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Tracking of sports activity during childhood/adolescence and bone mineral density in adulthood

Estabilidade da prática esportiva durante a infância/adolescência e densidade mineral óssea na idade adulta

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Abstract
The purpose of the study was to analyze the relationship between early sport practice and bone mineral density in adulthood, as well as, to identify whether this relation is independent of the current physical activity. Therefore, 69 men and 53 women (n= 122) were enrolled. The sample responded questions about drink, alcohol consumption and early physical activity. Body composition was assessed through the use of the dual-energy X-ray absorptiometry. Current physical activity was assessed during seven days by pedometer. Early and current physical activity were positively related (rho= 0.59; p-valor= 0.001). Early physical activity group had higher values of bone mineral content (+6.8%) and leg bone mineral density (+7.0%). Current physical activity was not related to bone densitometry, however, early physical activity was positively related to bone mineral content (β= 0.27 [$\beta_{95\%CI}$= 0.06; 0.48]), leg bone mineral density (β= 0.10 [$\beta_{95\%CI}$= 0.05; 0.16]) and height (β= 4.50 [$\beta_{95\%CI}$= 0.54; 8.46]), independently of other potential confounders, including current physical activity. It is possible to conclude that, in this particular sample, early sport practice is significantly related to improved bone mass in adulthood, independently of the current physical activity.

Keywords
Motor activity; Childhood; Adolescence; Height.

Resumo
O objetivo do estudo foi analisar a relação entre a prática de atividades esportivas na infância/adolescência e densidade mineral óssea na idade adulta, bem como, identificar se este efeito é independente da atividade física atual. Para tanto, 69 homens e 53 mulheres (n=122) participaram do estudo. Os voluntários responderam questões sobre etilismo, tabagismo e atividade física na infância/adolescência; foram submetidos à avaliação de composição corporal e densidade mineral óssea utilizando a técnica da Absorptiometria de Raios-X de Dupla Energia. Durante o período de sete dias foi monitorada a prática da atividade física atual utilizando o pedômetro. A atividade esportiva na infância/adolescência foi positivamente relacionada à atividade física atual (rho= 0.59; p-valor= 0,001). O grupo ativo na infância/adolescência apresentou maiores valores de conteúdo mineral ósseo (+6,8%) e densidade óssea das pernas (+7,0%). A atividade física atual não se relacionou com nenhum dos indicadores da densitometria óssea, porém, a atividade esportiva na infância/adolescência foi positivamente relacionada com o conteúdo mineral ósseo (β= 0.27 [$\beta_{IC95\%}$= 0.06; 0.48]), *densidade mineral óssea de pernas* (β= 0.10 [$\beta_{IC95\%}$= 0.05; 0.16]) *e estatura* (β= 4.50 [$\beta_{IC95\%}$= 0.54; 8.46]), *independente do ajuste de outras variáveis, inclusive a atividade física atual. Conclui-se que, na amostra investigada, a atividade esportiva realizada durante a infância/adolescência foi significativamente relacionada aos valores de massa óssea na idade adulta, independentemente da prática de atividade física atual.*

Palavras-chave
Atividade física; Infância; Adolescência; Estatura.

INTRODUCTION

It is well known that biological processes associated with human growth occurring during childhood/adolescence greatly influence adult bone matrix formation[1,2]. Likewise, greater decreases in bone mass occur due to the natural aging process combined with disorders stimulated by high osteoclastic activity[3], which can lead to osteoporosis in advanced ages.

During human growth, the bone remodeling process is a dynamic action occurring between the formation and reabsorption of bone tissue[4], which can be affected by different factors (age, sex, adiposity, nutrients essential to bone microstructure [calcium, vitamins D and K]) and risk behavior (smoking, alcohol drinking and insufficient physical activity)[2]. The scientific literature has shown that the bone strength and geometry are at least partly determined by the action of environmental stress agents. Such strength and geometry are modified at the bone locations influenced by these agents. Among environmental stress agents, muscle action resulting from physical activity can cause excessive load and tension on bones. Such load is a factor that stimulates bone mass gain[5]. In this sense, the practice of physical activity can be a potent modulator of bone mass during childhood/adolescence[6] and this additional bone mass gain in such stages of life can positively influence bone health in adulthood.

On the other hand, although the significant negative impact of osteoporosis on health/quality of life is well known and the above mentioned theoretical model can be associated with its prevention, little is known about whether this positive effect of physical activity practiced during childhood/adolescence is independent of its maintenance in adulthood.

Thus, the present study aimed to analyze the relationship between the practice of sports activities during childhood/adolescence and bone content and mineral density values in adulthood, and to identify whether this effect is independent of current physical activity.

