CHANGES IN LOWER LIMB BONE DENSITY IN YOUNG JUMPERS

ALTERAÇÕES NA DENSIDADE ÓSSEA DOS MEMBROS INFERIORES EM JOVENS PRATICANTES DE SALTO

CAMBIOS EN LA DENSIDAD ÓSEA DE LOS MIEMBROS INFERIORES EN JÓVENES PRACTICANTES DE SALTO

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Long Zhang[1]
(Physical Education Professional)

1. Huanghe Jiaotong University, Department of Sports, Jiaozuo, China.

Correspondence:
Long Zhang
Jiaozuo, China, 450000.
zhanglongmayuting@163.com

ABSTRACT

Introduction: The research on the exercise effect on the human bone density and skeletal muscle content mainly focuses on the middle-aged and elderly population. However, few studies on different sports' effects upon bone and muscle density in college students and adolescents. Objective: Study the effect of physical training on bone density and lower limb jumping ability in young people. Methods: The relationship between bone mineral density and lower limb jumping ability was analyzed by mathematical statistics. Male individuals aged 10-20 years were divided into the early adolescence group (n=26) and late adolescence group (n=37). According to training status, they were divided into preadolescent athletic group (n=11), non-athletic group (n=15); puberty athletic group (n=11) and non-athletic group (n=15). The following indicators were used: bone density, vertical jump test, continuous vertical jump test, RDJ index. Results: Athletes' bone mineral density (BMD) is related to their muscle strength. These results suggest a certain internal connection between the (BMD) of bone tissue and the development of muscle strength. Therefore, there is evidence of differences in lower limb bone mineral density and jumping ability between the two groups. Conclusion: Bone mineral density in the lower limbs of adolescents is correlated with jumping ability. Exercise can help improve bone density in adolescents. ***Evidence level II; Therapeutic Studies - Investigating the results.***

Keywords: Adolescent; Bone density; Sports; Lower extremity.

RESUMO

Introdução: A pesquisa no efeito do exercício sobre a densidade óssea humana e o conteúdo muscular esquelético está concentrada principalmente na população de meia-idade e na população idosa. Entretanto, há poucos estudos no efeito de diferentes esportes sobre a densidade óssea e muscular em estudantes universitários e adolescentes. Objetivo: Estudar o efeito do treinamento físico sobre a densidade óssea e a capacidade de salto nos membros inferiores de jovens. Métodos: Analisa-se a relação entre a densidade mineral óssea e a capacidade de salto dos membros inferiores por estatísticas matemáticas. Indivíduos do sexo masculino entre 10 a 20 anos de idade foram divididos em grupo de adolescência inicial (n=26) e tardia (n=37). De acordo com a situação de treino, foram divididos em grupo atlético pré-adolescente (n=11), não atlético (n=15); grupo atlético na puberdade (n=11) e não atlético (n=15). Os seguintes indicadores foram utilizados: densidade óssea, teste de pulo vertical, teste de pulo vertical contínuo, índice RDJ. Resultados: A densidade mineral óssea (DMO) dos atletas está relacionada com sua força muscular. Esses resultados indicam uma certa conexão interna entre a (DMO) do tecido ósseo e o desenvolvimento da força muscular. Portanto, há evidências de diferenças na densidade mineral óssea dos membros inferiores e na capacidade de saltar entre os dois grupos. Conclusão: A densidade mineral óssea nos membros inferiores dos adolescentes está correlacionada com a capacidade de saltar. O exercício pode ajudar a melhorar a densidade óssea nos adolescentes. ***Nível de evidência II; Estudos terapêuticos - Investigação de resultados.***

