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Effects of A 6-Month Football Intervention Program on Bone Mass and Physical Fitness In Overweight Children

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Abstract

Introduction: Physical activity is an important medium for improving bone mass and physical fitness of children, and as such is often emphasized in intervention programs with overweight/obesity children. Only few studies have examined the impact of a specific team sport intervention on the bone mass and physical fitness in overweight children. This study examined the effects of a 6-month football intervention program in bone mass and physical fitness of overweight children.

Methods: Nine boys (8-12 years; body mass index ≥ 85th percentile) participated in a structured 6-month football program, consisting of four weekly 60-90 min sessions with mean heart rate > 80%HRmax [football group (FG)]. A control group (CG) included eight boys of equivalent age from an obesity clinic located in the same area as the school. Both groups participated in two sessions of 45-90 min physical education per week at school. Bone mass indicators included whole-boy and lumbar spine bone mineral density (BMD) and bone mineral content (BMC). Physical fitness tests included 5- and 30-m sprints, countermovement jump (CMJ), and Yo-Yo intermittent endurance test level 1 (Yo-Yo IE1). Body composition was evaluated using dual-energy X-ray absorptiometry. Statistical procedures included unpaired *t* tests and repeated measures ANOVA models.

Results and discussion: From baseline to after 6 months, FG demonstrated greater increases in in lumbar spine BMD (%Δ= +4.3, p<0.05) and CMJ (%Δ= +28.9; p<0.05) compared to CG. For the other bone and physical fitness variables assessed, although FG has shown a higher increase in mean values across intervention, no significant differences were found between groups (p>0.05).

Conclusions: These findings suggest that a 6-month football intervention program in overweight children was effective on improving lumbar-spine BMD and muscle strength.

Keywords: Overweight children; Football intervention; Bone mass; Physical fitness

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Introduction

Childhood obesity has reached epidemic proportions and has become a major public health concern (World Health Organization, 2013). The increasing prevalence of childhood obesity is associated with a range of adverse health effects, including increased incidence of type 2 diabetes and elevated risk of cardiovascular disease [1]. Although the physiological health consequences of childhood overweight and obesity are well established, bone health consequences associated with obesity are considered less often [2].

Physical activity (PA) is accepted as an effective treatment for childhood overweight and obesity and associated comorbidities [3]. Football is one of the most popular, affordable, and widely practiced team-sports worldwide and has been recently suggested as a very effective strategy to stimulate musculoskeletal, metabolic and cardiovascular adaptations of importance for adult health [4]. Football practice is associated with relatively high energy expenditure and involves high impact activities which stimulate the muscular-skeletal system. The efficacy of a recreational football program on health and psychological well-being of overweight children has been recently investigated [5-8]. While no detailed about the effects of a recreational football program on bone mass and physical fitness were assessed, this novel data suggested that football has a high positive effect in weight control. Given this novelty, we believe that football being a highly popular sport, socially and culturally meaningful and accessible to all social strata has an increased potential to operate as an effective strategy to improve bone mass and physical fitness.

Thus, the present study examined the effects of a 6-month football intervention program on bone mass and physical fitness of overweight children.

Material and Methods

Participants

The football group (FG) consisted of 9 overweight boys recruited from a single school in the Porto district, Portugal, whereas a control group (CG) of 8 overweight boys of equivalent age followed at an outpatient hospital obesity clinic in the same area as the school that did not engage in formal sport activities during the study period. Eligibility for recruitment and participation in this study required children to be 8-12 years old and to have BMI≥85th percentile for age and gender (CDC/NDHS, 2000). Exclusion criteria included medical conditions contraindicating the participation in physical activities, the use of medication influencing the observed outcomes, and participation in structured exercise, nutrition or weight loss programs, within 1 year prior to the initial screening. The study was approved by the ethics committee of the Faculty of Sport of the University of Porto and by school and hospital authorities. Sample size calculations were performed a priori for repeated measures analysis of variance using the G*Power software 3.1.9.2 (Universität Düsseldorf, Germany). Hypothesizing an effect size [9] for a required power of 95% at $P < 0.05$, a sample size of at least eight in each group was required.

Intervention

The football intervention program occurred during 6 months, between January and June 2014. Training sessions were administered at school, after school time (16.00-17.30), 4 days per week, for 60-90 min. Practices consisted on warm-up (10-20 min), different technical exercises and small-sided games (40-60 min), and cool-down (10 min). Training intensity was monitored with heart rate monitors (Polar Team² Pro, Polar, Finland). Exercises and games were progressively intensified as individually tolerated. Members of the research team conducted all training sessions.

Measures

Anthropometric measures

Height and sitting height was measured with a fixed stadiometer (Holtain Ltd.) and body mass was estimated with a body fat monitor (Tanita®, BC-418MA). Body mass index (BMI) was calculated using the standard formula: body mass (kg)/height^2 (m).

