

Analysis of Bone Mass Characteristics of College Students with Different Physical Activity Levels in Shenyang Sport University

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Abstract

Objective: In order to reduce the incidence of osteoporosis, this paper attempts to analyze the relationship between physical activity and bone density, hoping to reduce the occurrence of osteoporosis, and to put forward effective suggestions. **Methods:** In this study, a random sample of 148 college students from Shenyang Sport University was randomly sampled and grouped according to physical activity, with male subjects less than 1,000 MET·min as the first group, 1,000-2,000 MET·min as the second group, and greater than 2,000 MET·min as the third group. Female subjects were discussed with less than 1,000 MET·min as the first group and 1,000-2,000 MET·min as the second group. The Lunar Prodigy dual-energy X-ray bone density scanner produced by GE (General Electric Company) was used to measure bone mass, while measuring physical activity using the International Physical Activity Scale. In this study, an independent sample t-test was performed for height, weight, and physical activity volume, and Pearson correlation analysis was used to analyze physical activity and bone mass indexes. **Results:** The bone density of the subjects was generally above the normal level, and the T value and Z value were positive. The bone mass index of college students from Shenyang Institute of Physical Education increased with physical activity, and the increase in male students was greater than that in female students. Physical activity has a greater impact on a man's bone health. **Conclusion:** Maintaining a proper amount of physical activity can enhance bone mass and reduce the occurrence of osteoporosis.

Keywords

Bone mineral density, Dual-energy X-rays, University student, Physical activity

Introduction

With economic development and advances in science and technology, population aging in modern society is becoming increasingly severe. Bone health is an important factor affecting the quality of life and well-being of the elderly. Therefore, it is crucial to strengthen bone mass during the sensitive period of bone development in adolescents. However, according to the 2019 "Report on the Nutritional Health Status of Chinese Residents", the calcium intake of Chinese adolescents and children is significantly low, with a daily intake of only 4,539.3 mg/d, far below the standard calcium intake for Chinese adolescents (1,000.0 mg/d). Chinese residents lack awareness of the importance of bone mass and solutions to improve it. Thus, to significantly enhance the bone quality of Chinese adolescents during this sensitive period, this paper analyzes the impact of

physical activity on bone density, identifies relevant influencing factors, and proposes corresponding strategies to increase adolescent bone mass, ultimately aiming to prevent osteoporosis [1].

The American College of Sports Medicine defines physical activity as follows: When an individual is in a resting state, a certain basal metabolic rate occurs, and muscle movement increases and accelerates this basal metabolic efficiency, significantly raising the energy consumed by the body [2]. This type of activity that increases energy expenditure is called physical activity. Dual-energy X-ray absorptiometry (DXA) refers to X-rays emitted from an X-ray tube, which are divided into 40 keV and 70-80 keV after K-edge absorption, used to measure bone density. Both Dual-energy X-ray absorptiometry (DXA) and Dual Photon Absorptiometry

(DPA) employ similar detection principles, except that DXA uses an X-ray generator or X-ray radiofrequency filter to produce different energy beams. Compared to DPA, DXA’s advantage lies in its ability to produce more photons through the X-ray tube, thereby shortening scan time while providing clearer imaging, improving detection accuracy and precision, making it the current “gold standard” for Bone Mineral Density (BMD).

Research subjects and methods

Research subjects

The study randomly recruited 148 college students from Shenyang Sport University. Prior to the experiment, screening was conducted, and all subjects were healthy according to their university entrance medical examinations, with ages ranging from 18 to 24 years old.

Table 1. Basic information of the subjects in this study (x±s).

Group	Physical activity level (MET·min)	Gender	Number of subjects	Height (cm)	Weight (kg)
1	<1,000	Male	20	178.2±6.6	79.5±11.8
		Female	29	163.8±6.6	59.3±7.4
2	1,000-2,000	Male	23	176.9±3.7	77.6±7.7
		Female	23	164.4±4.6	57.3±5.1
3	>2,000	Male	53	176.8±6.2	72.1±7.0

This study collected 148 valid data entries. A total of 148 subjects were included, comprising 96 males and 52 females. They were divided into three groups based on physical activity levels: less than 1,000 MET·min, 1,000-2,000 MET·min, and greater than 2,000 MET·min. Basic information such as height and weight was statistically analyzed for each group. As shown in Table 1, all 148 subjects had height and weight within the normal range, excluding factors like obesity that could affect the study.

