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Limited effects of a 2-year school-based physical activity intervention on body composition and cardiorespiratory fitness in 7-year-old children

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Abstract

The aim of this study was to assess the effects of a 2-year cluster-randomized physical activity and dietary intervention program among 7-year-old (at baseline) elementary school participants on body composition and objectively measured cardiorespiratory fitness. Three pairs of schools were selected and matched, then randomly selected as either an intervention ($n = 151$) or control school ($n = 170$). None of the effect sizes of body composition were statistically significant. Children in the intervention group increased their fitness by an average of 0.37 z score units more than the controls (95% CI: −0.27 to 1.01, $P = 0.18$), representing an improvement of 0.286 W/kg. Boys had higher fitness ($mean_{diff} = 0.35$ z scores, 95% CI: 0.13–0.58, $P = 0.001$) than girls, independent of study group, fitness z score at baseline and body mass index. Post hoc analysis showed that the intervention school with the highest fitness z score change was significantly different from two of the lowest control schools ($mean_{diff} = 0.83$ z scores, 95% CI: 0.44–1.21, $P < 0.0001$ and $mean_{diff} = 0.70$ z scores, 95% CI: 0.29–1.10, $P = 0.01$), but it was also significantly different from the lowest intervention school ($mean_{diff} = 0.59$ z scores, 95% CI: 0.19–0.99, $P = 0.05$). The results of this intervention are inconclusive as regards to the effects on fitness, but the intervention did not have any statistically significant effect on body composition.

Introduction

The rate at which results from school-based physical activity and dietary intervention studies are published has rapidly increased in the last few years [1, 2]. The primary reason for this growing body of literature is the increase in the number of intervention studies carried out as a response to the public health threat posed by childhood overweight and obesity. Although recent studies and reports from the United States [3], Scandinavia [4] and Iceland [5] point out that the childhood overweight and obesity epidemic may have stabilized in the past 5–10 years, the prevalence of overweight and obesity remains too high. Another reason for the researchers' keen interest in developing sustainable ways to increase physical activity is the alarming secular decline in aerobic fitness of children and adolescents reported from the same regions and Australasia [6–9]. Moreover, the link between children's fitness and fatness seems to be evident as studies have shown a negative association between young children's fitness and both overall and abdominal fatness [10–12]. Both physical inactivity and low fitness have also been shown to be associated with increasing prevalence of various health-related risk factors in children [13, 14]. Also,

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low physical activity in childhood has been shown to track into adulthood [15]. Thus, preventing the decline in children's fitness by increasing physical activity, or better yet reversing this downward trend, would likely have a positive impact on public health in the future.

The school setting has gained broad appeal as the primary venue for the implementation of childhood lifestyle intervention because of the accessibility to the majority of children of school age [16, 17]. Yet, the diverse methodologies and settings used have produced conflicting evidence as to whether these interventions were effective in either reversing the upward trend of overweight and obesity [18] or increasing children's fitness and physical activity [1, 2]. The goal of the study described herein was to implement a progressive school-based intervention at the class level where regular teachers conducted the primary intervention. As published elsewhere [19, 20], we successfully increased physical activity during school hours and improved the daily diet of the participants in the intervention schools. The primary aim of this paper was to assess the effects of this 2-year intervention program among the 7-year-old (at baseline) elementary school participants on: (i) body composition and (ii) objectively measured cardiorespiratory fitness. The secondary aim was to observe the relationship between the change in cardiorespiratory fitness over time and the change in body fat.

Methods

Study design and participants

The study was designed as a progressive 2-year cluster-randomized intervention trial. Three pairs of schools in the city of Reykjavik were selected and matched on size, i.e. number of students and total number of grades. One of each school in a pair was randomly selected to serve as an intervention school and thus the study included two groups with three intervention schools and three control schools. All children attending second grade (born in 1999) were invited to participate and to hand in a written parental consent form (signed by either parent and the child) before the first measurement sessions in the fall of 2006. This Icelandic study population consisted primarily (about 97%) of native children (Caucasian-white). Figure 1 shows the number of participants in each component of this study. In the intervention schools, the program started immediately following baseline measurements where all the children received the intervention, regardless of whether they consented to undergo physical measurements. The intervention focused on two major components of healthy lifestyle; physical activity through playful learning and healthy diet for all. The implementation of this study was approved by The National Bioethics Committee and the Icelandic Data Protection Commission (VSN b200605002&03).

