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ORIGINAL ARTICLE

Improving motor fitness in primary school children through a school based intervention

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Abstract

The aim of this study is to establish the effects of specially programmed circuit training on physical fitness in primary school children. A total of 58 (28 girls) primary school children aged 11-13 (experimental group 12.2±1.2, control group 12.4±1.1) years voluntarily participated in this study. Physical fitness of children is assessed based on motor skills, through the following tests: abdominal muscle endurance - Sit-ups test, upper body strength and muscular endurance - Bent-arm hang test, upper-body muscular endurance - Push-ups test, muscular strength and power of the lower limbs - Standing broad jump test, agility and speed - 4x10m test and flexibility - Sit and reach test. During the regular classes of physical education, the experimental group conducted a circular training lasting 15-20 minutes, at the same time control group practiced exercises that were in accordance with the plan and program of teaching physical education for a particular teaching unit. The treatment lasted for 15 weeks, with two classes of physical education per week. The results for the standing broad jump indicated significant differences between groups following 15 weeks. Furthermore, the group that participated in the circuit training program made significantly greater gains compared to the control group ($p<0.05$) in bent-arm hang, sit-ups and sit and reach. The results for the 4x10m test indicated no significant differences in time, group and their interaction ($p\geq0.05$). To conclude, circuit training appears to be an effective way of improving physical fitness in primary school children. The results of this study indicate that this method was more effective for performance than traditional school program.

Keywords school • training • motor abilities • effects

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Introduction

The development of physical fitness and its maintenance at the optimal or desired level represents one of the basic tasks of teaching physical education. During childhood, physical fitness is a strong predictor of health (Smith et al., 2014). In children, physical inactivity is associated with increasing prevalence of cardiovascular risk factors (Jimenez-Pavon et al., 2013). For this reason, more attention is being paid to assessment and improving physical fitness in children.

Muscular strength and endurance, as well as flexibility, are physical fitness components that are largely responsible for a person's good postural status. The results of the study (AVENA) indicate that there is an inverse relationship between so-called muscular fitness and risk factors that lead to cardiovascular diseases (average triglyceride, cholesterol, glucose values) in adolescent girls (Ortega et al., 2008). The fact is that physical fitness represents a certain kind of marker of good cardiovascular health and therefore should be included in the process of continuous monitoring and testing, or in the so-called health monitor system (Ruiz et al., 2006). Since the eighties of the last century until the present, the concept and notion of physical fitness has evolved so much that it is today perceived as an integral measure of almost all, if not all, functions of the organism (skeletal-muscle, cardio-respiratory, hemato-cirricular, physiological and neurological and endocrine-metabolic) which were involved in everyday physical activities or physical exercises of a person (Ortega et al., 2008). The concept of physical fitness continues to develop so that the so-called Medical batteries, except various measuring instruments (tests) for assessing cardio-respiratory and muscular endurance, muscular strength, flexibility and body composition, include assessments of metabolic components of fitness (Malina & Katzmarzyk, 2006). The term metabolic fitness is used when estimating lipids in a serum (cholesterol), triglycerides, blood pressure, blood glucose, and other risk factors for cardiovascular disease (Malina & Katzmarzyk, 2006).

The development of fitness in children is influenced by individual differences during maturation, especially during adolescence. For example, in a sample of children of the same age, children that mature earlier (accelerators), regardless of sex, are generally higher and heavier, have greater absolute power and greater maximum oxygen consumption than those who are late in maturing (Malina & Katzmarzyk, 2006). Regardless of the changes and improvements in the systems of monitoring students during physical education in other countries and the recently adopted model of monitoring physical development and development of physical fitness of students in schools, there is still a noticeable increase in obesity with reduced physical activity. Due to this fact, it is of great significance to explore the possibilities of establishing new programs in order to develop the physical fitness of students during the physical education classes in primary schools. Therefore, the aim of this research is to determine the influence of specially programmed circuit training on fitness in primary school children.

