ORIGINAL ARTICLE UDC: 613.95::613.73]::[612.75+613.25

Status of bone mineral content and body composition in boys engaged in intensive physical activity

Status mineralnog koštanog sadržaja i telesne kompozicije dečaka koji se intenzivno bave fizičkim vežbanjem

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Abstract

Background/Aim. It is well known that physical activity has an anabolic effect on bone tissue. But there is a lack of information about the effect of intensive physical activity in childhood, particularly at the prepubertal stage. To examine the influence of training on body composition and bone mineral density we have studied a group of prepubertal soccer players as well as a group of inactive prepubertal boys at the starting phase of their peak bone mass acquisition. **Methods.** A total of 62 healthy prepubertal boys took part in this study. They were divided into two groups. The first one consisted of 32 soccer players (aged 10.7 ± 0.5 years), who had been playing football for at least 1 year (10–15 h per week). The second group a control group 30 boys (aged 11.2 ± 0.7 years) doing 1.5 h per week physical activity at school. Body composition was assessed by a Body Fat Analyzer "BES 200 Z". Bone mineral density measurements of the left and the right calcaneus were done by using ultrasound densitometer "Sahara" (Hologic, Inc., MA, USA). **Results.** There were significant differences between soccer players and the control group in fat mass ($p = 0.01$). Besides, a significant difference was determined between the group of athletes and the control group in bone mineral density of both calcaneal bones ($p = 0.01$). **Conclusion.** The results of this study confirm the significant effects of physical activity on reducing body mass and increasing bone density. Considering that football training can be very easily implemented in the broader population of children and young people, which does not apply to many other sports, it should be used more in the prevention of obesity and osteoporosis.

Key words:
sports; physical endurance; child; bone density; body constitution.

Apstrakt

Uvod/Cilj. Fizička aktivnost ima anaboličko dejstvo na koštano tkivo. Međutim, još uvek nije potpuno jasno kakav je uticaj intenzivne fizičke aktivnosti tokom detinjstva, a posebno u prepubertetskom uzrastu. U cilju utvrđivanja uticaja vežbanja na telesnu građu i gustinu kosti kod dece koja se aktivno bave sportom, ispitali smo grupu dečaka prepubertetskog uzrasta koji treniraju fudbal, kao i grupu dečaka prepubertetskog uzrasta koji se ne bave sportom aktivno u početnoj fazi dostizanja maksimalne mase kosti. **Metode.** Uzorak ispitanika sastojao se od 62 dečaka prepubertetskog uzrasta, podeljenih u dve grupe: grupu od 32 dečaka, uzrasta 10,7 ± 0,5 godina, koji aktivno treniraju fudbal najmanje godinu dana (10–15 sati nedeljno) i kontrolnu grupu od 30 dečaka, uzrasta 11,2 ± 0,7 godina, koji se ne bave aktivno sportom, osim fizičke aktivnosti tokom redovne nastave u školi u trajanju od 1,5 sat nedeljno. Telesna građa procenjena je primenom uređaja *Body Fat Analyser* BES 200 Z, dok je gustina leve i desne petne kosti procenjena pomoću ultrazvučnog denzitometra Sahara (Hologic, Inc, MA, USA). **Rezultati.** Dobijeni rezultati pokazali su da postoji statistički značajna razlika između dečaka koji aktivno treniraju fudbal i kontrolne grupe u količini masnog tkiva ($p = 0,01$), kao i gustini obe petne kosti ($p = 0,01$). **Zaključak.** Rezultati ovog istraživanja potvrđuju značajne efekte fizičke aktivnosti na smanjenje telesne mase i povećanje gustine kostiju. S obzirom na to da je veoma lako ostvariti vežbanje fudbala u široj populaciji dece i mladih, što ne važi za mnoge druge sportove, treba ga što više koristiti u prevenciji gojaznosti i osteoporoze.

Ključne reči:
sport; izdržljivost, fizička; deca; kost, gustina; telesna konstitucija.