The intervention

The intervention primarily focused on increasing physical activity during school hours and promoting healthy dietary habits, both at school and at home. It was a teacher-led daily implementation of various intervention tactics, which were introduced and discussed during bimonthly meetings led by the research team. During these meetings, the researchers, the teachers and principals of the participating intervention schools exchanged on ideas and updates of the intervention progression. Our implementation approach was aimed at both encouraging teachers to perform physical activity with their students and to build their necessary skills to become the implementers of change needed to positively affect the children's lifestyles. This approach was intended to serve as the bridge between theory (social cognitive theory [21]) and intervention effects. This was done by offering physical activity and dietary experts, teachers and headmasters of the participating schools a platform for dialog and reflection to work toward optimizing the integration of intervention at school. The different components of the intervention have been described in detail elsewhere [19, 20], along with an assessment of the 2-year-change in physical activity and dietary intake of the participating children. In brief, the physical activity intervention was progressive in nature where general teachers

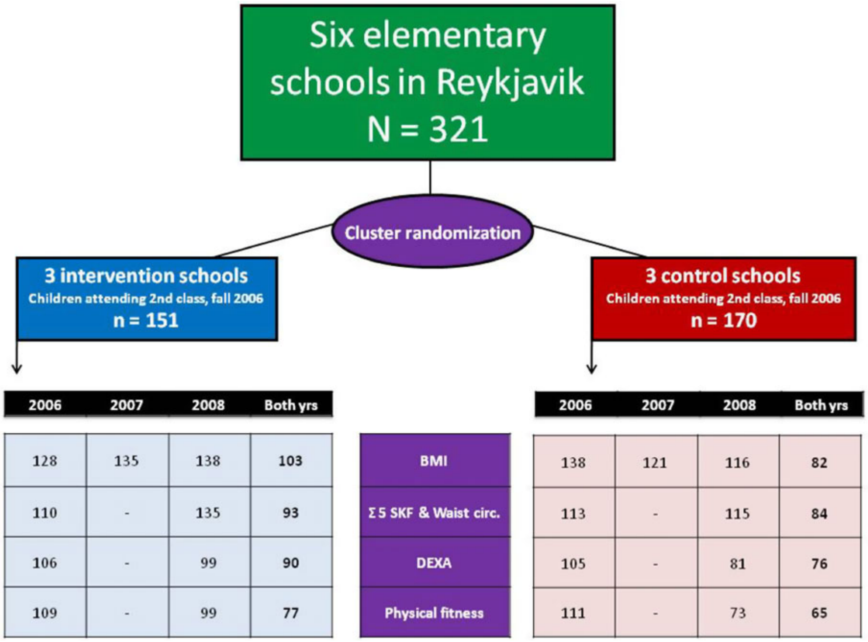

Fig. 1. Flow chart showing the number of participants in each component of the study.

implemented much of the intervention strategies and methods and integrated physical activity into the diverse subjects of the curriculum to the best of their ability. This included more frequent outdoor teaching, organized fieldtrips, promotion of active commute to and from school, one extra physical education (PE) lesson per week (three 40-min sessions per week instead of two compulsory 40-min sessions at the control schools) and more. Each of the three schools received a physical activity and nutritional teaching kit which comprised books, Digital Versatile Discs (DVDs) and equipment to use both inside the classroom and for outdoor play at their will. As the intervention implementation was at the class level, all children in each intervention class were exposed when attending school. School attendance is generally very high in Iceland and the primary reasons for children missing school are because of illnesses or occasional blizzards during the winter months. The teachers held a log-book which they used to keep track of all the different activities they performed with the children during each week of the 2-year intervention period which was used to estimate the progression of the intervention throughout the study period [19]. The dietary intervention aimed to have positive impact on dietary knowledge, awareness, preferences/taste, self-efficacy and parental influence. Nutrition education material was developed for the intervention and implemented during the latter intervention year in collaboration with teachers of the intervention schools. The main focus of the dietary intervention was on fruit and vegetable intake as the children's intake at baseline was far from meeting national food-based dietary guidelines on fruit and vegetables [20]. The teachers in the control schools knew that they were a part of an intervention study but were in no contact with the research team except during the measurement periods. Gifts were given to all children in the intervention and control schools in the form of backpacks in the fall of 2007 and athletic T-shirts at the end of the intervention period in 2008. No other incentives for participating in the study were offered to the children or the teachers in any of the schools.

Outcome measures of body composition, cardiorespiratory fitness and background variables

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/m^2)—for each child. Pre- and post-intervention body fat percentage was assessed with a dual energy x-ray scan (DEXA) ran by the same licensed radiologist at Landspitali—University hospital in Reykjavik, Iceland. Cardiorespiratory fitness (W/kg) was measured with a Monark ergometer bike using the study protocol from the European Youth Heart study [14]. This maximal ergometer test is run such that every 3 min the weight on the wheel is increased by 20–25 W, depending on the participant's weight. Each participant keeps a steady pace on the bike until exhaustion or until he or she can no longer keep a steady pace. One trained individual performed all fitness assessments both pre- and post-intervention. This person used the same verbal encouragement technique on all participants to motivate them during the test. Background variables such as parental education and measure of family income were collected pre- and post-intervention via questionnaires. Parents were asked to report their highest degree of education and to report the total family income, which was categorized into three main groups of low, middle and high income based on Icelandic reference values [22].