METHODS

Sample

Sample calculation was based on a correlation analysis equation, which showed the need to assess at least 114 individuals to detect correlation coefficients close to r=0.26, with a power of 80% and significance level of 5%[7,8]. The sample was recruited in fitness clubs of the city of Presidente Prudente, SP, Southeastern Brazil, and among workers of the *Universidade Estadual Paulista* (UNESP), also located in this city (fitness clubs: n= 100; university workers: 22 [administrative: n= 16 and general services: n= 6]). All volunteers had to meet the following inclusion criteria to participate in this study: 1) to report the practice of physical activities throughout time (active during childhood and adolescence and currently active during leisure time) or to report the absence of physical activities throughout life (inactive during childhood and adolescence and currently inactive during leisure time); 2) to be aged between 30 and 50 years; 3) not to have a previous history of cerebrovascular accident or myocardial infarction; and 4) not to have had an amputation or visual impairment resulting from diabetes mellitus.

Prior to the experimental procedures, all volunteers read and signed an informed consent form, approved by the Human Research Ethics Committee (CAAE: 07770112.3.0000.5402).

Anamnesis, anthropometric measures and body composition

On the first day of experiments, participants responded a specific questionnaire about alcohol drinking and smoking. A digital scale with an accuracy of 0.1 kg (PL 200, Filizola, Brazil) and a stadiometer (Standard, Sanny®, Brazil) with an accuracy of 0.1 cm were used to measure body weight and height, respectively. Body weight and height measurements were taken by the same evaluator (previously trained) to guarantee better quality of the information collected and instructions and procedures described in the literature were adopted[9,10].

Dual-Energy X-ray Absorptiometry (DEXA) was the technique used to analyze body composition, lean mass estimation, bone mineral density and adipose tissue.

The piece of equipment used was the Lunar model – DPX-NT (General Electrics [GE]). All participants were barefoot and wore light clothing (without any metal accessories). Measurements were taken while they stood still in an orthostatic position for approximately 15 minutes. Fat percentage results were expressed in percentage values, bone mineral content (BMC) values were expressed in grams (g) and the bone mineral density of limbs (BMD-arms and BMD-legs) in grams per square centimeter (g/cm^2), using specific software supplied with the equipment.

Physical activity during childhood/adolescence and current life

Physical activity practice in childhood/adolescence was assessed with two questions[11,12]: 1) “Outside of the school, did you practice any supervised sports activity (with a sports school teacher, team coach etc.) for at least one year, between the ages of seven and ten years?”; and 2) “Outside of the school, did you practice any supervised sports activity (with a sports school teacher, team coach etc.) for at least one year, between the ages of 11 and 17 years?”.

As this was one of the inclusion criteria, only individuals who responded either “yes” or “no” to both questions participated in the present study. Thus, only those who reported at least one year of practice or the absence of such practice in both periods were included in the sample. A “strict” definition was adopted in this study to characterize the practice of sports during childhood/adolescence. This methodology was selected due to the fact that, if sports activities performed without supervision had also been included, all individuals would probably have been categorized as sufficiently active during childhood/adolescence.

Current physical activity was assessed using a pedometer (Digi-Walker Yamax, SW200). This piece of equipment was fixed laterally on the hips and only removed during sleeping, swimming and bathing. This pedometer was used during a seven-day period. At the end of each day, individuals recorded the number of steps taken during the day. In the mornings, the “reset” button was pressed to start data collection again. The mean values of steps in the week were considered as current physical activity and categorized into physically active ($\geq$ 10,000 steps/day) or insufficiently active (< 10,000 steps/day)[13].

Statistical analysis

After testing the normality of the set of data used, the statistical analysis included mean and standard-deviation values. Rates were shown as percentage values (%) and their respective 95% confidence intervals (95%CI). Additionally, the Chi-square test and Fisher’s exact test were used for comparison. Student’s t-test was used to compare groups according to previous and current physical activity practice. Due to the use of a dichotomous variable (sports during childhood/adolescence: yes [score 1] or no [score 0]), Spearman's correlation was used to identify the relationship between sports activities during childhood/adolescence and bone densitometry indicators. Significant associations found with Spearman's correlation were included in a multivariate model (linear regression), where the relationship between the outcome and independent variable was adjusted for sex, age, adiposity, alcohol drinking and smoking (relationship expressed as β values). Statistical significance (p-value) was pre-established at values lower than 5% and the BioEstat software version 5.0, was used.

