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ORIGINAL ARTICLE

Bone mineral density gains related to basketball practice in boys: cohort study

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Abstract

Introduction: In recent decades, the prevalence of osteoporosis has significantly increased, impacting in a significant manner on health care costs worldwide.

Objective: To analyze the impact of basketball practice on bone mineral density of male adolescents.

Methods: 9 - month cohort study carried out with 27 adolescents (controls, n = 13 [11.9 ± 2.2 years] and basketball players, n = 14 [13.4 ± 1.2 years]). Bone mineral density was measured in different body segments (upper limbs, lower limbs, spine, and total) using the dual energy X-ray absorptiometry technique. Intake of vitamin D, chronological age, somatic maturation, fat-free mass, and height were adopted as confounders. The statistical analysis was composed of the Student's t-test, analysis of covariance, and Pearson/partial correlations.

Results: Regardless of confounders, there was a positive relationship between higher basketball practice time and bone density gains in the upper limbs (r = 0487 [95%CI = 0.131 to 0.732]).

Conclusion: The practice of basketball seems to affect bone mineral density gains in adolescents, mainly when the practice is prolonged.

Keywords: bone density, adolescent medicine, sports medicine, basketball.

INTRODUCTION

In recent decades, the prevalence of osteoporosis has significantly increased, impacting in a significant manner on health care costs worldwide. It is estimated that in 2000, about one percent of all retirement-related non-communicable diseases were attributed to osteoporotic fractures[1]. In adolescence, the occurrence of bone fractures is a common event[2,3], however due to trauma, not osteoporosis. In fact, there are cases of osteoporosis in childhood and adolescence, but the condition is very unusual[4].

About 70% of bone phenotype variance is determined by genetic variants[4], while the remainder of the variation is explained by factors such as nutrition, physical exercise, and others[2]. In the case of physical exercise, recommendations for improvement in bone health in childhood and adolescence are based on exercises that generate mechanical overload on the bone and are carried out at moderate/vigorous intensity[5].

Accordingly, different sports include these characteristics, such as basketball. Basketball is a collective dynamic sports activity, which includes significant mechanical impact on bones (running, jumping, quick changes of direction, etc.) and is performed predominantly at moderate and vigorous intensity (intermittent feature)[6].

Moreover, although widely practiced throughout the world, there is a shortage of scientific studies identifying the possible beneficial impact on bone growth and development in children and adolescents. The majority of these studies focus on international populations and sports such as soccer, tennis, swimming, and gymnastics[7-10] and therefore very little is known about the adaptations that occur in the skeletons of young people exposed to basketball practice.

In this sense, the objective of this study was to analyze the impact of basketball practice on bone mineral density (BMD) in male adolescents.

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METHODS

Sample

This is a longitudinal study, which forms part of the cohort study entitled “The practice of different sports and bone mass gain: 9-month cohort”, which was conducted from October 2013 to August 2014 in the city of Presidente Prudente. This study was approved by the ethics committee of the institution (Process: 216939/2013).

The sample size calculation was performed using an equation based on the comparison of two means (Student t test). Taking into account a minimum difference in BMD (whole body) of 0.10 g/cm^2 between the control and sports groups[11], standard deviation of 0.14 g/cm^2 for the sports group and 0.10 g/cm^2 for controls, and an 80% power and 5% alpha (Z = 1.96). Thus, the estimated minimum sample size was 11 adolescents per group. The inclusion criteria adopted were as follows: (i) chronological age between 11 and 17 years, (ii) prior parental permission to participate in the study, (iii) prior authorization of coaches to participate in the study, (iv) a minimum of six months practice in the sport mode (basketball group) or the absence of any organized sports activities in the previous three months (control group), (v) not using medications that could affect bone metabolism and (vi) the consent form signed by a responsible adult.

The control group comprised 13 adolescent students enrolled in either public (school units held by non-profit organizations were also considered) or private city schools. The basketball group was composed of 14 adolescents belonging to the basic team of the municipality, the state-level competitors, thus, the final sample included 27 individuals.

Body Composition and bone variables

The BMD (g/cm²), bone mineral content (BMC, grams [g]), fat-free mass ([FFM] kg), and trunk fat (TF [%]) were assessed through dual energy X-ray absorptiometry (DXA-Lunar DPX-NT, General Electric Healthcare, Little Chalfont, Buckinghamshire, UK) using Medical System GE Lunar software (version 4.7). The scanner quality was tested by a trained technician before each measurement day, following the manufacturer’s recommendations. At both moments of analysis, measurements were taken by the same evaluator. Participants were instructed to wear light clothing and no shoes, and remain in the supine position on the machine (about 15 minutes). Bone mineral density was measured in the whole body, which enables verification of the values of the upper and lower limbs and spine.