Descritores: *Adolescente; Densidade Óssea; Esportes; Extremidade Inferior.*

RESUMEN

Introducción: La investigación sobre el efecto del ejercicio en la densidad ósea humana y el contenido muscular esquelético se concentra principalmente en la población de mediana y avanzada edad. Sin embargo, hay pocos estudios sobre el efecto de los diferentes deportes en la densidad ósea y muscular en estudiantes universitarios y adolescentes. Objetivo: Estudiar el efecto del entrenamiento físico sobre la densidad ósea y la capacidad de salto de los miembros inferiores en jóvenes. Métodos: La relación entre la densidad mineral ósea y la capacidad de salto de las extremidades inferiores se analizó mediante estadística matemática. Individuos del sexo masculinos de entre 10 y 20 años se dividieron en el grupo de adolescentes tempranos (n=26) y adolescentes tardíos (n=37). Según el estado de entrenamiento, fueron repartidos en grupo atlético preadolescente (n=11), grupo no atlético (n=15); grupo atlético puberal (n=11) y grupo no atlético (n=15). Se utilizaron los siguientes indicadores: densidad ósea, prueba de salto vertical, prueba de salto vertical continuo, índice RDJ. Resultados: La densidad mineral ósea (DMO) de los deportistas está relacionada con su fuerza muscular. Estos resultados indican una cierta conexión interna entre la (DMO) del tejido óseo y el desarrollo *de la fuerza muscular. Por lo tanto, existen pruebas de las diferencias en la densidad mineral ósea de las extremidades inferiores y en la capacidad de salto entre los dos grupos. Conclusión: La densidad mineral ósea en las extremidades inferiores de los adolescentes está correlacionada con la capacidad de salto. El ejercicio puede ayudar a mejorar la densidad ósea en los adolescentes.* ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores**:** *Adolescente; Densidad Ósea; Deportes; Extremidad Inferior.*

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INTRODUCTION

There have been many reports on the influence of exercise training on bone density. Different sports have different stimulating effects on bone tissue. Bone density changes with different sports.[1] Strength sports have the highest bone density, endurance sports have the lowest bone density, and male and female athletes show similar changes. Studies have found that weightlifters have the highest bone density among sports items by comparing muscle isometric contraction strength. Some scholars have proposed that athletes' bone mineral density (BMD) is related to muscle strength. These results indicate a certain internal connection between BMD of bone tissue and the development of muscle strength. This study explored the changes in the jumping ability of lower limbs and the development of bone mineral density during the development of male adolescents.

METHOD

Object

The experiment subjects were 63 male adolescent students from 10 to 20 years old.[2] The test time of this experiment is April 2020. The samples were divided into pre-adolescent development (26 people) and late adolescence (37 people). According to the training situation of the subjects in the sports school, they are divided into the pre-adolescent athlete group (11 people) and the non-athlete group (15 people). Athlete group (22 people) and the non-athlete group (15 people) in late puberty development.

Testing indicators

Bone density, vertical jump, continuous vertical jump, when in the air, when touched down, RDJ index.

Test method

BMD value determination

We use Sahara (U.S.) ultrasonic bone densitometer to measure the ultrasonic attenuation (BUA). And the speed of sound (SOS) of the calcaneus to calculate the QUI index (QUI is the ultrasonic stiffness, which is a new parameter obtained after the linear combination of SOS and BUA parameters.[3] It is linearly related to the height of BMD. From this, the BMD of the calcaneus is estimated).

Measurement of jumping ability index of lower limbs

We use the Nissan Rebound Jumping tester to test. The vertical jump ability is estimated by taking the maximum value of 3 vertical jumps.[4] A computer connected to the measuring device automatically calculates the above values.

Predictive modeling and simulation of vulnerable parts of the body during strenuous exercise