Data analysis

We used R (version 2.11.1, http://www.r-project.org/) to run mixed linear regression analyses to compare the measurements of the intervention and control groups, adjusting for the clustering structure of the data at the school level. We calculated *z* scores for all dependent variables at pre- and post-measurements based on gender. The primary outcome measurements were cardiorespiratory fitness (W/kg), BMI, sum of five skinfolds (mm), waist circumference (cm), lean body mass (kg) and fat mass (%). The post *z* scores were treated as dependent variables and group and gender as fixed factors, school as a random effect and the respective *z* score for the baseline measurements as a covariate. We calculated the intra-class correlation to compare the variation between schools as a fraction of the total variance. Thus, adjusted differences in *z* scores, post-intervention, were reported as the intervention effect for any given outcome measure. Analysis of covariance (ANCOVA) was used as a secondary post hoc analysis to observe the fixed effects for schools. Tukey's multiple comparison post hoc test was performed following the ANCOVA to test statistical difference in the outcome measures between all six schools. Finally, we used multilevel regression analysis to assess the association between the 2-year change in cardiorespiratory fitness and change in body fat. The 2-year change in cardiorespiratory fitness *z* score was the dependent variable in this model with 2-year change in body fat percentage *z* score as our primary independent variable, adjusting for group status and gender. The school was treated as a random factor.

Initially, the study was powered to detect a medium effect sizes (0.25 SD units) of any of the outcome measures (BMI, skinfolds, waist circumference, percentage lean mass, percentage fat mass and cardiorespiratory fitness) with 80% probability, using ANCOVA to compare the post-intervention measurements adjusting for baseline, but not taking the clustering within schools into account. The sample size estimated was 175 children at the end of the study period. We assumed a 75% participation rate and due to the length of the study we assumed an attrition rate of about 20%. Thus, to achieve an acceptable sample size, all 321 children from six schools were offered the opportunity to participate in order to provide sufficient power to test the null hypothesis. Level of significance in the study was 5% ($\alpha = 0.05$).

Results

Figure 1 shows the sample size information throughout the study for the primary outcome measures. The characteristics of the study population at baseline are shown in Table I. No statistical differences were observed between intervention schools and control schools at baseline, except the intervention school children had on average 0.43 lower BMI *z* scores than the children in the control schools (95% CI: −0.94 to 0.08), adjusted for school clustering. Children with only one measurement (either baseline or post-intervention) did not differ from the remaining children in terms of primary outcome variables at either of those time points (data not shown). No statistical differences between the two study groups comparing median family income were observed (data from questionnaires in 2006 and 2008). However, only about half of the study population answered the specified question concerning family income.

Table I. *Baseline characteristics of the study sample according to study group. Values are presented as numbers (percentages) unless otherwise stated*

	Baseline	
	Intervention (*n* = 128)	Control (*n* = 138)
Girls [*n* (%)]	65 (51)	83 (60)
Mean age years (SD)	7.3 (0.3)	7.4 (0.3)
Overweight or obesity[a] (%)	16 (13)	22 (16)
Mothers with university degree[b] (%)	62/119 (52)	73/116 (63)
Fathers with university degree[b] (%)	50/114 (44)	48/104 (46)
Families in lowest category for income[c] (%)	11/100 (11)	12/86 (14)

[a]Overweight or obesity was categorized using the International Obesity Task Force criteria proposed by Cole *et al.* [23].
[b]For cases where parents did not answer at baseline, post answers were used.
[c]The lowest category for income was total family salary of ISK 280 000–369 000, which is about twice the minimum wage (ISK 153 000) for an individual as determined by confederation of trade unions in Iceland.