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Introduction

Although not completely clear, it is the fact that physical activity contributes to building tissue. Even a moderate physical activity in everyday life produces a significant anabolic stimulus [1].

Muscular contractions produce the highest loads on the skeleton. The bone accommodates to these loads in order to preserve its structural and functional roles in the skeleton and eventually prevent injuries and fractures [2, 3]. Anabolic effects of physical activity do not affect persons doing sports only, i.e. persons who increase their muscular power and functional endurance by means of training. As an example, complete immobilization of extremities or lack of mechanical load, *i.e.* gravity force (weightlessness) results in the loss of bone tissue [4]. Creation of new bone cells is increased substantially as soon as exercises are continued [5]. Such a fact leads to a popular conclusion that physical activity improves creation of new cells, consequently bone density, too. Reaching maximal bone mass in childhood and adolescence is a key determinant of a healthy skeleton in adult age [6]. Unfortunately, children nowadays devote little time to sports or any kind of physical activity for the sake of watching television or sitting in front of a computer [7]. Such "sedentary" lifestyle and incorrect attitude towards practicing physical activities provide preconditions of obesity [8, 9]. This may lead to decreasing bone mass with the final consequence of reduced maximal bone mass. Body mass developed through childhood is a key determinant of healthy bones during the latter age. Thus determination of the moment of developing bone mass is an important step in prevention of osteoporosis. Though there is no consensus as to the age when maximal bone mass is developed [10–12], a significant amount of bone minerals is accumulated during adolescence [13].

The aim of this study was to examine the influence of training on body composition and bone mineral density in healthy prepubertal boys.

Methods

The study included 62 subjects at the age of 10–12 divided into two groups.

The group of soccer players was consisted of 32 boys at the age of 10.7 ± 0.5 years, Tanner stage II*, engaged in a selected physical activity for at least one year. This group had training sessions of 10–15 h on weekly basis. The group of non-sportsmen was consisted of 30 boys at the age of 11.2 ± 0.7 years, Tanner stage II, not engaged in active sport.

The principal inclusion criteria to this study were age, sex, sport history (minimum one year of active sports occupation in soccer, *i.e.* training), absence of diseases and states yielding secondary effects on metabolism of bones.

Body composition and bone density in this research were represented by seven characteristics as follows: three evaluation measures of body composition and four of skeletal status, *i.e.* bone density.

Body composition evaluation measures included total body water (TBW kg), lean body mass (LBM kg), and fat mass (FAT kg).

Bone density of subjects was evaluated on the basis of the following measures: broadband ultrasound attenuation – left calcaneus (BUAleft – dB/MHz), broadband ultrasound attenuation – right calcaneus (BUAright – dB/MHz), speed of sound – left calcaneus (SOSleft – m/s), and speed of sound – right calcaneus (SOSright – m/s).

To have more information on the results of the research, body height (BH – cm) and body weight (BW – kg) as well as body mass index (BMI – kg/m^2) were calculated for each subject.

Bone density was determined by using "Sahara" (Hologic, Inc., MA, USA) sonometer. The results obtained by this method produce sufficient correlation with other methods, as well as with other localizations [14–16]. The selection of this method was also justified by the fact that Radiography (X-Ray) methods for determining bone density are not allowed for testing children in many countries.

In order to obtain the highest possible precise and valid data, testing was performed according to the relevant standards for body composition determination. Body composition was assessed by Body Fat Analyzer "BES 200 Z" (Bioelectrical Sciences, Inc., La Jolla, CA, USA).

Statistical procedures were carried out using SPSS programme (SPSS Inc., Chicago, USA, version 10.0 for personal computer). Standard statistical methods were used to calculate means, range and standard deviation. In addition, parameters of the data distribution were also calculated (skewness and kurtosis), as well as normality by Kolmogorov-Smirnov's test (KS). A statistical significance of differences between the group of boys exposed to intensive specific training load (soccer) and the control group, *i.e.* the group of boys not exposed to systematic and organized physical activities was calculated by Student's *t*-test.

