0.48 ± 0.05 | 0.48 ± 0.05 | 0.341[a] |
| MC (motor quotient) | 86.72 ± 14.40 | 83.56 ± 13.79 | 90.09 ± 14.34 | <0.001[a] |
| Accelerometer wear-time | 791.45 ± 60.34 | 784.49 ± 59.48 | 798.89 ± 60.66 | 0.082[a] |
| MVPA (mean min/day) | 82.45 ± 24.18 | 74.12 ± 19.30 | 91.35 ± 25.75 | <0.001[b] |
| Sedentary time (min/day) | 453.62 ± 32.75 | 463.17 ± 27.71 | 443.32 ± 34.42 | <0.001[b] |
| Sedentary time (%) | 75.60 ± 5.46 | 77.20 ± 4.62 | 73.90 ± 5.79 | <0.001[b] |

Abbreviations: MVPA, Moderate, vigorous and very vigorous physical activity; MC, Motor coordination; WHtR – Waist-to-height ratio.[a]$t$ test to compared gender differences.
[b]ANCOVA compared gender differences, adjusted for accelerometer wear-time.

*TABLE 2. Best trade-off between sensitivity and specificity for percentage of sedentary time to discriminate between motor coordination disorders/insufficiency and normal/good motor coordination by receiver-operating characteristics (ROC) analysis for each gender*

| | Girls | Boys |
|---|---|---|
| Sedentary time cut-off (%) | 77.29 | 76.49 |
| Sensitivity | 0.686 (0.541–0.809) | 0.770 (0.645–0.868) |
| Specificity | 0.661 (0.526–0.779) | 0.595 (0.433–0.744) |
| AUC | 0.659 (0.562–0.746); $P$ = 0.0021 | 0.668 (0.569–0.758); $P$ = 0.0023 |

Abbreviations: AUC, area under the ROC curve.

between 1 (a perfect test) and 0.5 (a worthless test). ROC analyses were performed separately by gender.

Binary logistic regression models were constructed to verify the relationship between sedentary time percentage and normal/good MC, adjusting for PA, accelerometer wear time, WHtR, and mother's education level.

Data were analyzed using IBM SPSS Statistics v.19 (SPSS, Inc. IBM Company, USA) and MedCalc statistical software (MedCalc software, Mariakerke, Belguim). A $P$ value lower than 0.05 denoted statistical significance.

## RESULTS

The descriptive characteristics are shown in Table 1. Girls displayed lower levels of MC and fewer minutes of MVPA than boys, while boys spent less sedentary time than girls ($P < 0.001$ for all). 46.3% of girls and 59.3% of boys showed normal or good MC ($P < 000.1$).

As presented in Table 2, ROC analysis showed that sedentary time significantly discriminates between children with low MC and high MC, with a best trade-off between sensitivity and specificity being achieved at ≥77.29% and ≥76.48% for girls and boys respectively ($P < 0.05$ for both).

To explore whether the association between this percentage of sedentary time threshold and MC is independent of PA, we performed a logistic regression analysis for each gender (Tables 3 and 4) according to the respective sedentary time cutoff (<77.29% and ≥77.29% for girls; <76.49% and ≥76.49% for boys). In both genders, the low sedentary group had significantly higher odds of having a good MC than the higher sedentary group, independent of PA, accelerometer wear time, WHtR, and mother's education level (Odds ratio (OR) = 5.065 for girls and OR = 9.149 for boys; $P < 0.05$ for both; see Model 3).

*TABLE 3. Odds ratios and 95% confidence intervals from logistic regression model predicting normal/good motor coordination, for girls*

| | | Normal/good motor coordination | | |
|---|---|---|---|---|
| Girls | | OR | 95% CI | $P$ |
| Model 1 unadjusted | ≥77.3% Sedentary time[a] | 1 | | |
| | <77.3% Sedentary time | 4.266 | (1.916–9.496) | <0.001 |
| Model 2[b] | ≥77.3% Sedentary time[a] | 1 | | |
| | <77.3% Sedentary time | 4.584 | (1.764–11.915) | 0.002 |
| Model 3[c] | ≥77.3% Sedentary time[a] | 1 | | |
| | <77.3% Sedentary time | 5.065 | (1.670–15.363) | 0.004 |

Abbreviations: OR, Odds Ratio. CI, Confidence Intervals.
[a]Reference category.
[b]Adjusted for physical activity and accelerometer wear time.
[c]Adjusted for physical activity, accelerometer wear time, waist-to-height ratio and mother' education level.