Body composition and cardiorespiratory fitness

Table II shows the results of the body composition outcomes at baseline and at the end of the intervention period for both study groups. The effect sizes were in all cases small except for BMI where the adjusted difference at baseline was 0.31 SD units, although this difference was not statistically significant. Children in the intervention group increased their cardiorespiratory fitness by an average of 0.37 *z* score units, representing an improvement of 0.286 W/kg, yet these results were not statistically significant (95% CI: −0.27 to 1.01). The analysis of the maximum heart rate values during the physical test at baseline yielded no statistical difference between the study groups (△ 0.9 bpm, 95% CI: −5.2 to 7.0). At the end of the study, similar analysis showed a statistical difference of △ 3.5 bpm (95% CI: 0.3–6.7), favoring the intervention group. Overall, boys had higher cardiorespiratory fitness ($mean_{diff}$ = 0.35 *z* scores, 95% CI: 0.13–0.58) than

Table II. *Primary outcome measures in children contrasting the 2 study groups after a 2-year school-based physical activity and dietary intervention. Values are mean (SD) unless otherwise stated*

	I-schools (*n* = 90)			C-schools (*n* = 76)			Adjusted difference at the end of intervention[a]	
Variables	Baseline	After	△%	Baseline	After	△%	95% CI	*p* value
BMI	16.0 (1.8)	17.4 (2.2)	8.8	16.7 (2.1)	17.5 (2.7)	4.8	0.31 (−0.16 to 0.78)	0.14
Skinfolds (mm)	31.7 (12.2)	38.3 (16.4)	20.8	33.6 (12.4)	40.4 (17.6)	20.2	0.10 (−0.28 to 0.48)	0.52
Waist circumference (cm)	57.0 (4.7)	61.1 (6.0)	7.2	57.6 (5.0)	60.8 (6.2)	5.5	0.15 (−0.47 to 0.77)	0.53
Lean mass (kg)	19.9 (2.2)	24.6 (2.8)	23.6	20.2 (2.8)	24.8 (3.6)	22.8	−0.02(−0.14 to 0.10)	0.65
Fat mass (%)	23.8 (6.5)	24.7 (7.6)	3.8	24.9 (5.2)	26.4 (6.6)	6.0	0.06 (−0.11 to 0.23)	0.38
Cardiorespiratory fitness (W/kg)	2.59 (0.53)	2.83 (0.49)	9.3	2.41 (0.44)	2.49 (0.49)	3.3	0.37 (−0.27 to 1.01)	0.18
Maximum heart beats/min	192.7 (6.0)	194.9 (6.4)	1.1	192.3 (6.6)	192.1 (5.7)	−0.1	3.5 (0.3 to 6.7)[b]	0.038

[a]Difference in average *z* score of respective outcome at the end of the study between intervention and control schools. Adjusted for sex and baseline measurement in mixed linear model with random effects for school.
[b]Difference reported in raw scores (bpm).

girls, independent of study group, fitness z score at baseline and BMI.

The differences in mean cardiorespiratory fitness z score change over time between the study schools is depicted in Fig. 2. The results from a post hoc analysis showed that the intervention school with the highest fitness z score change was significantly different from two of the lowest control schools ($mean_{diff}$ = 0.83 z scores, 95% CI: 0.44–1.21 and $mean_{diff}$ = 0.70 z scores, 95% CI: 0.29–1.10), but it was also significantly different from the lowest intervention school ($mean_{diff}$ = 0.59 z scores, 95% CI: 0.19–0.99). Finally, the intervention school, which fell in the middle of the fitness z score change, was significantly different from the lowest control school ($mean_{diff}$ = 0.66 z scores, 95% CI: 0.29–1.03). The data were analyzed to test not only the difference in means but also to test differential effects of the intervention within subgroups by quartiles. Those results (not reported here) did not suggest that the intervention was more effective for children who were less fit at baseline compared with those who were more fit. Figure 3 shows the negative relationship between change in cardiorespiratory fitness z score and change in body fat z score over the 2 years. For every 1 SD unit change in body fat percentage the change in cardiorespiratory fitness SD units decreased on average by 0.66 (95% CI: 0.35–0.96), adjusted for gender (95% CI: −0.04 to 0.45), group (95% CI: −0.54 to 1.16) and school clustering.

Discussion

This cluster-randomized controlled trial, that successfully increased physical activity during school hours [19] and improved dietary habits both at school and at home [20], did not yield any significant effects on body composition. The results focusing on the improvements of cardiorespiratory fitness are perhaps more difficult to interpret, although they give an indication of possible intervention effects in two of three intervention schools. However, this study did provide evidence of a negative association between change in fitness and

