LONG-TERM EFFECTS OF 4-YEAR LONGITUDINAL SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTION ON THE PHYSICAL FITNESS OF CHILDREN AND YOUTH DURING 7-YEAR FOLLOW-UP ASSESSMENT

Gregor Jurak[1], Ashley Cooper[2], Bojan Leskošek[1], Marjeta Kovač[1]
[1]Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia
[2]Centre for Exercise, Nutrition and Health Sciences, University of Bristol, Bristol, United Kingdom

SUMMARY

Many school-based physical activity (PA) interventions have been developed, but only a few have assessed their long-term effects. A PA intervention taking place in the first four years of some Slovenian primary schools entails an enhanced physical education (PE) curriculum, including two extra lessons of PE per week, a wider selection of PE content, and additional outdoor education delivered by both a specialist PE teacher and a general teacher. The effects of the intervention on children's physical fitness (motor tasks and anthropometry) were evaluated within a quasi-experimental study. In total, 324 children from nine Slovenian primary schools either received the enhanced curriculum (intervention (n=160)) or standard PE (control (n=164)), and were followed for a four-year intervention period and seven years post intervention. Data from the SLOFIT database were used to compare differences in the physical fitness of children each year. Linear Mixed Models were used to test the influence of the PA intervention.

Over an 11-year period, the PA intervention group significantly differed in all motor tasks, but not in anthropometric measures or body mass index, after controlling for year of measurement and sex. Differences between the control and intervention groups decreased with time.

This study highlights the importance of tracking the long term effects of PA interventions. PA intervention in the first four years of Slovenian primary school offers the possibility of improving physical performance in children; initiatives aiming to increase their performance (physical fitness, physical activity) and health outcomes are warranted.

Key words: school prevention programmes, physical education, physical development, childhood obesity, motor performance, long-term effects

Address for correspondence: G. Jurak, Faculty of Sport, Gortanova 22, SI-1000 Ljubljana, Slovenia. E-mail: gregor.jurak@fsp.uni-lj.si

INTRODUCTION

Poor physical fitness in childhood and adolescence is associated with many preventable diseases in adulthood, and represents a serious current and future public health problem (1). Regular physical activity (PA) can lead to improvements in numerous physiological and morphological variables in children and adolescents (2) and forms the basis for many interventions (3–11). Schools have been a popular setting for such interventions, as they offer continuous, intensive contact with children, and the school infrastructure and physical environment, policies, curricula, and staff have the potential to positively influence children's health. There are many school-based PA intervention programmes throughout the world, differing in setting, duration and content. Reviews of these intervention programmes (3, 5, 6, 10, 11) show that school-based PA intervention programmes may help children and adolescents attain a higher PA level and a healthy weight, but the results are inconsistent and short-term.

Many school-based PA interventions have been based upon physical education (PE) classes (5, 6), since PE serves both to prepare students to be physically educated persons, teaching them the importance of regular PA for health and building skills that support active lifestyles (12–15), and promotes motor development and physical fitness which are closely related to children's cognitive and emotional-social development (16–18). One such PA intervention programme has been delivered in Slovenia since 1984, and is currently offered by 7% of primary schools (19). The intervention comprises extra volume and quality of PE, offering extra time spent in PE, enhanced delivery and a greater range of opportunities for outdoor physical activities and sports. The programme is carried out with the permission of the school council, and the organisation and contents supplement the curriculum.

One of the important outcomes of such school-based PA interventions is the programme's potential influence on the physical fitness of children. Previous studies (20–23) have shown the positive effects of such a PA intervention in Slovenian schools on the physical fitness of children, yet all these studies were limited to assessing physical fitness at the end of intervention and did not explore longer term maintenance of fitness changes. The present study sought to determine to what extent the effects of this four-year PA intervention programme on the physical fitness

of children were maintained during the intervention period and for up to seven years after the intervention.