Anthropometry and peak height velocity

Body weight was measured using a digital scale (Filizola model Personal Line 200, Filizola Ltda., Brazil), with an accuracy of 0.1 kg, and the height and sitting height were determined using a wooden stadiometer fixed on the wall (Sanny, Professional model, Sanny®, Brazil) with an accuracy of 0.1 cm, according to the procedures described in the literature[12]. Biological maturation was estimated by the peak height velocity (PHV), from mathematical models based on anthropometric measurements, described by Mirwald et al, 2002[13]. These equations represent time (in years) lacking (negative values) or passed (positive values) from PHV, which is characterized as an important biological event in the human aging process. The PHV has a strong relationship with the release of important hormones during puberty[14].

Vitamin D Score

Although there was no nutritional monitoring in this cohort, with the help of a nutritionist, a questionnaire was created with groups of foods rich in vitamin D. Using a *Likert* frequency scale, the adolescents reported how often they consumed these foods in the week prior to the evaluation. The total score generated (all the food) was considered as vitamin D intake. In the present study, the sum of the scores from both moments was used as the vitamin D intake measure.

Statistical analysis

Descriptive statistics consisted of mean, standard deviation (SD), and 95% confidence interval (95% CI). Analysis of covariance (ANCOVA) compared changes in BMD in adolescents engaged and not engaged in the practice of basketball. In all ANCOVA models, homogeneity of variance was evaluated by the Levene’s test, while the effect size measures were provided by Eta Squared (Small effect size: 0.010, average effect size: 0.060 and large effect size: 0.140). Partial correlation examined the relationship between changes in BMD, the volume of weekly training, and previous time engagement in sport (adjusted for age, height, FFM, PHV, and vitamin D score). Statistical significance (p-value) was set at $p < 0.05$ and statistical software BioEstat (version 5.0) was used to perform analyzes.

Results

The total sample consisted of a group of 27 teenage males, who were followed for a period of nine months (Table 1). At baseline, the adolescents engaged in basketball practice were older (p-value = 0.047), heavier (p-value = 0.001), taller (p = 0.001), closer to achieving the PHV (p-value = 0.018), and presented a greater amount of muscle mass (p = 0.001). The trunk fat and vitamin D score did not differ between the groups, however, all BMD indicators were higher for the group engaged in sports (p-value = 0.001 for all).

Both groups analyzed presented significant gains in BMD in all body segments analyzed. In addition, although similar at baseline for both groups, the score of consumption of vitamin D differed between young people engaged and not engaged in basketball practice in the follow-up (Basketball 5.5 ± 1.5 and Control 4.1 ± 1.7; p = 0.026).

Throughout the cohort, indicators of percentage change in BMD were similar between the adolescents engaged and not engaged in basketball practice in the region of the lower limbs (p-value = 0.642) and spine (p-value = 0.748). On the other hand, in the region of the upper limbs (p-value = 0.001) and total body (p-value = 0.008) there were significant increases in BMD in the group of adolescents engaged in basketball practice.

Table 1: General characteristics of adolescents engaged and not engaged in basketball practice (n = 27).

Beginning of study	Control (n = 13) Mean (SD)	Basketball (n = 14) Mean (SD)	p - value
Age (years)	11,9 (2,2)	13,4 (1,2)	0,047
Body mass (kg)	44,5 (13,4)	63,2 (13,2)	0,001
Heigth (cm)	154,5 (13,1)	175,3 (7,4)	0,001
PVC (years)	-2,3 (1,5)	-1,1 (0,9)	0,018
FFM (kg)	33,2 (8,7)	48,3 (7,4)	0,001
TF (%)	20,7 (11,1)	19,7 (8,6)	0,793
Vitamin D score	5,6 (1,4)	5,3 (1,4)	0,566
DEXA – BMD (g/cm²)			
Upper limbs	0,679 (0,083)	0,789 (0,061)	0,001
Lower limbs	1,080 (0,157)	1,352 (0,126)	0,001
Spine	0,857 (0,130)	1,078 (0,164)	0,001
Total	1,001 (0,101)	1,163 (0,091)	0,001
Change (%)	Média (IC95%)	Média (IC95%)	
BMD - Upper limbs	7,2 (3,8 a 10,6)	17,6 (12,9 a 22,2)	0,001
BMD - Lower limbs	6,1 (4,1 a 8,1)	5,3 (2,4 a 8,2)	0,642
BMD - Spine	4,9 (2,5 a 7,3)	5,6 (2,1 a 9,1)	0,748
BMD - Total	4,1 (2,8 a 5,1)	7,1 (5,1 a 9,1)	0,008

DEXA = dual energy x-ray absorptiometry; BMD = bone mineral density; TF = trunk fat; FFM = fat free mass; PVC = peak growth rate; SD = standard deviation; CI95% = 95% confidence interval.