*TABLE 4. Odds ratios and 95% confidence intervals from logistic regression model predicting normal/good motor coordination, for boys*

| | | Normal/good motor coordination | | |
|---|---|---|---|---|
| Boys | | OR | 95% CI | $P$ |
| Model 1 Unadjusted | ≥76.5% Sedentary time[a] | 1 | | |
| | <76.5% Sedentary time | 4.937 | (2.094–11.641) | <0.001 |
| Model 2[b] | ≥76.5% Sedentary time[a] | 1 | | |
| | <76.5% Sedentary time | 5.741 | (2.132–15.457) | 0.001 |
| Model 3[c] | ≥76.5% Sedentary time[a] | 1 | | |
| | <76.5% Sedentary time | 9.149 | (2.465–33.964) | 0.001 |

Abbreviations: OR, Odds Ratio. CI, Confidence Intervals.
[a]Reference category.
[b]Adjusted for physical activity and accelerometer wear time.
[c]Adjusted for physical activity, accelerometer wear time, waist-to-height ratio and mother' education level.

## DISCUSSION

The main finding of this study indicates that for both genders the low sedentary group had significantly higher odds of having a good MC compared with the high sedentary group, independently of MVPA, accelerometer wear time, WHtR, and mother's education level.

In children and adolescents, self-reported leisure-time SB such as overall screen time (i.e., TV viewing, videogames, computer use) has commonly been studied; however, while these activities may represent a substantial portion of the time spent in total SB, they do not represent the total amount of everyday sedentary time. In this regard, as has been argued for PA (Ruiz and Ortega, 2009), objectively measuring total sedentary time by using devices such as accelerometers may offer particular advantages, as these devices do not rely on subject recall and may capture the entire daily patterns of both PA and SB. This study assessed both PA and SB using accelerometry.

The negative effects of sedentary lifestyles on children's health and health-related behaviors and outcomes are a source of concern. In this study, we observed that children spent on average 75.6% of their time in SB. Results from other studies using objective methods (i.e., accelerometry) have also shown that children spend significant proportions of their waking time being sedentary, between 50% and 80% (Colley et al., 2011; Martinez-Gomez et al., 2011; Matthews et al., 2008) and, as a result, they may be at risk of detrimental health outcomes (Hinkley et al., 2010). Mounting evidence has suggested recently that time spent in SB is associated with adverse health outcomes, an association that may be independent of the protective contributions of PA, as it remained significant after adjustments (van Uffelen et al., 2010). In a recent review of (both self-reported and objectively measured) SB and health indicators in school-aged children and youth, the authors concluded that spending more than 2 hours per day being sedentary was associated with unfavorable body composition, decreased fitness, lowered scores for self-esteem and prosocial behavior, and decreased academic achievement (Tremblay et al., 2011b).

In this study, ROC analysis showed the best trade-offs between sensitivity and specificity in discriminating between low and high MC using SB was achieved at 77.29% and 76.49% for girls and boys respectively. The values reported in this study are in line with those reported by Martinez et al. (2011) who performed a similar ROC curve and accelerometer analysis. Martinez et al. (2011) showed that girls who spent more than 69% of their waking time in SB were less likely to have high cardiorespiratory fitness (Martinez-Gomez et al., 2011).