In the process of constructing a prediction model for body parts that are vulnerable to damage during strenuous exercise, the intrinsic relationship between the attributes of sports injuries and the motion amplitude of body parts is first obtained.[5] We construct the relationship equation between the part that reflects the sports injury and the movement amplitude of the body part. Calculate the variable between the attributes of severe sports injury and the movement range of vulnerable body parts. We abstract the strenuous exercise data as a strenuous exercise data information system

$$A = \langle W, Q, V, f \rangle \quad (1)$$

The domain of the strenuous exercise data attribute is expressed as

$$W = \{x_1, x_2, \cdots, x_n\} \quad (2)$$

Suppose $Q = SUD$ represents a finite set of vigorous exercise data attributes. Indicates that the condition attribute set of strenuous exercise data is

$$S = \{s_1, s_2, \cdots, s_m\} \quad (3)$$

$D = \{d\}$ represents the decision attribute set of strenuous exercise data. $V = \{v_1, v_2, \cdots, v_m\}$ represents the value range set of the strenuous exercise data attribute. v_i represents the value range of the attribute c_i of the strenuous exercise data. f: $W \times S \rightarrow V$ stands for motion data information function.[6] This embodies the mapping from the entire universe W and the conditional attribute set S to the value range set V. Suppose a single decision attribute corresponds to a decision table, which satisfies

$$\{f(x_i, s_j) = u_{j,i}, f(x_i, d) = v_i\} \quad (4)$$

$u_{j,i}$ represents the amount of risk where sports injuries occur. v_i represents the amount of risk at the location where sports injuries occur. Q contains any attribute subset B of severe sports injury attribute data, then the equivalent relation of W corresponding to I satisfies

$$I(B) = \{(x, y) \in W \times W : f(x, a) = f(y, a), \forall a \in B\} \quad (5)$$

Statistical analysis

We use the statistical software package SPSS10.0 to perform statistical descriptions and test analyses on the data.[7] The specific methods are the correlation analysis of the binary variables in the correlation analysis and the test of independent samples.

RESULTS

Comparison of BMD (g/cm²) of male adolescents between 10-15 years old group and 16-20 years old group

The BMD of the 10--the 15-year-old group was (0.54±0.09) g·cm^{-2}, and the BMD of the 16-20-year-old group was (0.69±0.09) g·cm^{-2} (P<0.01). The BMD of the 10--15-year-old athlete group was (0.63±0.09) g·cm^{-2}, and the BMD of the non-athlete group was 0.54±0.08) g·cm^{-2} (P<0.04). The BMD of the 16-20-year-old athlete group was (0.69±0.07) g·cm^{-2}, and the BMD of the non-athlete group was (0.60±0.09) g·cm^{-2} (P<0.01). It can be seen that there are very significant differences in the BMD of the samples from the prepubertal development group and the later adolescent development group.[8] There are significant differences in BMD between the athlete group and the non-athlete group in the pre-spring development period. There are also very significant differences in BMD between the athlete group and the non-athlete group in the late spring development. The results suggest that BMD is affected by youth development, and exercise training during adolescence can increase the value of BMD. (Table 1,2 and 3)

DISCUSSION

During the entire youth development of male adolescents, BMD was significantly positively correlated with jumping ability indicators reflecting lower limb strength, including vertical jump, continuous vertical jump height, and RDJ index. At the same time, it is found that exercise training can affect the BMD value, which has a positive effect.[9] It can affect the correlation between BMD and lower limb jumping ability index.

BMD is age-dependent. A large number of studies have shown that the peak bone mass of the body is generally reached before the age of 40. The peak bone mass is gradually lost as age increases.[10] Studies have shown that male bone mass growth is more obvious throughout adolescence. And with the increase of age, the bone density of the cortical bone of the long bone also increases. It can be expressed as a linear growth model. The results of this experimental investigation also found significant differences between the BMD of male adolescents in the early and late puberty development period. This suggests that BMD tends to increase with age.

Some scholars have found a correlation between the BMD values of female ice hockey players in different positions and muscle strength.[11] And this correlation diminishes as the level of exercise increases.

The results of this experiment also found that the jumping ability index reflects the strength of the lower limbs of the teenagers throughout the youth development process.[12] Vertical jump, continuous vertical jump height, RDJ index, etc., were significantly positively correlated with BMD. This correlation is significantly different between the exercise group and the non-exercise group. This suggests that people with strong lower limbs have higher BMD values. Bone is the human body's mechanical level. It bears the mechanical strain when the body moves. Stress load can affect the peak bone value related to gravity load and muscle traction. Gravity plays an important role in the normal growth and functional maintenance of the human skeletal system. When the astronaut is in a microgravity environment, the gravity load on the bones decreases significantly. This leads to pathological changes such as loss of mineral salts in load-bearing bones and decreased BMD. The muscle is directly attached to the bone, and the traction force of the muscle can affect the bone. Both muscle mass and muscle strength are positively correlated with bone mass.