RESULTS

The sample of the present study was comprised of 122 adults of both sexes (69 men and 53 women) aged between 30 and 50 years. In this sample, only 27.8% (95%CI = 19.9% - 35.8%) of those assessed were categorized as physically active during adulthood (mean ≥ 10,000 steps/day throughout the week). On the other hand, almost half of individuals assessed (47.5% [95%CI= 38.6% - 56.4%]) participated in sports activities during childhood and adolescence (at least for one year in each of these periods). Sports activities during childhood/adolescence were positively associated with physical activities during adulthood (rho= 0.59; p-value= 0.001).

The comparisons made according to current physical activity showed that physically active individuals had lower body weight (-8.9%; p-value= 0.049) and body fat values (-28.5%; p-value= 0.001). However, there were no differences among bone mineral density values (Table 1).

Table 1 – Bone densitometry variables according to current physical activity.

Numerical variables	<10,000 steps/day (n= 88)	≥10.000 steps/day (n= 34)	p-value
	Mean (SD)	Mean (SD)	
Numerical			
Age (years)	39.8 (6.2)	39.1 (5.5)	0.589
Body weight (kg)	80.5 (16.9)	74.1 (12.6)	0.049
Height (cm)	170.8 (10.9)	172.5 (9.6)	0.440
%BF	35.1 (10.4)	25.1 (8.2)	0.001
Bone density			
BMC (g)	2.98 (0.49)	3.07 (0.49)	0.406
BMD (g/cm^2)	1.27 (0.10)	1.28 (0.10)	0.484
BMD-arms (g/cm^2)	1.02 (0.13)	1.03 (0.14)	0.507
BMD-legs (g/cm^2)	1.31 (0.15)	1.36 (0.15)	0.105
Categorical			
Smoking	5.7%	0%	0.321*
Alcohol drinking	3.4%	2.9%	0.631§

*= Fisher's exact test; §= Chi-square test 2x2; %BF= percentage of body fat; BMC = bone mineral content assessed with dual-energy X-ray absorptiometry; BMD = bone mineral density assessed with DEXA.

The comparisons made according to sports activities during childhood/adolescence showed that adults engaged in sports activities during these stages of life had lower body weight (-10.4%; p-value= 0.003) and body fat values (-34.3%; p-value= 0.001), in addition to higher height values (higher than 2.5%) (Table 2). Bone densitometry values were also higher among adults involved in sports activities during childhood/adolescence (BMC: 6.8% [p-value= 0.020] and BMD-legs: 7.0% [p-value= 0.002]).

Table 2 – Bone densitometry variables according to sports activity during childhood/adolescence.

Numerical variables	Inactive- childhood/adolescence (n= 64)	Active-childhood/adolescence (n= 58)	p-value
	Mean (SD)	Mean (SD)	
Numerical			
Age (years)	39.7 (6.3)	39.4 (5.7)	0.832
Body weight (kg)	82.8 (17.1)	74.2 (13.7)	0.003
Height (cm)	169.2 (10.2)	173.5 (10.6)	0.024
%BF	38.5 (9.2)	25.3 (7.8)	0.001
Bone density			
BMC (g)	2.91 (0.45)	3.11 (0.51)	0.020
BMD (g/cm^2)	1.25 (0.10)	1.29 (0.10)	0.058
BMD-arms (g/cm^2)	1.01 (0.13)	1.04 (0.13)	0.181
BMD-legs (g/cm^2)	1.28 (0.14)	1.37 (0.15)	0.002
Categorical			
Smoking	7.8%	0%	0.059*
Alcohol drinking	3.1%	3.4%	0.670§

*= Fisher's exact test; §= Chi-square test 2x2; %BF= percentage of body fat; BMC = bone mineral content assessed with dual-energy X-ray absorptiometry; BMD = bone mineral density assessed with DEXA.

Finally, the relationship among indicators of bone densitometry, height and current physical activity and physical activity during childhood/adolescence was tested and adjusted for confounding factors (Table 3). Current physical activity was not associated with any of the bone densitometry indicators, although sports activities during childhood/adolescence were positively associated with BMC (β= 0.27 [$β_{95\%CI}$= 0.06; 0.48]), BMD (β= 0.10 [$β_{95\%CI}$= 0.05; 0.16]) and height (β= 4.50 [$β_{95\%CI}$= 0.54; 8.46]), regardless of adjustment for other variables, including current physical activity. In general, independently of the adjustments made, individuals who reported being engaged in sports activities during childhood/adolescence had BMC, BMD-legs and height values that were respectively 0.27 g, 0.10 g/cm^2 and 4.5 cm higher than those who did not report performing any physical activities during these stages of life.

Table 3 – Relationship between bone densitometry and the practice of sports activities during childhood/adolescence and adulthood.