In the follow-up, the percentage changes in BMD in different body segments were compared with regard to potential confounders (Table 2). As regards the region of the upper limbs, although the changes in BMD did not present statistical significance, the changes in the basketball practice group presented a moderate effect size (ES-r = 0.083). In the same model, the adjustment variables were not significant and presented low/trivial effect sizes.

Table 2: Alterations in the bone density indicators in adolescents engaged and not engaged in basketball practice (n= 27)

		ANCOVA Parameters (effect size measures [Eta-Squared]) DEXA-DMO					
DEXA BMD	Mean (IC95%)	Basktball	Age	Height	PGV	FFM	Vitamin D
Upper limbs		0.083	0.001	0.011	0.016	0.029	0.031
Control (n = 13)	9.4 (3.7 to 15.1)						
Basketball (n = 14)	15.5 (10.1 to 21.1)						
Lower limbs		0.006	0.014	0.178*	0.011	0.292**	0.072
Control (n = 13)	5.3 (2.3 to 8.2)						
Basketball (n = 14)	6.1 (3.3 to 8.8)						
Spine		0.001	0.003	0.020	0.001	0.016	0.093
Control (n = 13)	5.1 (1.1 to 9.2)						
Basketball (n = 14)	5.4 (1.5 to 9.3)						
Total		0.074	0.030	0.100	0.056	0.027	0.150
Control (n = 13)	4.5 (2.4 to 6.6)						
Basketball (n = 14)	6.6 (4.6 to 8.5)						

* *= ANCOVA with p-value < 0.05; **= ANCOVA with p-value <0.01; ANCOVA= analysis of covariance; DEXA= dual energy x-ray absorptiometry; BMD= bone mineral density; FFM= fat free mass; PVC= peak growth rate; CI95%= 95% confidence interval.

The changes in the region of the lower limbs were not affected by the practice of basketball (ES-r = 0.006 [trivial effect]), but height (ES-r = 0.178 [large effect]), and FFM (ES-r = 0.292 [large effect]) were the main determinants of changes in BMD in this region of the body. In the spine, sports activities did not affect changes in BMD and no adjustment variable stood out. Finally, playing basketball (ES-r = 0.074 [moderate effect]), height (ES-r = 0.100 [moderate effect]), and consumption of foods rich in vitamin D (ES-r = 0.150 [large effect]) were highlighted in the effect of changes in total BMD.

Based on the parameters provided by the test for homogeneity of variances, except for total BMD (Total; p = 0.001), all other multivariate models created were adequately fitted (upper limbs; p-value = 0.111/lower limbs; p-value = 0.225/spine; p-value = 0.482).

Finally, we tested the linear relationship between changes in the bone indicators, with prior basketball practice and weekly training volume (Table 3). It was observed that even after the adjustments, there was a positive relationship between longer basketball practice and density gains in the upper limbs (r = 0.578 [95% CI, 0.254-0.785]), as well as between higher density gains in the arms and weekly training volume (r = 0.442 [95% CI, 0.074-0.704]). In the model in which the previous sports practice time and training volume were inserted simultaneously, only prior training practice remained significant (r = 0.487 [95% CI, 0.131-0.732]).

Table 3: Relationship between alterations in indicators of bone density, prior practice time and volume of training (n = 27)

Beginning of study	Partial correlation (change over the cohort [%]) BMD Upper limbs r (CI95%)	BMD Lower limbs r (CI95%)	BMD Spine r (CI95%)	BMD Total r (CI95%)
Entered separately in the model				
Practice time (years)	0.578 (0.254 to 0.785)*	0.049 (-0.337 to 0.421)*	0.294 (-0.097 to 0.606)*	0.261 (-0.132 to 0.583)*
Training volume (min/wk)	0.442 (0.074 to 0.704)*	0.048 (-0.338 to 0.420)*	0.172 (-0.223 to 0.518)*	0.296 (-0.095 to 0.608)*
Entered simultaneously in the model				
Practice time (years)	0.487 (0.131 to 0.732)§	0.032 (-0.352 to 0.407)§	0.250 (-0.144 to 0.575)§	0.162 (-0.232 to 0.511)§
Training volume (min/wk)	0.280 (-0.112 to 0.597)§	0.031 (-0.353 to 0.406)§	0.061 (-0.327 to 0.431)§	0.216 (-0.179 to 0.551)§

* *= correlation adjusted for age, height, fat-free mass, peak height velocity, and vitamin D score; §= correlation adjusted for age, height, fat free mass, peak height velocity, vitamin D score, and prior practice time (for training volume), or volume of training (for prior practice time); DEXA= dual energy x-ray absorptiometry; BMD= bone mineral density; CI95%= 95% confidence interval.