Bone measures

Whole BMC (g) and BMD (g/cm^2), as well as body fat percentage and lean body mass were determined by dual-energy X-ray absorptiometry (DXA; Hologic QDR 4500A). The equipment was calibrated according to the manufactures instruction; well-trained technician performed the exams. Children were scanned in supine position and the scans were performed in high resolution. BMC and BMD were measured for the whole body and the lumbar spine (L1-L4) using standard protocols, and the dominant and non-dominant lower limb using a region of interest program. The same investigator analyzed all total body scans. The principles behind body composition analyses with DXA are explained elsewhere [10,11].

Physical fitness measures

Speed was evaluated with a 15-m sprint test. Elapsed times were measured using 3 pairs of photoelectric cells (Speed Trap II, Brower Timing Systems), positioned at the starting line and at 5 and 15 m. Players were instructed to run as fast as possible from a standing position 30 cm behind the starting line. Jumping height was evaluated with a countermovement jump (CMJ) on a special mat (Digitime 1000, Digitest), following the protocol of Bosco et al. [12]. The Yo-Yo intermittent endurance test - level 1 (Yo-Yo IE1) required repeated 2x20-m runs (shuttles) between the start and finish line at progressively increased speeds controlled by audio bleeps from a tape-recorder; there was a 5-s period of rest between runs [12,13].

Biological maturity status/Physical activity/Dietary intake

Maturity offset, that is, time before or after PHV, was predicted with the equation of Mirwald et al. [14]. Daily PA was assessed at baseline using GT1M accelerometers (Actigraph). All participants provided 5 consecutive days of accelerometer data with ≥500 min of valid data per day. Dietary intake was completed by parents and comprised a 3-day dietary record that included 2 weekdays and 1 weekend day. Nutrient analysis was performed using the software Food Processor SQL (ESHA Research Inc., USA).

Reliability

In a pilot study, in-field reliabilities of all variables were estimated using a test-retest procedure with a random sub-sample of 10 children. Technical errors of measurement for anthropometry were 0.24cm for height, and 0.17kg for weight. Interclass correlation coefficients were 0.97 for 5- and 30-m sprints; 0.89 for CMJ. A replicate test was not given for the Yo-Yo IE2.

Data Analyses

Descriptive statistics (means and standard deviations) were calculated for the two groups at the start and conclusion of the study. None of the bone and physical fitness variables showed significant deviations from a normal distribution (Shapiro-Wilk test). Baseline differences in mean bone mass and physical fitness variables between FG and CG were tested with unpaired sample t-tests. Intervention effects were examined by repeated measures ANOVA. For each of the bone and physical fitness variables, change scores were calculated as the difference between baseline and 6-month values; the difference was then divided by the initial value to estimate percentage of relative change. Significance level in all analyses was set at 0.05. Statistical analyses were conducted using SPSS version 21.0.

Results

Characteristics of the study sample at baseline are shown in **Table 1**. No significant differences between FG and CG were noted in physical, bone and physical fitness characteristics at baseline (p>0.05).

Table 2 shows the results of the repeated measures ANOVA models for bone and physical fitness variables. For the bone variables, a significant main effect for time was found. Both groups had significantly higher BMD and BMC in the whole-body and lumbar spine after the intervention (p<0.05). However, a significant intervention by group interaction effect for lumbar spine BMD was observed; mean values increase across intervention in FG, but tended to be more constant in CG. FG also presented higher values in Yo-Yo IE1 (p=0.035) and were faster in 5-m sprint (p=0.014) than CG. After 6 months, both groups increased in Yo-Yo IE1 (p=0.009), CMJ (p=0.006) and 5-m sprint (p=0.028) performances, although increments were more pronounced in FG. A significant intervention by group interaction effect was evident only for CMJ; CMJ improved with the football intervention, while remained rather constant in CG.

Discussion

The major finding of the presented study was that the 6-month football intervention (60-90 min. 4 times/week) resulted in beneficial changes in bone mass indicators among overweight children. Participants in the football intervention experienced significantly greater increments in lumbar spine BMD and BMC (4.3% and 7.4%, respectively) than in whole-body measurements. The results were consistent with other studies that highlighted the importance of PA in enhancing bone mass among overweight and obese children [14-18]. The findings thus suggested that football participation is an effective short-term strategy to promote bone accrual in overweight/obese children (8-12 years old).

The football intervention program had even greater effects in physical fitness. Over the 6-month intervention period, the football participants showed greater improvements in Yo-Yo IE1 (20.0%), CMJ (28.9%), 5-m (-7.4%) and 15-m sprint (-16.4%) performances. The positive effect of a PA program in physical fitness was also reported in previous studies [16,18]. Another study [17] assessed muscular strength using the squat jump test and found a significant group-by-time interaction after a 24-week training program; after 16 weeks the same group had improvements over 10%. However, the findings from previous football intervention studies have reported no significant changes in BMI (0.2-0.6 kg/m^2; 0.8%-1.9%) in overweight children, suggesting that the increases in weight and height were due to normal growth over the intervention period [6,9].

