Organized leisure-time sport participation and academic achievement in preadolescents

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Abstract

Aims: The aims of this study were to study the correlation between lifestyle-related factors, such as organized leisure-time sport participation (OLSP), cardiorespiratory fitness, and adiposity, and academic achievement among preadolescents.

Methods: A cross-sectional study involving 248 nine-year-old school children was carried out. OLSP was self-reported with parental assistance, categorized as ≤ 1× a week, 2–3× a week, and ≥ 4× times a week or more. Academic achievement was estimated with results from standardized test scores in Icelandic and math. Cardiorespiratory fitness was estimated using a maximal cycle ergometer test. The sum of four skinfolds was used to estimate adiposity. Results: Tests of between-subjects effect indicated that OLSP significantly correlated with achievement in math only (F(2,235) = 3.81, p = 0.024). Further analysis showed that the two less active groups had significantly lower scores in math compared to the most active group with OLSP ≥ 4× times a week or more (2–3× times a week, unstandardized coefficient (b) = –4.08, 95% confidence interval (CI) [–7.09, –1.07]; ≤ 1× a week, b = –3.84, 95% CI [–7.59, –0.08]), independent of sex, age, maturity level (age to/from peak height velocity), family structure, and parental education. Neither cardiorespiratory fitness nor adiposity significantly correlated with academic achievements. Conclusions: The study’s result indicates that frequent (four times per week or more often) sport participation is not harmful but may be beneficial to learning. However, further intervention-based study of this topic is needed to determine if this relationship is causal.

Key Words: Physical activity, children, exercise, academic performance, preadolescent, learning

Introduction

It is well established that physical activity is associated with multiple health benefits in children and adolescents, but evidence suggests that physical activity is also associated with academic achievement [1,2], an important influential factor for the future educational attainment and health of individuals [3,4]. One aspect of physical activity is sport participation [5], which is offered to children and adolescents in school environments or as an organized leisure-time sport participation (OLSP) by sport clubs in most western countries. A positive correlation between sport participation and academic achievement has been established in studies primarily involving adolescents participating in school sports [6,7]. However, school sports have been argued to enhance school identification which may promote academic achievement [8], and requirements that athletes maintain minimum grades to be
eligible to participate may cause grade inflation [9]. Fewer studies have investigated the association between sport club OLSP and academic achievement, but adolescent OLSP has been shown to correlate with future educational attainment and cognitive performance [10,11]. In the only other known study involving OLSP in pre-adolescents, Haapala et al. [12] reported a positive association between engagement in OLSP of any kind and achievement in math among six-year-old children.

Cardiorespiratory fitness and adiposity are considered important health markers in children and adolescents [13,14]. The association of cardiorespiratory fitness [15,16] and adiposity [17,18] with academic achievement is contradictory and inconclusive. This discrepancy might be explained by the different methods used to measure and express fitness, and the lack of adjustments for confounding factors in some studies.

Given the importance of academic achievement, and resulting educational attainment, for future health and well-being, it is imperative to understand its determinants. The positive influence OLSP may have on academic achievement constitutes an argument for increasing the availability of sports for children to participate in without jeopardizing school learning. The aims of this study were, therefore, to: a) further the findings of Haapala et al. [12] by exploring if there is a dose–response present in the relationship between OLSP and academic achievement among preadolescents; and b) explore the correlation of adiposity and cardiorespiratory fitness with academic achievement among preadolescents.

We hypothesized that: a) based on the physical activity component of OLSP [19,20], it would positively correlate with academic achievement; b) adiposity would not correlate with academic achievement since our study included an estimate of socio-economic status (parental education) which has shown to eliminate the correlation when adjusted for [21]; and c) cardiorespiratory fitness would not correlate with academic achievement.