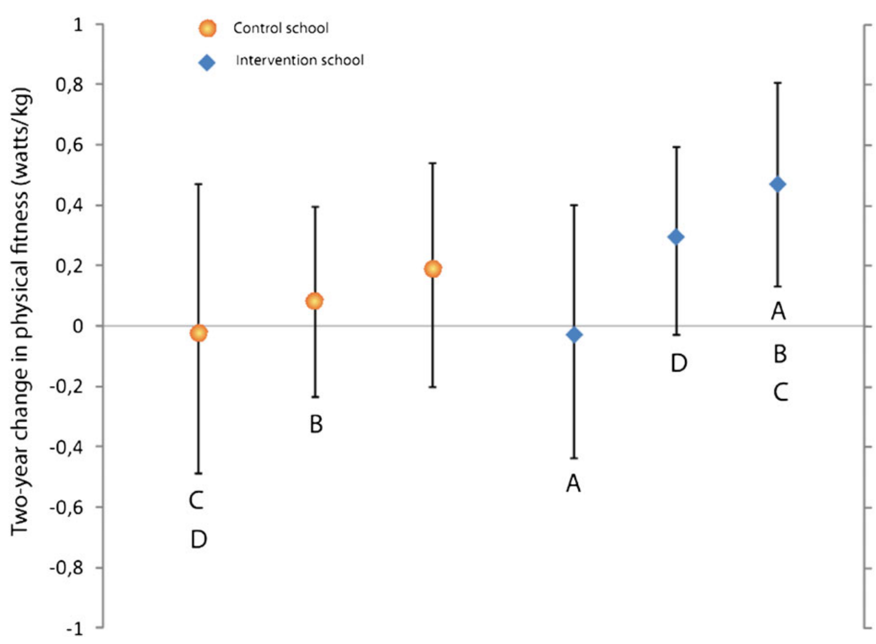

Fig. 2. Mean 2-year change of physical fitness (W/kg) scores and distribution (SD) for each participating school. The schools with the same alphabetical letter were statistically different from each other: A (P = 0.05), B (P = 0.01), C (P < 0.0001) and D (P = 0.008).

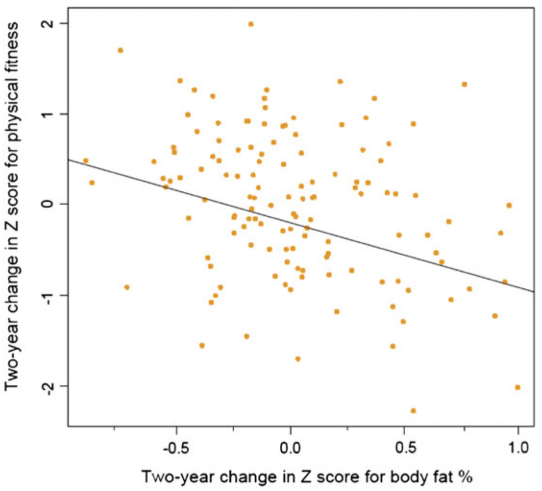

Fig. 3. Depiction of the relationship between change (z score) in physical fitness and body fat percentage over a 2-year period. The Pearson's correlation coefficient for the association between these variables was $r = -0.33$.

change in percent body fat mass over time in 7-year-old children.

A detailed description of the intervention program has been published elsewhere [19]. A subjective assessment of children's opportunity to be physically active during school hours within the intervention schools before the implementation of the intervention indicated that the teachers spent on average 37 min doing some type of physical activity with their students. However, during the most active month of the intervention implementation, the teachers reported spending on average about 70 min every school day doing some type of physical activity with their class. The results further suggest that physical activity dropped somewhat at the end of the intervention period during the fall 2008 measurements. Similarly to the above, objective assessment of physical activity by accelerometers after 1 year of intervention showed that the median of moderate-to-vigorous physical activity during school hours had increased for boys from 45 to 64 min, and for girls from 30 to 39 min. Median of total physical activity during school hours increased for boys from 830 cpm (counts per minute) to 1084 cpm and for girls from 642 cpm to 715 cpm. It was concluded that that children in the intervention schools were more active than children in the control schools after 1 year of intervention but not at the end of the intervention period.

The lack of intervention effects for BMI or any of the other body composition outcome measures are much in line with results from most school-based physical activity and dietary interventions [1, 18, 24]. Two recent studies have nevertheless shown promising results [25, 26]. Although a recent review of overweight and obesity treatments in children points out some positive advancements in behavioral therapy in the past few years, the authors realize that the long-term effectiveness of treatments is still scarce and inconclusive [27]. Harris *et al.* [18] proposed three possible mechanisms explaining the lack of effect in many of the intervention studies. Firstly, that the 'dose' of physical activity achieved was insufficient to alter children's BMI, either due to a lack of quantity in the intervention or adherence of the participants in the intervention. Secondly, the possibility that there may have been a small effect in a subset of participants, but this effect was perhaps attenuated in the assessment of the entire study population. Lastly, they contemplated the possibility that physical activity may have relatively little influence on body composition compared with dietary intake. It should be recalled that the intervention reported herein was a combination of physical activity and healthy dietary habits, yet there were no observed effects on body composition. Nonetheless, the aforementioned mechanisms apply and may have played an important role in explaining the lack of intervention effect. In addition, cross-sectional studies have generally shown weak association between physical activity and body fat in children [11, 12,28–30], partly due to the crude nature of the physical activity measurements [31]. The relative BMI change in the intervention group was less favorable (although not statistically) than in the control group. However, the effects of the intervention on changes in lean mass and fat percentage, which are much more accurate estimates of body composition than BMI, do not show the same trend. Therefore, despite significant positive changes in healthy food intake and an increase in physical activity during school hours after 1 year of intervention with a subsequent increase in physical activity during school hours throughout the latter intervention year [19, 20], the intervention was not enough to significantly affect any of the body composition outcome measures.

