Associations between domains of physical literacy by weight status in 8- to 12-year-old Canadian children

Childhood overweight and obesity represent a significant public health challenge globally [1]. Even though there is evidence that childhood obesity is stabilizing, levels are the highest they have ever been [2], with the prevalence of overweight and obesity in Canadian children aged 6 to 11 years estimated to be approximately 26% [3]. Childhood obesity is multifaceted; however, low levels of physical activity as well as high amounts of sedentary time are well-established correlates [4]. Physical literacy (PL) is defined as "the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" [5]. The concept of PL has gained interest in recent years as an important construct that may help to explain why children may or may not engage in physical activity [6]. Obesity has been identified as an important correlate that significantly influences an individual's level of PL [7]. Therefore, understanding how obesity impacts childhood PL may help children who are overweight or obese to live more active lives.

The Canadian Assessment of Physical Literacy (CAPL) was created to address the lack of objective PL data, and provides a robust and comprehensive aggregate assessment of PL. The overall aim of the CAPL is to provide a reliable, feasible, and valid instrument to assess PL in children [8–10]. In alignment with the Canadian consensus definition of PL [5], the four domains included within the CAPL are: Physical Competence, Daily Behaviour, Motivation and Confidence, and Knowledge and Understanding. Participants who complete the CAPL receive individual domain scores as well as an overall PL score [11]. There is a multitude of uses for the CAPL; these include but are not limited to: informing individual programs, providing evidence for resource allocation, influencing policy decisions, and providing national surveillance [10].

In order to ensure that the CAPL accurately assesses the various skills and behaviours included within it across all weight statuses, it is important to understand the associations between the individual domains for both healthy-weight and overweight/obese individuals. Furthermore, it has been suggested that PL is associated with weight status [7] and various behavioural, physical, social, and psychological factors [12]. Therefore, it is important to understand whether the individual domain scores assessed via the CAPL, and their associations between each other, vary between children of differing weight status.

Larouche et al. [13] investigated the associations between physical competence (i.e., physical fitness and motor skills) and daily physical activity, which is part of the Daily Behaviour domain, and found significant associations between the two domains. To date, no studies have investigated the correlations among all four domains of PL by weight status. A better understanding of these associations will provide important evidence as to whether the four domains of PL are related to each other and whether weight status influences these relationships. Therefore, the aim of this study was to determine the associations among the four domains of PL assessed via the CAPL in 8- to 12-year-old Canadian children stratified by weight status (i.e., healthy-weight versus overweight/obese).

Study design and participants

The Royal Bank of Canada (RBC) Learn to Play CAPL project was a nation-wide, cross-sectional study designed to assess the PL of Canadian children aged 8 to 12 years. Data were collected between February 2014 and February 2017 in 11 cities (seven provinces) across Canada. Participating cities included: Victoria, British Columbia; Lethbridge and Calgary, Alberta; Winnipeg, Manitoba; North Bay, Windsor, and Ottawa, Ontario; Trois-Rivières, Québec; Antigonish and Halifax, Nova Scotia; and Charlottetown, Prince Edward Island. In each testing site, a convenience sampling method was used to recruit participants, from a variety of settings (e.g., primary schools, after-school programs, and community centres) to obtain data for children from urban, suburban, and rural areas, and from various socioeconomic classes. Participants with missing data relevant to the analyses ($n = 1545$) as well as children who were classified as underweight ($n = 130$) were excluded from these analyses, which resulted in a final sample of 8343 children for the present analyses. The children included in these analyses did not differ from those excluded (based on missing data) with regard to demographic characteristics (e.g., gender, age, and body mass index [BMI]).

Parents or legal guardians provided written, informed consent and the children also provided assent to participate in this study. The CAPL project was approved first by the coordinating centre's Research Ethics Board (Children's Hospital of Eastern Ontario), and thereafter by each participating site's institutional Research Ethics Board and participating school boards as required.