Method

A total of 58 (28 girls) primary school children aged 11-13 years (experimental group 12.2±1.2, control group 12.4±1.1) voluntarily participated in this study. They were divided into experimental (30) and control (28) group. Children's characteristics are presented in the Table 1. Before the start of the research parents reported, through the questionnaire, the health history and current activity status of their child and only healthy children from 11 to 13 years old were chosen. All the children had two classes per week and were not involved in additional strenuous training during this study. Participants were excluded if they had any chronic disease or condition that would limit their efficiency during exercise. They were also excluded if they missed two consecutive classes during the research period. The study was approved by the Research Ethics Committee of the Faculty of sport and physical education in Novi Sad.

Table 1. Basic anthropometric characteristics of the study participants; values are Mean (±SD)

	Experimental group (N=30)	Control group (N=28)
Variable	Mean±SD	Mean±SD
Age (years)	12.2±1.2	12.4±1.1
Body height (cm)	154.75±5.78	153.99±6.18
Body weight (kg)	48.16±11.50	50.06±12.78
BMI (kg/m^2)	16.49±2.86	16.97±3.74

Children's anthropometric characteristics and components of fitness were measured early in the morning and 24h from the last high-intensity exercise effort. Measurements were taken in the late September with final measurement in December. All study procedures took place at a school athletic facility. The same instructors tested and trained the same participants, and the fitness tests were performed in the same order with identical equipment, positioning, and technique. All participants took part in one introductory session during which each fitness test (time of performance, correct form and technique) were reviewed and practiced. During this session assistants demonstrated proper testing procedures and participants practiced each test. After the training program, the subjects were instructed to perform the tests in the same order as they did before the training program.

Participants were asked not to perform any vigorous physical activity the day before or the day of any study procedure. Basic anthropometric characteristics (Body weight and Body height) were measured, in accordance with the IBP program, on the day of the testing. Before each testing, the participants performed a standard 20-minute warm-up. Standard warm up protocol consisted of 10min of warm up running and 10min of dynamic stretching and 5x30m of running exercises.

Physical fitness of children was estimated by the following tests: Sit-ups, Bent-arm hang, Push-ups, Standing broad jump, 4x10m and sit and reach. Most of the tests are briefly described in Bala, Krneta, & Katić (2010).

Sit-ups with crossed arms: The subject lies on the back, knees bent, arms crossed on the chest, and performs sit-ups, feet being held fast by an assistant. The number of correctly executed sit-ups in 60 s is recorded. This test assesses abdominal muscle endurance.

Bent-arm hang: The subject grips the bar, fingers on top and thumb underneath, pulls up (chin above the bar) and holds the position as long as possible without resting the chin on the bar. Time is measured in 0.1-s units. This test assesses upper body strength and muscular endurance.

Push Ups: The participant assumes a prone position on the floor with hands placed under or slightly wider than the shoulders, fingers stretched out, legs straight and slightly apart, and toes tucked under. The subject pushes up off the floor with the arms until the elbows are straight while keeping the legs and back straight. The back should be kept in a straight line from head to toes throughout the test. Then, the participant lowers the body using the arms until the elbows bend at a 90º and the upper arms are parallel to the floor. This movement is repeated as many times as possible, finishing when the subject stops, when the subject does not perform the push up completely or when subject does not keep the right position. This test assesses upper-body muscular endurance (Castro-Piñero et al., 2009).

Standing broad jump (SBJ): The subject jumps with both feet from the reversed side of Reuter's bounce board onto a carpet with scale. The jumping distance (in cm) is recorded from take-off line to the nearest point of contact on the landing (back of the heels). Result is the longest distance jumped, the best of three attempts. This test assesses muscular strength and power of the lower limbs.

The 4x10m shuttle run test was performed according to a previous description (Ortega, et al, 2008). Two parallel lines were drawn on the floor 10m apart. The participants ran as fast as possible from the starting line to the other line and returned to the starting line, crossing each line with both feet every time. Every time the participant crosses any of the lines, he/she should pick up (the first time) or exchange (second and third time) a sponge that has earlier been placed behind the lines. The person who measured the time was situated at the starting line and stopped the stopwatch when the participants crossed the line with one foot. The time taken to complete the test was recorded to the nearest tenth of a second. Participants wore sport shoes and performed the test twice with one-minute rest and the best time was selected. The 4x10m shuttle run test measured with the stopwatch is valid and reliable to assess motor fitness and has been recently included in health-related fitness test battery for children and adolescents (Ruiz et al., 2011). This test assesses agility and speed.