The findings of the present study should be interpreted in the context of several limitations. First, children were not randomly assigned to FG and CG. This was in part by design since it was of interest to assess the feasibility of the football intervention before attempting randomized trials in the future. The absence of randomization introduced a greater theoretical potential for confounding than a randomized controlled trial; however, in the present study both groups were similar in most bone mass and physical fitness variables at baseline. Moreover, several statistical adjustments were attempted in the analyses, which alleviated some of the potential problems. Second, the sample size was rather small, which might have reduced the statistical power for group comparisons and in turn the generalizability of results. Nevertheless, the *post hoc* statistical power tests for detecting bone mass and physical fitness differences between the two groups ranged from 61-92%. Third, neither PA nor dietary intake, outside of the intervention, was formally controlled. It is possible that this may have influenced the ability to detect changes, specifically in body weight and composition. All children, however, were instructed to maintain their normal PA and dietary intake during the intervention.

In summary, a 6-month football intervention program (60-90 min, 4 times/week) can be effectively implemented in school settings; the program was effective in enhancing bone mineral content and density and physical fitness of overweight children. The present findings permit further investigation so that the benefits can be more prominent in long-term outcomes of larger-scale studies. In addition, the findings of this football intervention study are promising and support that educational and public health authorities should be encouraged to develop and adopt effective, viable and economical school-based intervention programs that increase bone health and struggle childhood obesity.

Table 1 Means (standard deviations) for baseline physical, bone mass and physical fitness variables in the football and control groups, and p values for differences between groups.

Characteristics	Football group	Control group	p-value
Physical			
Age (years)	10.67 (1.80)	9.50 (1.69)	0.191
Height (cm)	1.50 (0.09)	1.41 (0.12)	0.086
Weight (kg)	52.48 (12.82)	50.60 (10.92)	0.751
BMI (kg/m²)	22.94 (3.20)	25.32 (2.32)	0.103
Maturity offset (years)	-0.65 (1.18)	-1.32 (1.12)	0.331
MVPA (min/day)	117 (60)	107 (47)	0.735
Energy intake (kcals/d)	1708 (354)	1631 (428)	0.741
Bone			
BMD (g/cm²)			
Whole-body	0.89 (0.06)	0.86 (0.06)	0.382
Lumbar spine	0.67 (0.07)	0.71 (0.09)	0.286
BMC (g)			
Whole-body	1412.18 (258.93)	1228.46 (272.78)	0.175
Lumbar spine	30.24 (4.29)	28.55 (5.89)	0.505
Physical Fitness			
YY-IE1 (m)	569 (249)	360 (98)	0.056
CMJ (cm)	19.09 (3.19)	21.01 (4.95)	0.361
5-m sprint (sec)	1.45 (0.11)	1.57 (0.12)	0.054
15-m sprint (sec)	3.84 (1.26)	3.76 (0.25)	0.595
Abbreviations: BMI: Body Mass Index; MVPA: Moderate-to-Vigorous Intensity PA.			

Table 2 Changes in bone and physical fitness variables between baseline and after 6 months in the football and control groups.

	Football group			Control group			Repeated analysis of variance		
	Baseline	**Post**	**% Change[a]**	**Baseline**	**Post**	**% Change[a]**	**I**	**G**	**I*G**
BMD									
Whole-body	0.89 (0.06)	0.91 (0.06)	2.2	0.86 (0.06)	0.88 (0.06)	2.3	<0.001	0.317	0.274
Lumbar spine	0.67 (0.07)	0.70 (0.08)	4.3	0.71 (0.09)	0.71 (0.09)	0	0.003	0.504	0.004
BMC									
Whole- body	1412.18 (258.93)	1507.74 (284.02)	6.3	1228.46 (272.78)	1305.40 (317.71)	5.9	<0.001	0.180	0.458
Lumbar spine	30.24 (4.29)	32.65 (5.44)	7.4	28.55 (5.89)	29.65 (6.17)	3.7	<0.001	0.387	0.058
Physical fitness									
Yo-Yo IE1 (m)	569 (249)	711 (319)	20	360 (98)	400 (129)	10	0.009	0.035	0.113
CMJ (cm)	19.09 (3.19)	26.83 (4.42)	28.9	21.01 (4.95)	21.14 (2.87)	0.6	0.006	0.285	0.007
5-m Sprint (sec)	1.45 (0.11)	1.35 (0.14)	-7.4	1.57 (0.12)	1.53 (0.13)	-2.6	0.028	0.014	0.261
15-m Sprint (sec)	3.84 (1.26)	3.30 (0.21)	-16.4	3.76 (0.25)	3.67 (0.26)	-2.5	0.208	0.595	0.369

[a] Differences between baseline and after 6 months values then dividing each result by its initial value; I: Intervention; G: Group

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