Research methods

(1) Literature review method

Using “bone mineral density”, “dual-energy X-ray”, and “physical activity level” as keywords, relevant literature was searched in databases such as Wanfang, CNKI, and the Shenyang Sport University Library. Data on bone density testing and physical activity levels of college students were reviewed to provide valuable references for this study.

(2) Questionnaire survey method

The International Physical Activity Questionnaire (IPAQ) was used to measure subjects’ physical activity levels. The internationally standardized physical activity level is calculated as the product of activity intensity and single or cumulative duration, generally expressed in MET·min (metabolic equivalent minutes). Metabolic Equivalent of Energy (MET) refers to the energy metabolic equivalent, which is based on the energy expenditure at rest while sitting and serves as a common indicator for relative energy metabolism levels during various activities. An activity intensity of 1 MET is

defined as consuming 3.5 mLkg⁻¹ min⁻¹. A 1 MET activity intensity is slightly higher than the basal metabolic rate of healthy adults, equivalent to the metabolic level of a healthy adult sitting quietly. Questionnaire results were statistically analyzed to group physical activity levels. Male subjects were divided into three groups: less than 1,000 MET·min (Group 1), 1,000-2,000 MET min (Group 2), and greater than 2,000 MET·min (Group 3). Female subjects were divided into two groups: less than 1,000 MET·min (Group 1) and 1,000-2,000 MET·min (Group 2) for discussion.

(3) Experimental method

During the period of March 2022 to April 2022. A total of 148 college students from Shenyang Sport University were randomly selected. Bone density testing was conducted on the first floor of the Science and Technology Building at Shenyang Sport University. The testing equipment included a GE Lunar Prodigy dual-energy X-ray absorptiometry (DEXA) bone density scanner for whole-body BMD measurement. Additionally, it includes a height and weight scale, a soft measuring tape, and other tools.

When measuring height and weight, the subject must be barefoot, wearing appropriate lightweight clothing, standing on the height scale’s floor with heels, sacrum, and the area between the shoulder blades pressed firmly against the scale’s vertical column to avoid inaccurate measurements. The measurer can stand on either the left or right side of the subject, adjust the subject’s head so that the upper edge of the tragus aligns with the lowest

point of the orbital floor, then activate the height and weight scale, move the horizontal bar to the top of the subject's head, and record their height and weight.

When using the dual-energy X-ray method for bone density measurement, wear loose clothing for the test or change into examination attire in the testing room to facilitate the procedure. First, removing any objects that may attenuate X-rays, such as items with zippers, clasps, or buttons, to avoid artifacts. The subject must lie flat at the center of the scanner, with the computer recording and analyzing the data. The test indicators for this experiment includes: height, weight, bone mineral density (BMD), T-score, Z-score, and physical activity level.

(4) Mathematical statistics method

Excel 2013 software was used to statistically organize and analyze the obtained data. SPSS 26.0 statistical software was employed for data processing and analysis. Experimental data are expressed as mean ± standard deviation. Independent sample t-tests were conducted for bone mass indicators across groups, and Pearson correlation analysis was performed between physical activity levels and bone mineral density.

Results and analysis

The bone mineral density, T-scores, and Z-scores of Shenyang Sport University students measured based on different physical activity levels are detailed in Table 2.

Table 2. Analysis results of the relationship between physical activity levels and bone mineral density in Shenyang Sport University Students (x±s).

Group	Physical activity level (MET·min)	Gender (Numbers of subjects)	Bone mineral density (g/cm ³)	T-score	Z-score
1	<1000	Male (20)	1.321±0.118	1.885±0.942	1.546±0.774
		Female (29)	1.176±0.113	0.909±0.905	1.152±0.773
2	1000-2000	Male (23)	1.342±0.103	2.052±0.829	1.761±0.757#
		Female (23)	1.193±0.099#	1.05±0.759#	1.382±0.749#
3	>2000	Male (53)	1.366±0.106##*	2.179±0.848##*	2.034±0.778###*

Note: # indicates a significant difference compared to Group 1 (p<0.05), ## indicates a highly significant difference compared to Group 1 (p<0.01); * indicates a significant difference compared to Group 2 (p<0.05), ** indicates a highly significant difference compared to Group 2 (p<0.01).