Flexibility (sit and reach). This test is part of the FITNESSGRAM battery (Welk, & Meredith, 2008). The subjects attempted to reach forward as far as possible from a seated position with both legs straight and without bending the knees. Two alternative repetitions were carried out and the best attempt was recorded.

Table 2. PE class and circuit training

P.E. class	Experimental program
- Warm up	- Warm up
- PE unit	- PE unit
- Drills	- Circuit training
- Cool down	- Cool down

The experimental group had circuit training (15-20 minutes) twice per week on non-consecutive days for 15 weeks, during the regular classes of physical education. Coach specialist discussed and demonstrated proper drills procedures during one week, and children had an opportunity to ask questions. The duration of circuit training was recorded, with drills typically lasting 15-20 minutes. Besides these drills, usual physical education classes were performed. Each class consisted of a warm-up period (5-8 minutes), PE unit phase (15 to 20 minutes) and circuit training (10–15 min), following 5 minutes of cool down. During the warm-up period subjects performed a series of six to ten mobility exercises. The exercises included push-ups, planks, burpees, half squat, shuffles, medicine ball throws. Each station lasted 20-30 sec with the same amount of rest after which students change places. Session included 2 circuits with 2 minutes rest between circuits. Participants in control group only attended their regular PE classes twice per week during the study period, under the guidance of a PE teacher.

Descriptive characteristics were calculated for all variables. Independent sample t-test was used to evaluate differences between groups before experiment. The normal distribution of data, before and after treatment, was tested using Kolmogorov-Smirnov test. A two-way repeated measure ANOVA (2 × 2) was used to test for interactions and main effects for time (initial vs. final) and group (experimental vs. control) on the dependent physical fitness variables. Statistical analyses were conducted in SPSS (SPSS, Version 18.0, Chicago; IL). Statistical significance of differences was established a priori at $p < 0.05$ to test the hypothesis that experimental group would be more effective than control in improving physical fitness measures in children.

Results

The Kolmogorov-Smirnov test showed that the distribution of the results in the applied variables were not statistically significantly deviate from the normal distribution. The independent sample t-test showed that there were no statistically significant differences between groups in all variables before the applied program. The group that participated in the circuit training program made significantly greater gains compared to the control group ($p < 0.05$) in standing broad jump, bent-arm hang, sit-ups and sit and reach (Table 3).

Table 3. Mean±SD results of different parameters: strength, jumping, and running performance before the experimental period (initial) and after the 15-week experimental period (final).

	Experimental group (N=30)			Control group (N=28)		
	Initial	Final		Initial	Final	
Variable	Mean±SD	Mean±SD	EF	Mean±SD	Mean±SD	EF
Sit-ups (n/60s)	25.06±4.26	30.16±5.05*	1.09	26.10±5.31	27.56±5.45	0.27
Bent-arm hang (s)	33.05± 15.67	43.53±14.12*	0.70	32.23±16.47	33.27±15.37	0.06
Push-ups (freq.)	11.80±3.40	16.13±3.07*	1.34	10.33±4.17	12.80±4.32*	0.58
Standing broad jump (cm)	126.65± 14.68	137.56± 13.56*	0.77	124.66± 16.44	128.70± 17.56	0.24
4x10m (s)	13.23±1.09	12.87±1.05	-0.34	13.35±1.12	13.19±1.07	-0.15
Sit and reach (cm)	26.34±3.13	31.16±2.67*	1.66	27.47±4.16	29.38±4.21	0.46

Legend: * Significantly different from initial, $p<0.05$; EF - effect size

The results for the Push-ups indicated no significant differences in repetitions, but there was a significant main effect for time. The results for the 4x10m test indicated no significant differences in time, group and their interaction ($p \geq 0.05$).