As a kind of physiological stress, exercise training can promote a series of adaptive changes in the function and morphology of the limbs, such as the increase of lean muscle mass, the decrease of body fat, the rigidity of bone, and the hypertrophy of myocardium. Many existing studies have confirmed the relationship between bone mineralization and body muscles and exercise. Data are showing effective and appropriate exercise before skeletal growth and development stops. It has a good promoting effect on increasing the value of bone mineral density in adolescence and peak bone mass (PBM) in adulthood. Physical exercise, especially active, weight-bearing exercise, provides mechanical stimulation to maintain or improve bone health. Some scholars believe that weight-bearing exercise promotes bone formation by increasing muscle strength and maintains or even increases BMD in postmenopausal women. This shows that the greater the muscle strength, the more obvious the effect on bone formation. Studies have shown that exercise has a positive effect on the BMD of early adolescent girls. It further suggests that regular exercise can promote the increase of BMD value. Exercise methods including jumping and explosive power can promote BMD value more than simply running. It can significantly increase the BMD of the lower limbs and pelvis.

Table 1. Comparison of the jumping ability of teenagers between 10-15 years old group and 16-20 years old group.

	Overall	
Group	**10-15 years old group**	**16-20 years old group**
n	26	37
h vertical jump/m	38.81±8.82	50.65±5.83
RDJ index/(m·s)	1.70±0.5	2.34±0.61
ta, RDJ/s	0.47±0.04	0.56±0.05
tc, RDJ/s	0.18±0.04	0.16±0.03
*h*RDJ/m	27.07±6.54	38.94±6.46
P	<0.01	
	10~15 years old	
Group	**Sports group**	**Non-exercise group**
n	1	15
h vertical jump/m	45.47±5.54	34.08±7.63
RDJ index/(m·s)	2.26±0.43	1.45±0.41
ta, RDJ/s	0.51±0.02	0.43±0.05
tc, RDJ/s	0.15±0.02	0.19±0.05
*h*RDJ/m	31.92±3.14	23.42±6.16
P	<0.01	
	16-20 years old	
Group	**Sports group**	**Non-exercise group**
n	2	15
h vertical jump/m	3.62±5.26	48.74±5.53
RDJ index/(m·s)	2.71±0.49	1.80±0.26
ta, RDJ/s	0.58±0.04	0.52±0.03
tc, RDJ/s	0.15±0.01	0.18±0.03
*h*RDJ/m	41.83±6.17	34.54±4.16
P	<0.01	

Table 2. Correlation analysis of BMD and lower limb jumping ability index of sample male adolescents.

	BMD/(g·cm^{-2})		
	Sports group + non-sports group	**Sports group**	**Non-exercise group**
h vertical jump/m	0.35	0.27	0.09
RDJ index/(m·s)	0.57	0.5	0.54
t_a, RDJ/s	0.4	0.35	0.15
Tc, RDJ/s	-0.57	-0.4	-0.12
h RDJ/m	0.42	0.35	0.27

Table 3. Correlation analysis of BMD and lower limb jumping ability index of male adolescents in the 10-15-year-old group and 16–20-year-old group.

	BMD/(g·cm^{-2})	
	Prepubertal group	**Late puberty group**
h vertical jump/m	0.14	0.19
RDJ index/(m·s)	0.44	0.52
t_a, RDJ/s	0.2	0.37
Tc, RDJ/s	-0.6	-0.52
h RDJ/m	0.21	0.31

CONCLUSION

This study also shows that the indicators reflecting the ability of lower limbs to jump are positively correlated with BMD. And sports training improves jumping ability while simultaneously increasing BMD.

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