The study was approved by the School of Sports and Physical Education at the University of Novi Sad. The trainers/coaches and players parents received verbal and written information about the study and gave their acceptance before the investigation.

Results

According to the values of the central and dispersion statistical parameters, as well as normality parameters of data distribution, presented in Table 1, it may be concluded that the data distribution of all the applied variables in this research did not show statistically significant deviation from the normal distribution, at the significance level of $p = 0.01$

* Puberty is divided into five stages, called Tanner Stages (numbered 1–5). Tanner stage II is prepubertal stage which defines following physical measurement of development: small amount of long, downy hair with slight pigmentation at the base of the penis and scrotum, testicular volume between 1.6 and 6 ml, skin on scrotum thins, reddens and enlarges.

This age is not characterized by hormone changes due to puberty, while sex hormones are at puberty level. It is assumed that sex hormones at this age do not have a significant role in forming bone tissue, thus the conditions are the same for all tested children.

Table 1

Descriptive statistics and distribution normality of the applied variables

Variables	Min	Max	x̄	SD	Skewnes	Kurtosis	KS*
TBW (L)	18.40	40.90	24.74	25.20	1.054	1.663	0.763
LBM (kg)	25.50	47.20	34.35	5.98	0.560	-.595	0.868
FAT (kg)	2.00	21.10	6.56	4.21	1.147	0.722	1.291
BUAleft (db/MHz)	31.10	104.10	52.60	13.31	1.248	2.365	1.176
BUAright (db/MHz)	31.00	108.40	54.61	13.34	1.600	3.687	1.272
SOSleft (m/s)	1515.60	1671.70	1572.09	28.036	0.966	1.449	0.670
SOSright (m/s)	1521.90	1675.30	1575.93	29.87	0.969	1.007	1.051
BH (cm)	129.30	173.50	147.5823	8.42170	0.634	0.687	1.062
BW (kg)	28.20	63.40	41.0258	8.77745	0.702	-.294	0.916
BMI (kg/m^2)	14.50	25.08	18.6577	2.55290	0.789	0.061	0.835

TBW – Total body water; LBM – Lean body mass; FAT – Fat mass; BUAleft – Broadband ultrasound attenuation – left calcaneus; BUAright – Broadband ultrasound attenuation – right calcaneus; SOSleft – Speed of sound – left calcaneus; SOSright – Speed of sound – right calcaneus; BH – Body hight; BW – Body weight; BMI – Body mass index.
***Kolmogorov-Smirov test**

providing good discrimination of subjects in terms of assessed characteristics.

Multivariate analysis of variance showed statistically significant differences (Wilks Lambda = 0.615) in the applied variables at the significance level of 0.01 ($p = 0.00$).

A statistical significance of differences between the group of boys exposed to intensive specific training load (soccer) and the control group, *i.e.* the group of boys not exposed to systematic and organized physical activities was estimated by *t*-test (Table 2).

Table 2

Differences in parameters of body composition and bone mineral density between the groups of subjects (*t*-test)

Parameters	Groups	n	x̄	SD	*t*	*p*
TBW (L)	1*	32	24.63	3.06	-.210	0.834
	2**	30	24.87	5.59		
LBM (kg)	1	32	33.94	4.50	-.555	0.581
	2	30	34.78	7.19		
FAT (kg)	1	32	4.99	3.02	-3.138	0.003
	2	30	8.25	4.97		
BUAleft (db/MHz)	1	32	53.54	16.84	0.524	0.602
	2	30	51.60	11.65		
BUAright (db/MHz)	1	32	55.19	17.49	0.322	0.748
	2	30	53.99	10.96		
SOSleft (m/s)	1	32	1582.42	29.80	3.120	0.003
	2	30	1561.07	23.49		
SOSright (m/s)	1	32	1585	34.48	2.698	0.009
	2	30	1565	24.39		
BH (cm)	1	32	145.5781	6.76107	-1.981	0.052
	2	30	149.7200	9.54793		
BW (kg)	1	32	39.1281	6.65865	-1.790	0.079
	2	30	43.0500	10.31744		
BMI (kg/m^2)	1	32	18.3610	2.10778	-.944	0.349
	2	30	18.9742	2.95954		

