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Short Communication

Organized sport and physical activity participation and body mass index in children and youth: A longitudinal study

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ABSTRACT

The relationship between sport participation and BMI in children and adolescents is unclear, with some studies showing no association at all and others suggesting that sport is linked to lower BMI. Another possibility, however, is that this relationship is bidirectional, with sport leading to lower BMI but BMI also influencing sport participation. Here, we examine the direction of this association by analyzing a longitudinal dataset.

Data come from the Physical Health Activity Study Team (PHAST) study, a prospective open cohort study including 2278 children at baseline, followed from 2004 to 2010. We fit 3 lagged mixed effects models: One examining the simultaneous relationship, one regressing past BMI on present sport participation, and one regressing sport participation on present BMI.

Our baseline sample included 1999 children, of whom 50% were female. Mean BMI increased over the study period from 19.0 (SD = 3.7) to 21.2 (SD = 4.1), while organized sport participation declined. Model results showed that BMI and sport are weakly associated, and that each of these variables predicts the other, which generally supports a bidirectional relationship. Consistent with some previous reports, however, the effect size in both directions is very small. At the levels of participation in our sample, activity and BMI are very weakly related. Findings should not obscure the other benefits of physical activity.

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In Canada and the United States a quarter of children and adolescents are overweight or obese, making unhealthy weight one of the most pressing current public health problems in North America (Ogden et al., 2010; Rodd and Sharma, 2016). Increasing physical activity in children and youth is widely considered to be among the core interventions required for prevention and treatment of the problem.

The World Health Organization has identified sport participation as important to the health and development of children, including prevention and maintenance of healthy weight (WHO, 2010). Yet, while existing research shows positive associations between youth sport participation and knowledge of healthy diet and nutrition, meeting consumption of fruits and vegetables guidelines (e.g., Nelson et al., 2011), and compliance with recommended physical activity guidelines (e.g., Lee et al., 2016), studies on body weight and composition are at best equivocal. Body mass could plausibly affect participation through its effects on performance, motivation or confidence. While some research has shown such a link (e.g., Sirard et al., 2006; Drake et al., 2012), other work has not (e.g., Katzmarzyk and Malina, 1998; Trost et al., 2001; Beets and Pitetti, 2005; Velia et al., 2013). Recent systematic reviews show no clear association between sport participation and relative weight status (Nelson et al., 2011; Lee et al., 2016.

In addition to equivocal findings, methodological limitations are also evident in the extant literature. Among the most notable is the reliance on cross-sectional designs (Nelson et al., 2011). Although such designs would be expected to detect a strong causal relationship if it were present, they can offer only very limited evidence on causality. This is critical, because the association between sport participation and weight may be more complex than a simple, uni-directional pathway. For example, it is not necessarily the case that low participation causes high BMI; children and youth with high BMI scores may choose not to participate in sport, owing to perceptions of body consciousness (Zabinski et al., 2003). Research has also shown a link between BMI and increased risk of injury in young athletes (Gribble et al., 2016), which may also be a deterrent to participation. The association may therefore be better characterized as reciprocal: children who do not participate in sport have higher BMI, which in turn leads to lower participation and higher weight over time, in a negative feedback loop.

The purpose of this study is to address two questions using a large, longitudinal sample of children: First, is there a meaningful association between organized physical activity and BMI? And, second, is there evidence for the direction of this relationship?

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1. Methods

The Physical Health Activity Study Team (PHAST) project was a longitudinal open cohort study of children's physical activity, anthropometry, and fitness. Details of the study design have reported in previous publications (Cairney et al., 2010). In brief, the target study population was all fourth-grade children (ages 9 to 10 years) enrolled in the public school system in the Niagara region of Ontario, Canada. Data were collected between 2004 and 2010. A total of 75 of 92 (83%) schools agreed to participate. 2278 of 2378 (95.8%) children enrolled were consented into the study (consent was provided by parent or legal guardian). The first wave of data was collected in the spring of 2005 with reassessments done in the fall of 2005 (wave 2), spring and fall of 2006 (wave 3 and wave 4), spring and fall of 2007 (wave 5 and wave 6), fall of 2008 (wave 7), and fall of 2009 (wave 8). The total follow-up period was approximately five years. We used data from waves 2 to wave 7. We omitted wave 1 because we required lagged variables in our models, and wave 8 because children at this age switched to a different (and not directly comparable) version of the Participation Questionnaire intended to reflect age-related changes in activities. This resulted in a total of 12,477observations. Of these, we removed 1528 (12.2%) because of missing data, leaving a total of 10,949 observations. Ethics approval for the study was obtained from the district school board and Brock University.