MATERIALS AND METHODS

Participants

The sample consisted of 324 children from 27 classes from nine Slovenian primary schools. Schools were from urban locations in different regions of Slovenia, and were eligible for inclusion if they offered both standard PE and enhanced PE classes. All schools that met this criterion were included in the study.

The sample comprised 74 girls and 86 boys attending enhanced PE classes (intervention group) and 84 girls and 80 boys receiving standard PE (controls). Baseline age in both groups was similar (intervention group mean 7.76, SD 0.33; control group mean 7.71, SD 0.32).

Instruments

Data were collected within SLOFIT, the Slovenian system for monitoring children's physical fitness, which was first implemented in 1987 (24). The SLOFIT test battery includes eight motor tests (arm plate tapping, standing long jump, polygon backwards, sit-ups, standing reach touch, bent arm hang, 60-meter run, and 600-meter run), and three anthropometric measurements (body height, body weight and triceps skinfold thickness). Measurements are taken annually in April during PE classes. All measurements are conducted according to the standard protocol by trained PE teachers who have completed a 30-hour course in anthropometric measurement and a 15-hour course in the measurement of motor function. To include and evaluate children's measurements in the SLOFIT system, and to use the data for scientific purposes, children are required to provide the written consent of their parents; throughout the existence of this system, the response rates have remained above 94% in primary schools and between 60% and 86% in secondary school. Currently, about 210,000 children and adolescents take part in SLOFIT every year.

PA Intervention

The enhanced PE programme aims to positively influence the physical and motor development of children, and to build skills that support active lifestyles. The programme is delivered in the first four years of schooling, and includes three standard PE lessons (45 minutes per lesson) delivered by general teachers and two extra lessons of PE per week, delivered with the joint teaching of a specialist PE teacher and a generalist teacher. The lesson content and structure are determined by the specialist teachers. In addition, the enhanced programme includes a wider selection of PE content (e.g. other sports), which can also be conducted outside of school. The intervention lessons usually take place in the middle of the daily schedule. The PE activities that schools offered in courses were also usually organised during the educational process and less frequently after school hours, on holidays or on weekends (19).

Design

The study was quasi-experimental, with the school as the unit of intervention. To exclude as many environmental factors as possible (conditions for PE offered by individual schools and the impact of the school social environment), nine primary schools that performed both PA intervention and regular classes (control group) were selected in the study (23).

The SLOFIT database was used to extract the annual data for the eight motor tests and the three anthropometric measurements for every child included in the eleventh year of schooling (after four years of intervention and seven years post-intervention). The baseline and all follow-up measurements took place at primary and secondary schools during PE lessons every April from 2000 to 2010.

Data Analysis

A linear mixed model was constructed for each dependent variable (all eleven tests from SLOFIT and body mass index) to test the influence of the intervention on the physical fitness of children controlling for sex and year of measurement. Body mass index (BMI) was calculated from body weight and height as weight (in kg) divided by squared height (in m). A total of 445 students were involved in the study, however, 121 students were excluded from the analysis (27.2% drop-out) due to high proportions of randomly occurred missing values (most of drop-out occurred from nine to eleventh year of schooling, when children attended high schools), while for students with less than three missing values in each year, missing data were imputed using the EM algorithm. Hence, sample consisted of 324 students (Table 1).

The R 2.13 (http://r-project.org) programming environment with nlme library and lme procedure function was used for model construction. Default options for all arguments of the function were chosen (i.e. restricted maximum-likelihood method for model fit, no within-group correlations, and homoscedastic within-group errors). After testing of several models for goodness of fit and parsimony (taking statistical significance of model effect, AIC and BIC criteria into account), programme, year, gender and programme: year and year: sex interactions were used as fixed effects and subject (within class), class (within school) and school as random effects. nlme ANOVA function was used to evaluate fixed effects of the model.