***Group 1 - group of soccer players; **Group 2 – control group**
TBW – total body water; LBM – lean body mass; FAT – fat mass; BUAleft – broadband ultrasound attenuation – left calcaneus; BUAright – broadband ultrasound attenuation – right calcaneus; SOSleft – speed of sound – left calcaneus; SOSright – speed of sound – right calcaneus; BH – body hight; BW – body weight; BMI – body mass index.

As shown in Table 2 the boys exposed to different intensity levels of physical activities, demonstrated a statistically significant difference in bone density, total body fat, body height (limited significance), but they did not show any statistically significant difference in body weight, total body water and lean body mass in relation to the control group. The subjects exposed to a more intensive physical exercising had statistically significant lower height and fat body mass than the control group of boys. They did not have lower weight regardless the fact that they had lower total amount of body fat. It is an interesting fact that the subjects did not show any significant difference in terms of lean body mass or body mass index, which might have been expected.

Discussion

The prepubertal boys exposed to soccer training showed statistically significant differences within the whole system of applied variables, *i.e.* indicators of body composition and bone density, in relation to their age-matched controls ex-

posed only to usual physical activity during regular school obligations.

Analyzing the mean values of the examined groups, it was noticed that body mass index was lower in the group with more intensive physical activity, which might be an indicator of lower amount of body fat, although this parameter did not achieve the level of statistical significance as compared to that of the control groups. No significant differences in body mass index, in spite of significant difference between subjects in total body fat, might be explained by the fact that body mass index does not take into account a direct subcutaneous fat amount, and this cannot be a more reliable measure than total fat amount assessed by bioelectrical impedance.

The absence of statistically significant differences in lean body mass between the physically active and physically inactive group of prepubertal boys might be explained by two arguments. The first one is the fact that prepubertal age of boys is not characterized by an intensified growth of muscular mass, which usually occurs in later stages of biological development when hormone system (primarily testosterone) contributes to muscular mass increase owing to proper physical exercising and correct nutrition. It is an important fact that the boys of the control group were not completely physically inactive but rather practiced it at a moderate level which could also lead to minor differences in lean body mass. The second argument is represented by the fact that the characteristics of the program of intensified physical activity are not based exclusively on the strength training but also on exercises of specific coordination, speed, and flexibility, which led to significantly improved motor abilities of the boys in the physically active group, as well as to the reduction of total body fat, and higher bone density.

Intensity of motion activities in soccer ranges from walking to running. During a soccer match, adult soccer players run an average distance of 11 km at an average intensity which is similar to marathon run (70–80% of maximal oxygen consumption) [18].

Soccer comprises sprints which create additional mechanical load on lower extremities, owing to a greater reaction of surface developed during running [19]. In addition, a high number of activities which are typical for this sport have anabolic character in terms of bone tissue. As an example, forces developing during sudden change of direction, during stopping and landing, as well as during jumps and shots provide soccer with excellent anabolic characteristics [20–24].

Conclusion

Kinesiological treatment in soccer has significant effect on body composition and mineral bone density in prepubertal boys.

Kinesiological treatment in soccer does not have any statistically significant effects on increased lean body mass containing significant percentage of muscle tissue of prepubertal boys.

Soccer practice can be very easily realized in a wider population of children and youth which is not true for many others sports. This is why the results of this research are important as they confirm significant effects of the mentioned activities on reduction of body mass and increased bone density which makes it a good instrument against obesity and osteoporosis.

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Received on March 30, 2009.
Revised on May 14, 2009.
Accepted on August 3, 2009.