Recent studies have focused on understanding the relationships between MC and health-related behaviors and outcomes. Indeed, a recent systematic review identified eight potential benefits of MC (global self-concept, perceived physical competence, cardiorespiratory fitness, muscular fitness, weight status, flexibility, PA, and reduced SB) and found evidence for a positive association with PA and cardiorespiratory fitness and an inverse association with weight status. The remaining benefits, including SB, were classified as uncertain, due to an inadequate number of studies (Lubans et al., 2010). Rivilis et al. (2011) performed a systematically review and summarize the literature on the association between poor motor proficiency and fitness and PA outcomes in children. They concluded that body composition, cardiorespiratory fitness, muscle strength and endurance, anaerobic capacity, power, and PA have all been negatively associated, to various degrees, with poor motor proficiency. However, differences in flexibility were not conclusive because the results on this parameter were mixed. Recently, Stodden et al. (2009) have hypothesized a developmental recursive model suggesting a reciprocal relationship between MC and PA. The authors postulated that children with high motor skill proficiency will have higher levels of fitness and perceived sports competence, which in turn predict greater participation in PA and *vice versa*. However, in this model, as in the general literature, the SB appears to be defined as the inverse of PA (i.e., insufficient levels of PA), instead of being considered as an independent behavior. In fact, we only found four studies in literature linking SB to MC (Cliff et al., 2009; Graf et al., 2004; Williams et al., 2008; Wrotniak et al., 2006), and only three of them (Cliff et al., 2009; Williams et al., 2008; Wrotniak et al., 2006) were performed using objective measures. However, in those studies the relationship between PA and motor skills did not take into account the possible confounding effect of SB, and the associations between SB and motor skills were not adjusted for the influence of PA.

Our study suggested that high time spent in SB was a predictor of low MC, regardless of PA levels, and other confounders. Our findings, in combination with the studies of Wroniak et al. (2006) and Williams et al. (2008) that indicated a positive relationship between motor skill performance and PA and an inverse association with sedentary activity in children (Williams et al., 2008; Wrotniak et al., 2006), may suggested a reciprocal relationship between SB and MC. In this context, we could speculate that providing children with alternatives to SB, namely daily physical education classes, opportunities for sports participation in and outside school, and school recesses more conducive to activity, could have a positive impact on their MC, which could in turn increase PA and decrease time spent in SB. However, further longitudinal and intervention studies are necessary to confirm or disprove this hypothesis.

Our findings have important implications as they suggested that PA levels *per se* may not overcome the deleterious influence of high levels of SB on MC. Therefore, to establish healthy lifestyles from a young age, actions aiming to address the current inactivity crisis should attempt to both increase PA levels and decrease SB (Tremblay et al., 2011b). Indeed, the necessity for public health recommendations targeting SB has already been suggested (Hojbjerre et al., 2010). Based on the mounting evidence of the health-related benefits of low SB, the Canadian Society for Exercise Physiology, in partnership with the Healthy Active Living and Obesity Research Group at the Children's Hospital of Eastern Ontario Research Institute, recently launched the Canadian Sedentary Behavior Guidelines, which extend the American Academy of Pediatrics' guidelines for screen time (Education, 2001) to include transportation, sitting time, and time spent indoors. These guidelines suggest that for health benefits, children, and adolescents should minimize the time they spend being sedentary each day by limiting recreational screen time to no more than 2 hours per day (lower levels are associated with additional health benefits) as well as limiting sedentary (motorized) transport, extended sitting time, and time spent indoors throughout the day (Tremblay et al., 2011a); however, recommendations regarding limits on total time per day spent in sedentary activities are still lacking. Indeed, only a few studies have addressed links between total SB time and health outcomes in children and adolescents (Martinez-Gomez et al., 2011).

### *Strengths and limitations*

Strengths of this study included the novelty of the analyses of the associations between SB and MC; the objective assessment of both total MVPA and total sedentary time (most previous studies have limited their analysis to self-reported leisure time SB and/or PA); and the use of a cut-point of <100 counts $min^{-1}$ to identify SB, as this cutoff was shown to have an excellent classification accuracy (Trost et al., 2011).

This study has some limitations that must be considered when interpreting its results. First, accelerometers do not identify PA or sedentary patterns or contexts, and the accelerometers used in this study do not allow us to distinguish the type of SB (i.e., lying, sitting, or standing still). Second, the data has been derived from a cross-sectional study; therefore, results do not indicate causality. More research is needed to further study the relationship between SB and MC. Longitudinal and interventional studies would provide information on the direction of this association.

## CONCLUSIONS

In conclusion, in both genders the percentage of time spent in SB was negatively associated with MC, independently of MVPA and other confounders. Our findings suggested that PA levels *per se* may not overcome the deleterious influence of high levels of SB on MC. Our data stress the importance of discouraging SB among children to improve MC.

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