Table 1. *Description of the number of participants in the study*

Students involved in the study	Control	Intervention	Total
Boys	115	113	228
Girls	114	103	217
Total	229	216	445
Drop-out			
Boys	35	27	62
Girls	30	29	59
Total	65	56	121
Analysed sample of students			
Boys	80	86	166
Girls	84	74	158
Total	164	160	324

RESULTS

Only small differences were observed between the intervention and control group in the morphological variables at baseline. The children from both groups had similar physical development (Fig. 1), becoming taller and heavier. The results for triceps skinfold thickness differed by sex, with girls gaining subcutaneous fat throughout the observation period (7- to 17-year-olds) and the boys losing it after the fourth year. Analysed by intervention arm, at the end of the PA intervention programme (4th year), the intervention group had increased their triceps skinfold thickness in comparison to the control group; however, differences at the end of the observed period (11th year) were similar to the baseline.

The children from both groups had also similar motor development (Fig. 2). Differences were found between the intervention and control group in motor variables at baseline, with children from intervention group generally having better results in all motor tests (lower results in the tests polygon backwards, 60-m and 600-metre run mean better fitness) in the observed period. It can be seen that differences between groups remained the same or became smaller throughout the 11-year period. In particular, the trend of decreasing the differences after the end of intervention (4th year) can be observed in the polygon backwards, sit-ups, bent arm hang, and 600-metre run.

After controlling for year of measurement and sex, the programme groups (intervention/control) significantly differed in all motor tasks, but not in anthropometric measures. However, there was an interaction with time in six of the eight motor tasks as well as in BMI and triceps skinfold programme (Table 1). ANOVA for the fixed mixed-model effects also revealed that the sex and age of students had much stronger impacts on physical fitness than the programme. As expected from results presented in Figures 1 and 2 most of year: sex interactions (except for sit-ups and bent arm hang) were statistically significant.

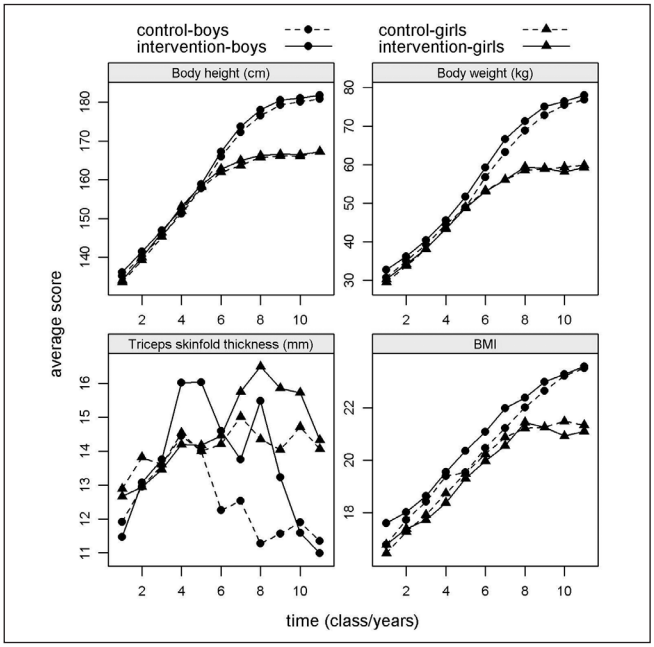

Fig.1. *Mean values of morphological variables by time (year of observation), programme and sex.*