The impact of different physical activity levels on bone mineral density of students at Shenyang Sport University

Bone mineral density (BMD) refers to the content of bone minerals in bone tissue, reflecting the mass of bone minerals in the skeleton. It is calculated through a procedure called densitometry and is clinically expressed as optical density per square centimeter. As an effective indicator for osteoporosis diagnosis, BMD is also a primary metric in fracture risk assessment systems. The mean BMD for male subjects in Group 1 was 1.321 (g/cm³); for females, it was 1.176 (g/cm³). In Group 2, the mean BMD for male subjects was 1.342 (g/cm³), and for female subjects, it was 1.193 (g/cm³). In Group 3, the mean BMD for male subjects was 1.366 (g/cm³). The average BMD for healthy young males is 1.228 (g/cm³), and for females, it is 1.167 (g/cm³). Compared to the normal levels, the BMD of students at Shenyang Sport University is generally higher. The BMD values of

female subjects in Group 2 showed a significant difference compared to Group 1 (p<0.05). The BMD values of male subjects in Group 3 showed significant differences compared to both Group 1 and Group 2 (p<0.05).

As seen in Table 2 and Figure 1, BMD values increase with higher physical activity levels, showing a positive correlation with a coefficient of 0.6. The BMD of male subjects in Group 3 and female subjects in Group 2 was higher compared to the other groups. Male subjects had higher BMD than females with the same level of physical activity. The change in BMD with physical activity was more pronounced in male subjects than in females, indicating that physical activity has a greater impact on BMD in males. In the study by Chen et al. on the dose-response relationship between physical activity and bone mineral density improvement in obese children and adolescents, it was confirmed that short-term exercise intervention can improve bone mineral density in obese

children and adolescents [3]. Although the study subjects differ from those in this paper, it proves that physical activity can indeed have a positive impact on increasing bone mass. Similarly, in the study by Liu et al. on the correlation between skeletal muscle content, physical activity level, and bone mineral density, it was also concluded that bone mineral density has a highly significant correlation with the subjects' physical activity levels [4]. Bone mineral density is influenced by various

factors such as exercise, diet, and metabolism. Exercise's impact on bone mass is currently a focus of scholars both domestically and internationally. Extensive data indicate that exercise is an effective way to increase bone mass, especially during the sensitive period of adolescent skeletal development. Before bone growth stagnates, exercise can significantly improve bone mass during adolescence and markedly enhance peak bone mass in adulthood [5].

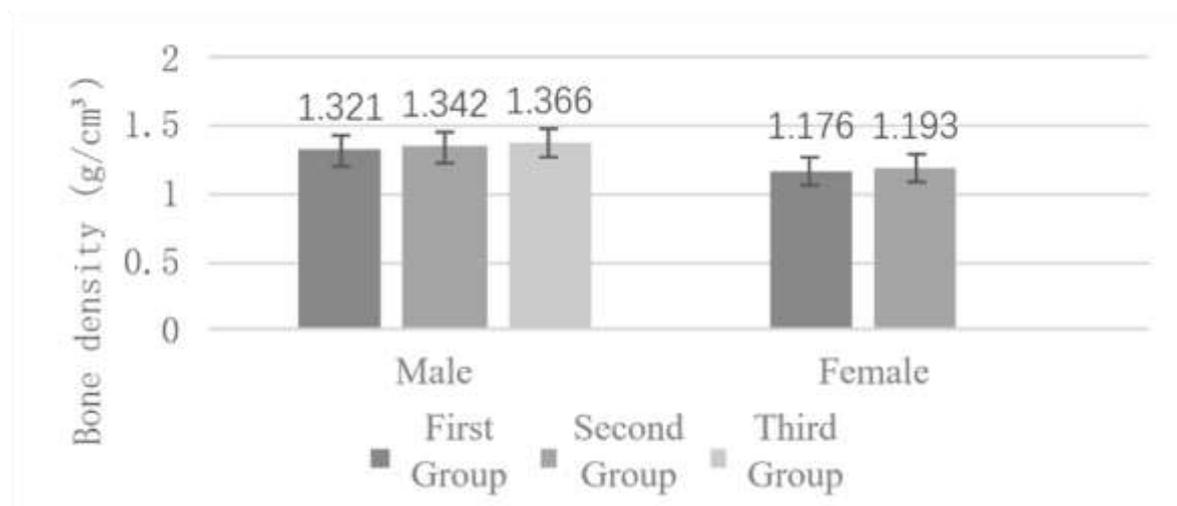


Figure 1. The impact of different physical activity levels on bone mineral density of students at Shenyang Sport University.