		BMC	BMD	BMD-arms	BMD-legs	Height
Correlation	Physical activity	rho	rho	rho	rho	rho
	Childhood/adolescence	0.22	0.15	0.14	0.26**	0.19*
	p-value	0.012	0.09	0.115	0.003	0.033
	Current	0.08	0.01	0.11	0.11	0.02
	p-value	0.349	0.835	0.199	0.230	0.762
Linear regression§		β ($\beta_{95\%CI}$)	β ($\beta_{95\%CI}$)	β ($\beta_{95\%CI}$)	β ($\beta_{95\%CI}$)	β ($\beta_{95\%CI}$)
	Childhood/adolescence	0.27 (0.06; 0.48)	--	--	0.10 (0.05; 0.16)	4.50 (0.54; 8.46)
	p-value	0.012			0.001	0.026
	r^2 of the model	0.379			0.561	0.527

95%CI= 95% confidence interval; rho= Spearman's correlation coefficient; *= p-value <0.05; **= p-value< 0.01; §= adjusted for sex, age, %BF, alcohol drinking, smoking and physical activity; %BF= percentage of body fat; BMC = bone mineral content assessed with dual-energy X-ray absorptiometry; BMD = bone mineral density assessed with DEXA.

DISCUSSION

In the present study, nearly half of the sample was engaged in sports activities during childhood/adolescence, which was positively associated with a higher number of steps taken weekly. In fact, this information shows the existence of characteristics of physical activity stability in this group of adults, a finding similar to those observed in other Brazilian studies[11,14]. This information is important, as there is evidence that the maintenance of physical activity practice throughout life helps to prevent not only osteoporosis in adulthood, but also metabolic syndrome components[11,12,15].

On the other hand, it should be emphasized that at least 30% of the adults assessed were categorized as sufficiently active. This information is similar to that found in a previous study[12] and it corroborates the fact that effective governmental efforts should be made to promote the practice of physical activities in all age groups of the Brazilian population.

Previous cohort and intervention studies conducted with children and adolescents have shown a significant association between the practice of physical activities and bone mass gain even during adolescence[1,16,17]. Similarly, when bone mass was analyzed according to previous sports activities in the present sample, adults engaged in sports activities during childhood/adolescence were found to have higher values of BMC, BMD-legs and height.

Curiously, the only BMD indicator that was associated with sports activities during childhood/adolescence was the BMD-legs. Anatomical differences in the accumulation of bone mass found in the present study may have been caused by the type of sports activity performed during childhood/adolescence[18-20]. It is well known that team sports such as soccer, volleyball and handball are frequently practiced in Brazil[11,14,21]. These types of sports involve movements such as running, jumping and changing direction, requiring lower limb muscles to work and, thus, stimulating greater bone mass gain[22].

The greatest contribution of the present study is believed to be the identification of the association between sports activities during childhood/adolescence and greater bone mineral density, even after adjusting for current physical activity, obesity and behavior harmful to bone formation. Differently from other physiological outcomes (hemodynamic and metabolic ones) in which there is a strong influence from current physical activity, bone mineral density/content is an outcome of which 90% is formed until the end of adolescence[23]. In this sense, current physical activity could function as a factor that helps to reduce bone loss resulting from the aging process, although its content is determined during childhood/adolescence. According to this perspective, such finding enables one to observe the importance of the practice of sports activities during childhood/adolescence to prevent outcomes such as osteoporosis during adulthood[24].

In its turn, in addition to the above mentioned associations, the harmful effects of high-risk behavior such as smoking and excessive alcohol drinking affect the bone tissue[25]. Combined with alcoholic substances, nicotine decreases osteoblastic activity and increases osteoclastic activity. Additionally, it can also interfere with serum levels of estrogen in women, directly affecting bone re-absorption, stimulating the osteoporotic process[3].

The following can be mentioned as study limitations: 1) the cross-sectional design with retrospective characteristics, which restricts the strength of the inferences made; 2) the absence of nutritional information, especially the intake of calcium and vitamins D and K during childhood/adolescence and adulthood; and 3) the bias resulting from remembering activities practiced years before should be considered when interpreting the findings, although a stricter criterion was adopted to identify sports activities during childhood/adolescence.

In conclusion, in the present sample of adults, sports activities performed during childhood/adolescence were significantly associated with bone mass values during adulthood, regardless of one's current physical activities. In contrast, future studies using representative samples and longitudinal designs are still required to achieve a better understanding of this theme.

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Authors' contributions

MCSL developed the project and manuscript, participated in the field work and approved the final version of this manuscript;

SUC, RRA and IHI participated in the writing of the manuscript, making key intellectual contribution to its conclusion and approval of its final version;

RAF developed the project and manuscript, made intellectual contribution and approved its final version.

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