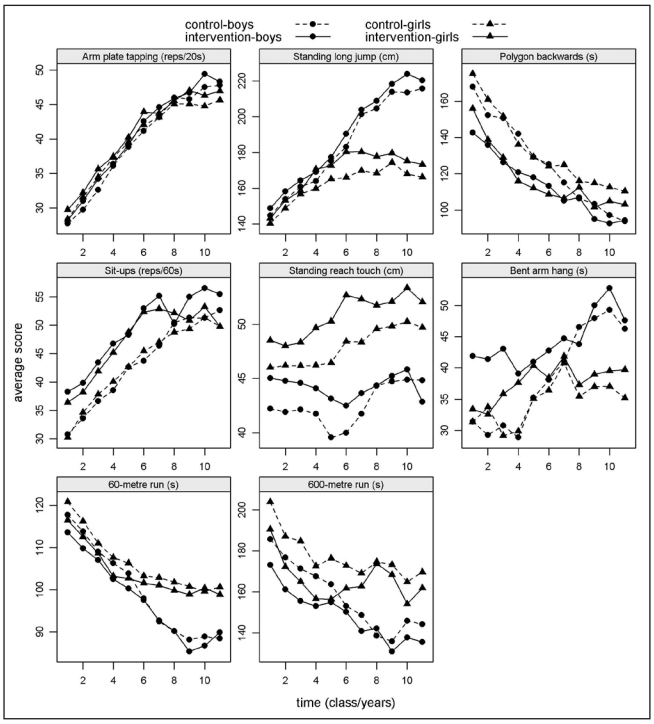

Fig. 2. *Mean values of motoric variables by time (year of observation), programme and sex.*

DISCUSSION

This study showed that the enhanced PA intervention programme delivered in the first four years in some Slovenian schools had limited long-term impact on children's physical fitness in comparison to standard PE classes. The post intervention evaluations showed that the intervention group continued to achieve better results than the control group, but differences between the groups decreased with increasing time of follow-up, especially in the polygon backwards, sit-ups and 600-metre run tasks. Therefore, this PA intervention programme is in line with other interventions in which the obtained positive intervention effects could not be sustained (25–27).

The PA intervention in Slovenian schools is a long-term intervention, in contrast to the majority of interventions elsewhere using supervised programmes of moderate to vigorous physical activity of 30 to 45 minutes, three to five days per week, which last less than six months (3). In the four-year period of the intervention, 280 more lessons of PE were delivered (total of 700 lessons) to the intervention group, and positive short and long-term effects would be expected. However, the results do not confirm this expectation, raising questions about the reasons for this.

The physical development of both groups was as expected for the age group (7 to 17 years) and time of study (2000–2010). Subcutaneous fat increased in both sexes to the age of 10 and then decreased in boys, with girls continuing to gain fat (28, 29). The secular trend of an increasing proportion of overweight and obesity in boys than in girls also should be mentioned, especially among 11- to 13-year-old boys, who already show a prolongation of gain of subcutaneous fat (30).

Long-term interventions have the advantage of maintaining positive health-related behaviours (31), yet despite this PA intervention had no significant effect on BMI or adiposity. Such

Table 2. *Statistical significance for ANOVA for standardised values of variables by programme, year of observation (age of students), sex, programme: year interaction and year: sex interaction*

	ANOVA for the fixed mixed-model effects				
	programme	year	sex	programme: year	year: sex
Body height	0.190	<0.0001	<0.0001	0.782	<0.0001
Body weight	0.624	<0.0001	<0.0001	0.118	<0.0001
BMI	0.940	<0.0001	<0.0001	0.010	0.001
Triceps skinfold thickness	0.848	<0.0001	<0.0001	<0.0001	<0.0001
Arm plate tapping	0.001	<0.0001	0.733	0.206	<0.0001
Standing long jump	0.001	<0.0001	<0.0001	0.003	<0.0001
Polygon backwards	<0.0001	<0.0001	0.017	<0.0001	0.000
Sit-ups	<0.0001	<0.0001	0.372	0.000	0.134
Standing reach touch	0.000	<0.0001	<0.0001	0.012	<0.0001
Bent arm hang	0.008	<0.0001	0.015	0.348	0.229
60-metre run	0.009	<0.0001	<0.0001	0.014	<0.0001
600-metre run	<0.0001	<0.0001	<0.0001	0.013	<0.0001

non-effectiveness has also been observed in some other PA interventions (32–36). Studies using objective methods to investigate the relationship between PA and adiposity have shown conflicting results, some studies show overweight status or adiposity to be inversely related to PA (37, 38) whilst others report no association (39–42). In addition, the study of Ekelund et al. (43) showed that only obese children, and not overweight children, are involved in less PA than their normal-weight peers.