Methods

Participants

The study population stems from two different epidemiological studies conducted in Iceland involving nine-year-old children. The first study, “Lifestyle of 9- and 15-year-old Icelandic children” [22], included nationally representative data collected from September 2003 to January 2004 on children born in 1994 (n = 662 invited to participate, n = 488 accepted), and is a part of the European Youth Heart Study (EYHS) [23]. Half of the cohort was randomly selected and offered to participate in the cardiorespiratory fitness test. Participants in the study were approached in 2014, at age 20 years, by mail and phone and asked for their consent to add their academic achievement to the database. Of the 307 of those who consented to participate, 152 had a valid cardiorespiratory fitness test (heart rate ≥ 185 bpm). The second study, “Lifestyle of 7- and 9-year-olds: Intervention toward better health” [24], was an intervention study conducted in 2006–2008. It involved children born in 1999 (n = 324 invited to participate, n = 256 accepted) from the nation’s capital, Reykjavik. In the last phase of data collection (used in this study), conducted from late August to early December 2008, 172 had a valid cardiorespiratory fitness test. The total number of participants in the aforementioned studies with a valid cardiorespiratory fitness test was 324, and 258 possessed all the information required for statistical analysis in the current study; that is, questionnaire information and a valid cardiorespiratory fitness test. The National Bioethics Committee in Iceland approved the study (VSNa2003060014/03-12/BH/–).

Questionnaire

With the assistance of their legal guardians, participants filled out a questionnaire assessing various health behaviours, which was based on the EYHS questionnaire. The legal guardians also completed a separate questionnaire on themselves, including educational level and income. The question concerning respondents’ OLSP was as follows: “How often do you participate (practice or compete) in sports with a club?” The response options were: “Never” (n = 37); “Less than once a week” (n = 6); “Once a week” (n = 12); “2–3 times a week” (n = 129); “4–5 times a week” (n = 60); and “Almost every day” (n = 14). Due to the low response rate in some options and to equalize group sizes, responses where coded into three categories with “Once a week or less” as “inactive”, 2–3 times a week as “active”, and 4 times a week or more often as “very active”.

Academic achievements

Grades from standardized tests in Icelandic and math in fourth grade, retrieved from The National Examination Institute, were used to assess academic achievement. These tests were developed by The National Examination Institute and are administered once a year in September to all students attending 4th, 7th, and 10th grade in the country, to assess standing in Icelandic and math. The test in Icelandic estimates performance in reading, writing, and grammar and
comprises multiple choice questions, reading comprehension, writing short stories, and correct use of words. The test in mathematics comprises multiple choice questions, word problems, sentence completion, operations, geometry, and numerical understanding [25,26]. The nationwide results were normalized with a mean of 30, and a standard deviation of 10. Total scores ranged from 0 to 60 [25,26].

**Cardiorespiratory fitness and anthropometry**

Height (cm) and weight (kg) were measured to the nearest 0.1 using standard procedures allowing for the calculation of body mass index (BMI; kg/m²). Cardiorespiratory fitness was measured with a progressive and maximal cycle ergometer test using the study protocol from the EYHS [23]. The workload was pre-programmed on a computerized Monark 829E cycle ergometer (Monark Exercise AB, Vansbro, Sweden) to increase every third minute until the subject reached exhaustion. Cardiorespiratory fitness was expressed with the commonly used ratio scaling (W/kg) to adjust for different body sizes. Mathematically, ratio scaling assumes a linear relationship between absolute values and body weight, with a y-intercept equal to zero. This assumption is, in fact, rarely satisfied in biological research [27]. Therefore, body size was also adjusted for using linear regression scaling [28], but since results were not affected by the cardiorespiratory fitness expression the more commonly used ratio scaling is displayed in the results. Adiposity was estimated as the sum of four skinfold sites: triceps, biceps, subscapular, and suprailiac.

**Covariates**

Maturity level was estimated using newly developed sex-specific equations, which estimate years from/to peak height velocity (i.e. maturity offset = \(-7.99994 + (0.0036124 \times \text{age} \times \text{height})\) for boys and \(-7.709133 + (0.0042232 \times \text{age} \times \text{height})\) for girls [29]. Maturity level has been considered to be a proxy for neuromuscular function, a size-independent factor associated with growth and maturation [30]. A large proportion of the Icelandic population is of Norse and Celtic origin and about 86% belonged to the Lutheran Church at baseline [31]. Because of this homogeneity, demographic factors such as race, ethnicity, and religion were considered irrelevant and not included in the analysis. Other factors, known to be confounders when studying the relationship between health behaviours and academic achievement [31], were used as covariates in this study. These included: a) level of parental education, used as a proxy for socio-economic status and consisted of a dichotomous variable (0 and 1) with 1 representing one or both parents with a university degree; b) family structure, assessed by the question "how is your current living arrangement?" with the response options, "living with both parents", "living with a single parent", "living with a parent and his/hers spouse", and "other arrangement"; c) sex; and d) age in months [32].