The experimental group, which was involved in circular training, made significantly greater gains in the final measurement compared to the initial measurement in SBJ (ES=0.77), Bent-arm hang (ES=0.70), Push-ups (ES=1.34), Sit-ups (ES=1.09) and Sit and reach (ES=1.66). Control group made significantly greater gains in the final measurement compared to the initial measurement only in Push-up (ES=0.58). Effect size was classified according Hopkins, Marshall Batterham, & Hanin (2009).

Discussion

The present study researched the effects of circuit training during PE classes on fitness components in primary school children. The primary finding of this study was that participation in a circuit training program produced greater improvement in physical fitness than traditional physical education lessons in primary school children after 15 weeks of training. To measure explosive power, we used Standing broad jump. Significant improvement was observed for circuit training group in jumping test. These results demonstrate that specific circuit training, as part of the overall physical education process, can be considered as useful tool for the improvement of jumping ability. One earlier study showed the positive impact of interval running training on power (vertical jump performances) (Adeniran & Toriola, 1988). On the contrary, Krističević, Sporiš, Trajković, Penčić, & Ignjatović (2016) have used game-based approach and found no significant improvements in jumping performance in young female children.

In our study there was a significant improvement in bent-arm hang, sit-ups and push-ups in experimental group. Performance gains in the push up test following circuit training were similar to control group concerning the fact that push-ups are the most frequent exercise in PE programs. Furthermore, training intervention did not include exercise specifically designed to enhance core strength except for one exercise. However, it is possible that the performance of other movements with proper exercise technique contributed to improvement in sit-ups for experimental group. During a 15-week intervention program Bronikowski et al. (2016) found that there are statistically significant differences in the final measurement compared to the initial in the Sit-ups, 20-meter shuttle run and handgrip. In the present study, the circuit training has not produced a significant improvement in 4x10m shuttle run test. The content of circuit training had more resistance exercise which might explain why the improvement didn't occur. Vestraete, Cardon, De Clercq, & De Bourdeaudhuij (2007) did not find statistically significant differences in motor skills using a Eurofit test battery in primary school children.

A novel finding from the present investigation was that 10-15min of circuit training performed twice per week resulted in significantly greater gains in physical fitness measures than normally achieved with standard PE in children. Since both groups participated in the same traditional PE lessons during the study period, such differences in fitness performance are likely due to the specific training adaptations that resulted from circuit training. One study found that the circuit training in British primary school children had a positive impact on BMI compared to the control group (Duncan, Al-Nakeeb, & Nevill, 2009). Moreover, it was reported that 6 weeks of circuit-based exercise resulted in improvements in body image compared to controls (Williams & Cash, 2001). One recent study suggests that it is possible to develop and maintain muscular and cardiovascular endurance through a circuit short-term program conducted in physical education program (Mayorga-Vega, Viciana, & Cocca, 2013). Nevertheless, discrepancies in the results are possible due to different pedagogical approaches employed in physical education teachers (McKenzie, Sallis, Kolody, & Faucette, 1997). Schools are considered as the best setting in which a healthy lifestyle can be promoted also in children with low fitness levels (Ortega et al., 2008). A school based multi-component physical activity intervention, including compulsory elements, can improved physical activity and fitness (Kriemler et al., 2010). Therefore, one of the main strategies of education should focus on giving health a more important role in the Educational System.

Future studies should focus on programs based on stations with games because children find it hard to support the traditional fitness training (Wall & Côt, 2007). Therefore, the limitation of the present study was that the applied program was not made up of more playful tasks. At these ages in PE classes it is important to develop contents mainly through fun activities. Future interventions should focus on physical fitness programs based on stations with games.

To conclude, circuit training appears to be an effective way of improving fitness in primary school children. The results of this study indicate that this method was more effective for performance than traditional school program. From a practical viewpoint, these findings demonstrate that circuit training should be implemented in regular curricula to enhance the physical characteristics of children. Teachers and coaches could use this information in the process of planning the program in schools and teams.

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