Cross-sectional epidemiological studies have shown that physical activity is positively associated with aerobic fitness in children although the strength of the relationship is generally weak [11, 28, 30, 32] and others have failed to confirm this relationship in 9-year-olds [12]. Several researchers have concluded that prepubescent children may be less adaptive to endurance training than adolescents and adults [12, 33, 34]. This lack of training effect could be explained by high physical activity and relatively high aerobic power in children, i.e. ceiling effect [33]. As overweight and obese children tend to have lower aerobic fitness than normal weight children [10–12], the effect of increased physical activity can therefore be expected to be higher in these children. Several school-based physical activity studies have not shown any effect on children's fitness levels [35, 36], which is likely due to interventions that lacked time during school hours of intense physical activity. However, some studies have shown that with an intensive training stimulus, prepubescent children show improvement in maximum aerobic power compared with control children of same maturation [34, 37, 38].

Physical activity has been shown to not only affect cardiorespiratory fitness but also muscular fitness in adolescents [39]. Physical activity may also affect physiological variables like exercise economy (motor development) and anaerobic (lactate) threshold without significantly changing peak oxygen consumption [37]. Although, the cardiorespiratory fitness test used in this study is highly predictive of peak oxygen uptake (cardiorespiratory fitness), the outcome is slightly affected by exercise economy and lactate accumulation [40]. There may be several explanations for the significant increase in maximum heart rate among the intervention schools in our study. First, a higher maximum heart rate indicates that the children in the intervention schools were more resilient during the fitness test than the children in the control schools. A probable reason for it not resulting in more peak workload is a lack of statistical power. The reason for higher resilience may be due to a higher anaerobic threshold, more muscular fitness or familiarity with the research personnel. In this regard, the measurement of cardiorespiratory fitness with this method may be affected by other indicators of physical fitness such as muscular fitness and motor skills.

The results from the cardiorespiratory fitness test suggest differential intervention effects between the three intervention schools as the physical activity intervention may only have significantly improved cardiorespiratory fitness among children in two of the three intervention schools. One possible explanation for these results was the fact that the school whose children did not change much over the 2-year period had on average relatively high fitness level at baseline, compared with the other five schools. Thus the room for improvement was perhaps lower than for the intervention school whose mean cardiorespiratory fitness level was low in comparison with others. Another factor that may have contributed to the lack of effect in this school was the relatively high teacher turnover rate at the school for the classes involved (e.g. maternity leave and teachers assigned to different classes by the school authorities), which may have affected the effectiveness of intervention implementation, as pointed out elsewhere [19]. Furthermore, two teachers out of the three who started the intervention implementation at the school that increased the children's fitness the most, worked with the children up until the month of May 2008 (nearly 2-year time). That was the longest stretch of time any two or more teachers implemented the intervention at any of the three intervention schools. Another potential reason for the differences between schools may have been that the intervention school with the largest increase in fitness was the school that had children with the lowest fitness at baseline, possibly introducing greater potential for improvement over the 2-year intervention period.

Our findings suggest that although school-based physical activity may have been significantly increased during school hours in this study [19], it was not enough to result in an increase in cardiorespiratory fitness in all three intervention schools. Nevertheless, a 2-year-school-based physical activity intervention program in Norway increased the cardiorespiratory fitness (peak oxygen uptake directly measured) in 9-year-old children at post-intervention [38]. The intervention had a differential effect on cardiorespiratory fitness contrasting those who had low versus high fitness at baseline and concluded that the children who initially had low fitness benefited more from the intervention than children who had higher fitness levels initially. The intervention included 60 min of daily moderate intensity physical activity in PE lessons and was implemented at only one school while another school served as control. Another, and perhaps more comparable study to the one present herein, also showed a marginally significant increase (P = 0.04) in cardiorespiratory fitness by a one school-year intervention in a clustered randomized controlled trial [26]. This intervention was based on socioecological conceptual model within nine intervention schools and six control schools. Cardiorespiratory fitness was tested by the 20-m shuttle run test [41]. This test is a maximum power-output test, as was the test used in the present study, and is thus also slightly influenced by economy and lactate accumulation. The effect size in this study was similar to that in the present study (adjusted improvements were 5 versus 6%, respectively) but had more statistical power. The present study which included three intervention schools and three control schools, showed the effect on cardiorespiratory fitness to be clustered among schools. Two of the intervention schools increased their fitness significantly more than the control school that showed the least change in fitness. Relative total fat content of the body is highly associated with aerobic fitness in children [12, 42]. This strong association is confirmed in our study as there is a relationship between changes in body composition and changes in fitness.