The initial differences in motor tests indicate that children with better physical fitness more frequently enrolled in the enhanced PE programme, which was confirmed also in previous studies (22, 44). One possible explanation may be that children enrolled in the PA intervention have parents with more positive attitudes to an active lifestyle, and who are prepared to pay for such a lifestyle (45), though the monthly contribution (€11.40 on average) is not so high that most parents cannot afford for their children to attend the PA intervention (19). Assuming greater family support for children in the PA intervention programme, it might be expected that these children take part in more frequent out-of-school PA than others. The decrease of differences in physical fitness after intervention suggests some other possible explanations. In an overview of findings from PA interventions, De Meester et al. (6) found that improvements in PA levels by school-based interventions are limited to school-related PA with no conclusive transfer to leisure time PA. Specifically, although most school-based programmes intended to achieve a change in lifestyle habits and did not intend to restrict their intervention to changes in school-related PA, intervention in a school setting could have unintentionally focused more on the mechanisms of behaviour change for school-related PA.

One more possible explanation, which should be more thoroughly investigated, is that schools offering the enhanced PE intervention also have a higher level of PE in classes within the regular PE curriculum as a result of the positive transfer of knowledge between generalist teachers (44). In support of this assumption, results of previous study, in which a standardised comparison of physical fitness of interventional and control groups with physical fitness of population was performed, found that children from the control group improved in motor tests in comparison to the population during time of PA intervention. At the end of intervention, the control group also achieved above-average results in motor tests (23).

Therefore, studying the long-term effect of PA intervention remains an even more challenging task. It seems that PA intervention has positive effects, yet its long-term efficiency is questionable. Many factors should be controlled and some other possible outcomes in addition to the physical fitness of children should be investigated to obtain better insight into the impact of PA intervention.

Limitations

There are limitations to our study, and care should be taken in generalising it to different countries, since there are considerable differences in the organisation and contents of PE curricula and PA interventions around the world. The study was a quasi-experiment and did not control for many important environmental and social factors influencing the physical and motor development of children, although we attempted to control for those factors by sampling classes for the intervention and control groups from the same schools. However, this could also be a weakness due to the possible transfer of knowledge of planning and performing PE among teachers in the intervention and control groups. We were unable to gather the information on teachers' actual PE planning and teaching competencies, which surely influence the quality of curriculum delivery. We also have no information on whether the children's out-of-school activities affected the results.

CONCLUSIONS

The results of the study reveal the shortfalls of current work in the studied PA intervention. Since less positive results were found in interventions that targeted also other health behaviours in addition to PA (26, 46–48), it is recommended that the focus in intervention in Slovenian schools remain on PA, yet the changes should be made to achieve better maintenance effects of the in-

tervention on physical fitness. On the basis of the findings from other PA interventions (46, 47, 49–52), better effectiveness could be achieved by:

- introducing more health-oriented contents in PE lessons in programme;
- inclusion of more cooperative, fitness and goal-oriented activities in PE lessons;
- providing sports equipment during recess periods and extracurricular schoolwork;
- parental involvement and support through homework assignments and through supervision.

In addition, the development of the PA intervention should be underpinned by the transfer of knowledge of planning PE, as it has been found that generalist teachers lack skills in this area (53). With the increased competencies of teachers, it will be possible to utilise more moderate-to-intense PA of children as the amount of time that children spend at school is rising. Therefore, children could participate in proper intensity PA as part of their extracurricular schoolwork.

The different school environments (i.e. working hours of parents, socio-cultural status, sports facilities and natural environment, partnership with multiple parties) and the autonomy of teachers require the flexible organisation of PA intervention according to the specifics of the particular school situation and the teacher's competencies, yet it must still serve the same purpose: to build knowledge and skills that support active lifestyles, which should be manifested in better physical and motor development of children. To obtain a more comprehensive picture of the effects of PA intervention, other maintenance effects, such as the socialisation, physical self-concept and academic achievement, should also be studied.

Conflict of Interest

None declared

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