CAPL protocol

The PL of all participants was evaluated following the published CAPL protocol [9, 14]. The CAPL manual [11] as well as other relevant material (e.g., training videos) are available online at https://www.capl-ecsfp.ca. The CAPL is made up of four domains (Physical Competence, Daily Behaviour, Knowledge and Understanding, and Motivation and Confidence), and provides domain scores as well as an overall PL score [9]. The Physical Competence and Daily Behaviour domains had maximum scores of 32

points each, whereas the Knowledge and Understanding and Motivation and Confidence domains had maximum scores of 18 points each. Thus, the maximum PL score was 100 points [9, 14]. A brief description of each of the four domains of PL is provided below, with more details provided elsewhere in this supplement [15].

Physical competence

This domain included objective measures of physical fitness, motor performance, and body composition. Physical fitness was assessed using: the Progressive Aerobic Cardiovascular Endurance Run (PACER) (cardiorespiratory fitness) [16], handgrip strength (muscular strength) [17], the abdominal plank test (muscular endurance) [18], and the sit-and-reach test (flexibility) [17]. Motor performance was evaluated using the Canadian Agility and Movement Skill Assessment (CAMSA) [19], and body composition was measured using BMI z-scores [20] as well as waist circumference [17]. The total number of available points for this domain was 32, with the PACER and CAMSA comprising of 8.4 points each; grip strength, plank, BMI z-score, and waist circumference comprising of 3.4 points each; and sit and reach comprising of 1.6 points [9].

Daily behaviour

The Daily Behaviour domain included objective and subjective measures of physical activity and sedentary behaviour. Physical activity was measured objectively using pedometers (YamaxDigiWalker SW-200, Yamax Corporation, Tokyo, Japan) for seven consecutive days, in which the participants were required to wear them during waking hours. Two questionnaire items were used to assess the number of days the children engaged in at least 60 min of moderate to vigorous physical activity (MVPA) in the past week as well as to assess their daily screen time habits on both weekdays and weekend days [11]. The majority of this domain score was from the objectively measured physical activity (21 of 32 available points), while the subjectively measured sedentary and MVPA times were comprised of 8 and 3 points, respectively [9].

Motivation and confidence

This domain was assessed using a questionnaire, with items extracted from published instruments, to evaluate the children's motivation and confidence to be physically

Prevention reference values, which were based on the National Health and Nutrition Examination Surveys from 2011 to 2012 and 2013–2014 [24]. Using sex- and age-specific percentiles, children less than or equal to the 85th percentile were defined as healthy-weight, whereas children greater than the 85th percentile were grouped into the overweight/obese category.

Statistical analysis

Values are presented as means and standard deviations. Differences between groups (healthy-weight versus overweight/obese) for demographic characteristics, domain scores, and the overall PL score were determined using multivariate analysis of variance (MANOVA). Categorical demographic characteristics were compared using the chi-squared test.

Partial correlations were used to assess the associations between each of the domain scores of PL separately, while controlling for age and gender (as these have been shown to influence some CAPL domain scores as well as the overall PL score) [9]. Correlation coefficients were classified as weak ($0.1 \leq$, < 0.3), moderate ($0.3 \leq$, < 0.5), or strong (≥ 0.5) [25]. Analyses were conducted separately

as between modified Physical Competence and Knowledge and Understanding, were significantly higher in the healthy-weight children compared to the overweight/obese children ($Z = 2.69$ and 2.65, respectively; both < 0.01). However, the difference in the correlation coefficients was small.

In sensitivity analyses, we conducted the same analyses, except the analyses were stratified by waist circumference (≤ 85th percentile and > 85th percentile) (see Additional file 1), and we compared only healthy-weight and obese children as classified by BMI (see Additional file 2). The effect sizes were slightly larger for both sensitivity analyses when stratifying by waist circumference or healthy-weight versus obese; however, the effect sizes were still classified as weak to moderate. The largest differences were observed for modified Physical Competence and overall PL. With regards to the associations between the domains of PL, similar results were obtained for both sensitivity analyses in comparison to the original analysis.

who are healthy-weight, the results of this study have broader implications for PL. The associations between most of the domains of PL were stable across children of different weight status. Even though significant differences were found between the healthy-weight and overweight/obese children for the associations between modified Physical Competence and Daily Behaviour, and between modified Physical Competence and Knowledge and Understanding, for both groups the correlations were classified as weak. This suggests that future interventions aimed at improving PL probably do not need to be tailored based on weight status, although longitudinal studies are needed to confirm these conclusions. Finally, the re-

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