Strengths and limitations

The primary strengths of this study were the length of the intervention period (2 years), the objective measurements of cardiorespiratory fitness and body composition via DEXA scan and all measurements were conducted by the same trained personnel pre- and post-intervention. Since the model for this intervention depended on the teachers to implement the intervention, we must consider the relatively high teacher turnover rate in two of three intervention schools as one of the main weaknesses of this study. The reasons for this turnover rate have been discussed elsewhere [19] and were unlikely to have been the result of the study itself.

Perspectives

The results of this intervention are inconclusive as regards the effects on cardiorespiratory fitness, but the intervention does not seem to have had any effect on body composition. However, those whose body fat percentage increased over the study period were more likely to decrease in fitness, irrespective of study group. These results highlight the complicated task at hand for those who aim at positively affecting these parameters among children within the school environment where teacher's ambition and interest in healthy lifestyle is of great importance. From these results and previously reported physical activity data [19], we hypothesize that future intervention programs may need to be more aggressive when it comes to promoting intense physical activity via school-based interventions in order to positively impact cardiorespiratory fitness or body composition.

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Conflict of interest statement

The authors have no conflict of interest.

References

1. Dobbins M, De Corby K, Robeson P *et al*. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *Cochrane Database Syst Rev* 2009; **1**: CD007651.
2. van Sluijs EMF, McMinn AM, Griffin S. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. *BMJ* 2007; **335**: 703–7.
3. Ogden CL, Carroll MD, Curtin LR *et al*. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA* 2010; **303**: 242–9.
4. Pearson S, Hansen B, Sorensen TIA *et al*. Overweight and obesity trends in Copenhagen schoolchildren from 2002 to 2007. *Acta Paediatr* 2010; **99**: 1675–8.
5. Jonsson SH, Hedinsdottir M. Body Weight of Children in the Reykjavik Area. Reykjavik, Iceland: Public Health Institute of Iceland, 2010: Reportin Icelandic. Available at: http://www.lydheilsustod.is/media/manneldi/rannsoknir/Likamsthyngd.barna.a.hofudborgarsv.pdf. Accessed: 12 January 2011.
6. Ekblom OB, Bak E, Ekblom BT. Cross-sectional trends in cardiovascular fitness in Swedish 16-year-olds between 1987 and 2007. *Acta Paediatr* 2011; **100**: 565–9.
7. Eisenmann JC, Malina RM. Secular trend in peak oxygen consumption among United States youth in the 20th century. *Am J Hum Biol* 2002; **14**: 699–706.
8. Tomkinson G, Olds T. Secular changes in aerobic fitness test performance of Australasian children and adolescents In: Tomkinson G, Olds T (eds). Pediatric Fitness. Secular Trends and Geographic Variability. Med Sport Sci, Vol. 50. Basel, Switzerland: Karger, 2007, 168–82.
9. Andersen LB, Froberg K, Kristensen PL *et al*. Secular trends in physical fitness in Danish adolescents. *Scand J Med Sci Sports* 2010; **20**: 757–63.
10. Stigman SSS, Rintala P, Kukkonen-Harjula K *et al*. Eight-year-old children with high cardiorespiratory fitness have lower overall and abdominal fatness. *Int J Pediatr Obes* 2009; **4**: 98–105.
11. Rizzo NS, Ruiz JR, Hurtig-Wennlof A *et al*. Relationship of physical activity, fitness, and fatness with clustered metabolic risk in children and adolescents: the European Youth Heart Study. *J Pediatr* 2007; **150**: 388–94.
12. Sveinsson T, Arngrimsson SA, Johannsson E. Association between aerobic fitness, body composition, and physical activity in 9-and 15-year-olds. *Eur J Sport Sci* 2009; **9**: 141–50.
13. Brage S, Wedderkopp N, Ekelund U *et al*. Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children—the European Youth Heart Study (EYHS). *Diabetes Care* 2004; **27**: 2141–8.
14. Andersen LB, Harro M, Sardinha LB *et al*. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *Lancet* 2006; **368**: 299–304.
15. Telama R, Yang XL, Viikari J *et al*. Physical activity from childhood to adulthood—A 21-year tracking study. *Am J Prev Med* 2005; **28**: 267–73.
16. Harrell JS, Gansky SA, McMurray RG *et al*. School-based interventions improve heart health in children with multiple cardiovascular disease risk factors. *Pediatrics* 1998; **102**: 371–80.
17. Kann L, Brener ND, Allensworth DD. Health education: results from the School Health Policies and Programs Study 2000. *J Sch Health* 2001; **71**: 266–78.
18. Harris KC, Kuramoto LK, Schulzer M *et al*. Effect of school-based physical activity interventions on body mass index in children: a meta-analysis. *Can Med Assoc J* 2009; **180**: 719–26.
19. Magnusson KT, Sigurgeirsson I, Sveinsson T *et al*. Assessment of a two year school-based physical activity intervention among 7-9-year-old children. *Int J Behav Nutr Phys Act* 2011; **8**: 138.
20. Kristjansdottir AG, Johannsson E, Thorsdottir I. Effects of a school-based intervention on adherence of 7-9-year-olds to food-based dietary guidelines and intake of nutrients. *Public Health Nutr* 2010; **13**: 1151–61.
21. Bandura A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice-Hall, 1986.
22. Statistics Iceland. Wages. Available at: http://www.statice.is/Statistics/Wages,-income-and-labour-market/Wages. Accessed: 12 January 2011.
23. Cole TJ, Bellizzi MC, Flegal KM *et al*. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; **320**: 1240–3.
24. Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev* 2009; **10**: 110–41.
25. Gorely T, Nevill ME, Morris JG *et al*. Effect of a school-based intervention to promote healthy lifestyles in 7-11 year old children. *Int J Behav Nutr Phys Act* 2009; **6**: 5.
26. Kriemler S, Zahner L, Schindler C *et al*. Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial. *BMJ* 2010; **340**: c785.
27. Whitlock EP, O'Connor EA, Williams SB *et al*. Effectiveness of weight management interventions in children: a targeted systematic review for the USPSTF. *Pediatrics* 2010; **125**: E396–418.
28. Rowlands AV, Eston RG, Ingledew DK. Relationship between activity levels, aerobic fitness, and body fat in 8- to 10-yr-old children. *J Appl Physiol* 1999; **86**: 1428–35.
29. Ekelund U, Sardinha LB, Anderssen SA *et al*. Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old European children:

a population-based study from 4 distinct regions in Europe (the European Youth Heart Study). *Am J Clin Nutr* 2004; **80**: 584–90.
30. Butte NF, Puyau MR, Adolph AL *et al*. Physical activity in nonoverweight and overweight Hispanic children and adolescents. *Med Sci Sports Exerc* 2007; **39**: 1257–66.
31. Ekelund U, Anderssen SA, Froberg K *et al*. Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Diabetologia* 2007; **50**: 1832–40.
32. Strong WB, Malina RM, Blimkie CJR *et al*. Evidence based physical activity for school-age youth. *J Pediatr* 2005; **146**: 732–7.
33. Pate RR, Ward DS. Endurance trainability of children and youth. In: Bar-Or O. (ed.). The Child and Adolescents Athlete. London, UK: Blackwell Science Ltd, 1996, 130–7.
34. Baquet G, Guinhouya C, Dupont G *et al*. Effects of a short-term interval training program on physical fitness in prepubertal children. *J Strength Cond Res* 2004; **18**: 708–13.
35. Graf C, Koch B, Falkowski G *et al*. School-based prevention: effects on obesity and physical performance after 4 years. *J Sports Sci* 2008; **26**: 987–94.
36. Jago R, Froberg K, Cooper AR *et al*. Three-year changes in fitness and adiposity are independently associated with cardiovascular risk factors among young Danish children. *J Phys Act Health* 2010; **7**: 37–44.
37. Matos N, Winsley RJ. Trainability of young athletes and overtraining. *J Sports Sci Med* 2007; **6**: 353–67.
38. Resaland GK, Andersen LB, Mamen A *et al*. Effects of a 2-year school-based daily physical activity intervention on cardiorespiratory fitness: the Sogndal school-intervention study. *Scand J Med Sci Sports* 2011; **21**: 302–9.
39. Martinez-Gomez D, Welk GJ, Puertollano MA *et al*. Associations of physical activity with muscular fitness in adolescents. *Scand J Med Sci Sports* 2011; **21**: 310–7.
40. Arngrimsson SA, Sveinsson T, Johannsson E. Peak oxygen uptake in children: evaluation of an older prediction method and development of a new one. *Pediatr Exerc Sci* 2008; **20**: 62–73.
41. Leger LA, Mercier D, Gadoury C *et al*. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci* 1988; **6**: 93–101.
42. Lee SJ, Arslanian SA. Cardiorespiratory fitness and abdominal adiposity in youth. *Eur J Clin Nutr* 2007; **61**: 561–5.