1.1. Measures

Height was measured using a medical stadiometer and was recorded to the nearest 0.2 cm. Weight was measured using an electronic weight scale and was recorded to the nearest 0.1 kg. Height and weight measurements were obtained without footwear and children wore light clothing suitable for physical education class (e.g., t-shirt, shorts). BMI (kg/m^2) was calculated by dividing weight in kilograms over height in meter squared. Although the use of BMI z-scores can produce results that are more easily understood in terms of age-specific levels of adiposity, we opted to use actual BMI. We made this choice partly due to concerns that have been raised about the interpretability of BMI z-score in longitudinal analyses (Berkey and Colditz, 2007), and partly because our research questions are concerned with relative differences in rates of change, not in age-adjusted levels of adiposity.

Participation in physical activity was measured with the Participation Questionnaire (PQ). The PQ is a self-reported questionnaire that asks children and youth to report their participation in free-time physical activity (PA) and organized sport and (PA) (e.g., intramurals, school and community sport teams, and other organized activities over a one-year period) (Hay, 1992). Responses were used to create an index of participation by summing the total number of reported activities over the past year from the time of the survey (e.g., "*In the last year*, *how many sports teams (outside of school) have you played on?*"). Scores for active free-time PA range from 0 to 20 and scores for organized sport and physical activities range from 0 to 29. Higher scores indicate increasing levels of participation. There is good evidence of construct validity for the scores generated by the PQ: Previous studies have reported significant differences between boys and girls, those living in urban and rural settings, and significant correlations with body fat, aerobic capacity, and teacher assessed physical activity in children ($r = 0.62$) (Hay, 1992). Two week, test-retest reliability is reported to be 0.81 (Hay, 1992).

1.2. Analysis

In our main analysis, we followed the scheme outlined in Duckworth et al. (2010) for causal analysis of longitudinal datasets. We fit 3 mixed effects models: Model 1 measured the overall association between organized PA and BMI; Model 2 used a lagged variable to test the effect of past BMI on present PA; and Model 3, a 'reverse' model, tested the effect of past PA on present BMI. All models included a random intercept and a random slope for age, and all used an unstructured covariance matrix, and all included age, sex, and an age*sex interaction. In models including organized PA as a predictor, we also included current self-reported levels of free play. Free play and organized activity are correlated in these data (at the approximate study mid-point, $r = 0.36$, $p < 0.01$), and omitting free play would therefore make it difficult to draw conclusions about the importance of participation in organized sport specifically.

2. Results

Descriptive statistics are shown in Table 1. During the study, children aged from about 10 to about 13.5 years, and BMI rose slightly, as expected, from about 19 to 21. Self-reported levels of PA declined somewhat over the study period.

Model results are shown in Table 2. Models are linear, and coefficients for fixed effects can therefore be interpreted in the same way as linear regression coefficients. Model 1 demonstrated a modest association between BMI and organized sport and PA, independent of age, sex, age * sex, and free play. This result shows that there is a relationship to be explored. Model 2 showed that organized sport and PA at the previous time point weakly predicted current BMI, and Model 3 showed that BMI at the previous time point also weakly predicted the current level of organized sport and PA and free-time PA. These results are consistent with a bidirectional relationship: (past PA, organized or free-time) predicts current BMI, but past BMI also predicts current PA.

3. Discussion

Our results show that there is a relationship between self-reported sport participation and BMI, and that this relationship appears to be bidirectional: Past PA predicts current BMI, and past BMI also predicts current PA. However, these effects are quite small. Converting them to standard effects (by dividing the model coefficients by the standard deviation of the outcome at the approximate study mid-point) produces results which, like the coefficients themselves, are close to 0.01. As effect sizes of this type are conventionally called "small" if below 0.2 (Cohen, 1988), an effect of 0.01 is clearly very small indeed. Thus, while there is evidence for reciprocal effects, the relationship is clearly a weak one. Factors other than sport per se are therefore important for maintenance of healthy weight in this population. Existing work supports important roles for parent overweight status, family socioeconomic status, and birth weight (Danielzik et al., 2004), as well as nutrition

Table 1
Descriptive statistics of participants at each wave.

	2	3	4	5	6	7
N	1999	2027	1964	1994	1408	1557
Age (mean (SD))	10.3 (0.35)	10.8 (0.49)	11.3 (0.34)	11.9 (0.38)	12.4 (0.33)	13.4 (0.33)
BMI (mean (SD))	19 (3.71)	19.2 (3.76)	19.6 (3.97)	20.1 (4.04)	20.3 (4.05)	21.1 (4.12)
Org Sport & PA (mean (SD))	4.6 (4.6)	5.8 (5.2)	4.3 (4.33)	5.6 (5.09)	4.3 (4.13)	4 (4.01)
Free PA (mean (SD))	10.3 (3.58)	11.1 (3.54)	10.5 (3.53)	11.6 (3.35)	10.8 (3.29)	9.9 (3.22)
% Female	50%	49%	49%	50%	49%	49%

Note: Org Sport & PA = Participation Questionnaire "organized sport and physical activity" subscale; Free PA = Participation Questionnaire "free-time physical activity" subscale.

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