**Data analysis**

The data were analysed using SPSS 22.0 (IBM Corp., Armonk, NY, USA). All variables were inspected for normality, the sum of four skinfolds was reciprocally transformed, and cardiorespiratory fitness log-transformed to correct for skewness [33]. Therefore, all positive skinfold slopes (betas) are in reality negative, and vice versa for negative slopes. One-way analysis of variance (ANOVA; continuous variables) and Chi-square (categorical variables) were used to explore the differences on key variables between the study sample and the rest of the cohort (excluded). One-way ANOVA and analysis of covariance (ANCOVA) were used to analyse differences in academic achievement between OLSP groups. The Tukey post hoc test was administered to explore differences between OLSP groups on academic achievement in crude analysis. Levene’s test was used to estimate homogeneity of variance. No interactions were found between the OLSP groups and the other independent variables. Effect size was estimated using Cohen’s d [34]. Statistical significance was accepted at α level of 0.05.

**Results**

The study sample and those who did not meet the inclusion criteria significantly differed on only two variables. The study sample had a lower sum of skinfolds and higher cardiorespiratory fitness level than those excluded (see Table I). The two study cohorts did not differ significantly in academic achievement with 1994 cohort’s average score in Icelandic being 31.69 (± 9.95) vs. 32.69 (± 10.28) for the 1999 cohort (p = 0.427). In math, the 1994 cohort’s average was 30.34 (± 10.37) vs. 31.7 (± 10.11) for the 1999 cohort (p = 0.275). The nationwide average score in the two academic subjects was 30.0 (± 10) [25,26].

In crude analysis, the Tukey post hoc test revealed that the very active group, which participated in OLSP four times or more a week, had significantly higher grades in math than the active group and the inactive group, p = 0.014, 95% confidence interval (CI) [0.70, 7.85]; effect size 0.45, and p = 0.042, 95% CI [0.14, 9.97]; effect size 0.42 respectively (see Figure 1).
The ANCOVA analysis, with math as the dependent variable \((n = 247)\), showed that the very active group had significantly higher grades than the other two less active groups (see Table II). Neither adiposity nor cardiorespiratory fitness correlated significantly with academic achievement. When grades in Icelandic were entered as the dependent variable instead of math \((n = 248)\), no significant association between OLSP and academic achievement were observed. Neither adiposity nor cardiorespiratory fitness correlated with achievement in Icelandic (see Table III).

**Discussion**

The main finding of this study is that the very active group had significantly higher grades in math than the two less active groups, independent of age, sex, adiposity, family structure, parental education, cardiorespiratory fitness, and maturity level. Therefore, the current study furthers the findings of Haapala et al. [12] by establishing a threshold in the association between OLSP and achievements in math among preadolescents. Our hypothesis that OLSP would be associated with academic achievement is partly explained as OLSP was only associated with achievement in math but not in Icelandic. The finding of no correlation of adiposity and cardiorespiratory fitness with academic achievement is congruent with our hypothesis. Haapala et al. [12] reported that participation in any kind of OLSP in first grade was associated with better math skills in grades 1–3, but not with reading fluency or reading comprehension, compared with those who did not engage in such activities.

This study did not reveal a significant dose–response relationship in the association between OLSP and academic achievement. Dose–response relationships have been reported among adolescents [7,35]. Fox et al. [7] reported a dose–response relationship between the number of sports teams that participated and academic achievement (grade point average) among high-school students but not among middle-school students. This indicates that the strength of the dose–response might be smaller in younger participants. However, our study reveals a frequency threshold where participation may start to affect math scores, indicating that certain OLSP frequency [36] or intensity [37] must be met in order for OLSP to affect academic achievement. Another possible explanation is that only the most dedicated participants in OLSP possess or acquire the skills, for example, self-discipline, necessary for affecting academic achievement.