DISCUSSION

In the present study, young basketball players presented higher BMD and FFM at baseline. These findings corroborate previous research, which showed that young people engaged in sports activities have greater muscle mass, bone mass, and height[15-18]. On the other hand these findings may reflect not only the physiological effects of basketball practice (bone deformities caused by vibrations from the impact with the ground during running and jumping, as well as the stimulation of muscle contraction)[19], but also the effects of the existing selection process in the sport, i.e., basketball players have more chance of being selected if they are taller and stronger.

The gains in BMD in the basketball players were significantly higher compared to the control group. In fact, the practice of basketball adds different biomechanical and physiological components (moderate/vigorous intensity, jumping, running, quick changes of direction)[6,20], which are identified by the American College of Sports Medicine as osteogenic[5]. Interleukin-6 is an inflammatory agent which affects the functioning of the GH-IGF-1 axis and also the stem cell differentiation process in osteoclasts and osteoblasts[21]. Moreover, basketball besides being conducted in intensities considered important to enable the anti-inflammatory mechanisms linked to exercise[21,] also helps control body fat (major producer of interleukin-6 in the body) [22]. These physiological pathways offer, at least in part, to support the understanding of how basketball practice can positively affect bone formation, but need further investigation.

It is worth noting that the most osteogenic effect of basketball practice occurred in the upper limbs. In this regard, Tenforde and Fredericson[23] identified that bone mineral density increases more effectively in places directly affected by mechanical stress. In this sense, handling the ball and the frequent use of the arms for protection during the game can be characterized as osteogenic stimuli, which are not observed in the control group and thus justify the differences. The same theory[23] could be applied to explain the absence of differences in the lower limbs, since human gait is a behavior with osteogenic characteristics performed daily, regardless of involvement in sports.

Variables affected by biological maturation proved to be important in the analyzed outcome. Biological maturation greatly affected both the gain in bone mass and gain in height and muscle mass[24]. In this sense, the role of biological maturation (and therefore the variables affected by it) on the analyzed outcome is not surprising and confirms the importance of being controlled. It is worth noting an important finding of this study, which shows that the longer engaged in basketball practice (years), were the largest BMD gains. In terms of health promotion in pediatric populations, this information has an important weight as it confirms the need to encourage regular sports activities among young[25.26], especially in a society where physical inactivity and obesity are public health problems among children and adolescents[27.28]. Similarly, the practice of sports can take leading role in the fight against physical inactivity and obesity actions because it is characterized as an important component of physical activity of children and adolescents worldwide.

Although this study is notable for the absence of similar experiments in Brazil, its main limitations need to be highlighted. First, the sample only included boys, and caution is therefore needed in the inference of such findings for girls. As a second limitation, the short follow-up period, which could produce greater differences between the groups analyzed over a longer time. A third point to note is the lack of supervision of training parameters (intensity of training), which could impact on hormone release. Finally, calcium intake of participants was not controlled.

In summary, it is concluded that basketball practice appears to significantly impact on increases in bone mineral density in teenagers, and the strong effect of variables related to growth and maturation in the process are highlighted. Finally, the prolonged practice of sport seems to lead to more consistent gains in bone structure.

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Resumo

Introdução: Ao longo das últimas décadas, a prevalência de osteoporose tem aumentado de forma significativa, impactando de maneira relevante nos custos com a saúde em todo o mundo.

Objetivo: Analisar o efeito da prática de basquetebol na densidade mineral óssea de adolescentes do sexo masculino.

Método: Coorte de 9 meses de seguimento realizado com 27 adolescentes (n = 13 controles [11,9 ± 2,2 anos] e n = 14 jogadores [13,4 ± 1,2 anos]). Densidade mineral óssea foi mensurada em diferentes regiões do corpo (membros superiores, membros inferiores, espinha e total) por meio da técnica de absortiometria de raio-x de dupla energia. Consumo de vitamina D, idade cronológica, maturação somática, massa livre de gordura e estatura foram adotados como fatores de confusão. Análise estatística foi composta pelo teste t de Student, análise de covariância e correlação de Pearson e parcial.

Resultados: Independentemente dos fatores de confusão, houve relação positiva entre maior tempo de prática do basquetebol e ganhos de densidade nos braços e corpo total (r = 0.487 [IC95% = 0.131 a 0.732]; r = 0.162 [IC95% = - 0.232 a 0.511]).

Conclusão: A prática do basquetebol parece impactar significativamente os ganhos de densidade mineral óssea de adolescentes.

Palavras-chave: densidade óssea, medicina do adolescente, medicina esportiva, basquetebol.