In line with the findings of Haapala et al. [12], OLSP was significantly associated with achievement in math but not in language. Based on these results, the most probable explanation for the established association between achievement in math and OLSP is the physical activity component of OLSP [19,20]. Fox et al. [7] reported that the association of sport participation and physical activity with academic achievement could not be separated from one another in middle-school students, which supports these
speculations. The positive effect physical activity has on academic achievement may be explained by the effects it has on student’s behaviour and cognitive abilities; for example, enhanced arousal, increased concentration, and lower rate of inappropriate talking [38]. Neurological and hormonal theories
state that changes in brain structure, function, and neurotransmitter concentration occur in individuals who are more physically active, which again can enhance learning capabilities [39]. The stronger association of physical activity with math than language shown in this study is supported by results from previous studies [40,41].

Cardiorespiratory fitness was not associated with academic achievement in this study. In the literature, the correlations between cardiorespiratory fitness and academic achievement are inconclusive. This discrepancy might be explained with different ways to measure cardiorespiratory fitness. Studies using weight-bearing cardiorespiratory fitness tests (running or walking) [15,42] have shown positive associations, but studies using non-weight-bearing tests (cycle ergometer), which are relatively free from motor competence [16], have not. Motor control has been shown to associate with adolescent year's academic achievement [43], and Haapala et al. reported that poor motor performance was associated with worse academic skills among 6–8-year-olds [16].

Adiposity and academic achievement were not associated in our data. Findings in the literature concerning adiposity and academic achievement are inconclusive. An inverse correlation has been reported [44], while others have reported no correlation [17]. We can only speculate about the reasons for this discrepancy, but factors such as differences in adiposity estimation methods, age of participants, or statistical covariates may serve as plausible explanations. The negative association between obesity and academic achievement have been reported to disappear or be minimized when socio-economic status is adjusted for [21]. However, in our data, adiposity was still not correlated with academic achievement after parental education (a proxy for socio-academic status) was removed from the model (data not shown).

The real-life significance of this study’s result can only be speculated; that is, whether the grade difference between activity groups is enough to affect future academic attainment and health. The reported effect sizes of 0.42 and 0.45 for the two groups with lower OLSP are close to the medium strength cut point of 0.5 [34]. Furthermore, effect sizes of 0.41–0.51 were reported to equal four months of learning gains compared to the control group in a randomized controlled trial exploring the association between physical activity and academic achievement [45].

This study possesses several strengths. Firstly, it included a high-quality estimate of academic achievement, using results from standardized tests which include all of the nation’s fourth graders which are reviewed by an independent party at the National Examination Institute. Secondly, it employed a clearly defined aspect of physical activity or weekly frequency of OLSP. Finally, it included a high-quality laboratory-based cardiorespiratory fitness test. Limitations include that OLSP frequency was estimated via a questionnaire, and the validity of physical activity questionnaires has been questioned by some [46]. However, others have stated that questionnaires are the only currently feasible method to assess different types of physical activity and sedentary behaviour in population-based samples [47]. Information regarding the OLSP duration were not collected but the duration may possibly affect the associations between OLSP and academic achievement. Even though acute effects of physical activity on academic achievement have been reported [48], it may take months or years for other possible learning-enhancing factors (cooperation, discipline, obedience) to develop. Due to the cross-sectional study design, a definite causal relationship cannot be established. Future studies should collect data regarding what kind of sport students participated in since the association between sport participation and academic achievement may depend on the type of the sport [49]. Also, gathering information regarding motor control may also be important because of the possible confounding effect it may have on the association with physical activity and academic achievement [16,50].

In conclusion, this study supports the hypothesis that in addition to the many health benefits of physical activity, it may also be associated with better academic achievement. Cardiorespiratory fitness and adiposity are not associated with academic achievements in 9-year-old Icelandic children. The results indicate that even though children participate in OLSP four times a week or more, it is not harmful to their academic achievement and may even benefit learning. Thus, communities may look to increase OLSP offerings independently and in cooperation with non-profit sport clubs. OLSP can be costly for families, so communities may consider assisting low-income families with OLSP for their children.

Declaration of conflicting interests
None declared.

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References
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