The impact of different physical activity levels on the bone mass T-score of students at Shenyang Sport University

The T-score compares the measured bone mineral density with the peak bone mass of healthy young adults aged 30-35 years old, yielding the standard deviation above (+) or below (-) that of young adults. Therefore, the bone mineral density T-score is a relative value, and a T-score between -1 and +1 indicates normal bone quality. A bone mineral density T-score below -2.5 indicates osteoporosis. The T-score is the most meaningful value for diagnosing osteoporosis. Among the 148 subjects, only one female had a negative bone mass T-score, which is considered a result of both genetic factors and lack of physical activity. The remaining 147 subjects had positive values, meaning 99.4% of the subjects had bone mass higher than the peak bone mass of healthy young adults aged 30-35 years old. This also suggests that the bone mass level of students at Shenyang Sport University is relatively high. The bone mass T-score of female subjects in the second group showed a significant difference compared to that of the first group

($p < 0.05$). The bone mass T-score of male subjects in the third group showed significant differences compared to both the first and second groups ($p < 0.05$).

As shown in Table 2 and Figure 2, the T-score of bone mass increases with higher physical activity levels, indicating a positive correlation. The T-scores of bone mass in male subjects of the third group and female subjects of the second group were the highest compared to those in the other groups. The T-scores of bone mass in male subjects were significantly higher than those in female subjects of the same group. The variation in T-scores of bone mass with physical activity levels was greater in male subjects than in female subjects. In the study by Cheng et al. on the current bone mass status and fracture risk assessment among elderly residents in a Kaifeng community, it was similarly concluded that physical activity could increase the T-scores of bone mass in males [6]. However, their findings suggested that physical activity did not influence the increase in T-scores for females, which contradicts the results of this study and warrants further investigation.

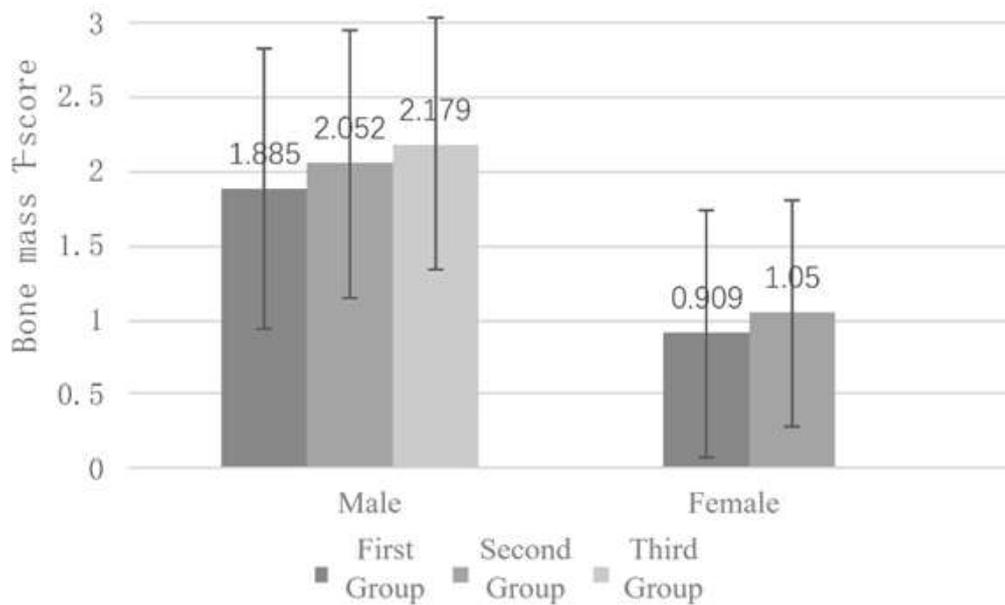


Figure 2. The impact of different physical activity levels on the bone mass T-Score of students at Shenyang Sport University.

The impact of different physical activity levels on the Z-scores of bone mass among Shenyang Sport University students

The Z-score compares the measured bone mineral density with that of peers of the same age. Statistical analysis showed that all subjects had positive Z-scores for bone mass, suggesting that Shenyang Sport University students have bone mass values above the average for their age group. There were significant differences in Z-scores of bone mass between male and female subjects in the second group and those in the first

group ($p < 0.05$). The Z-scores of male subjects in the third group showed highly significant differences compared to the first group ($p < 0.01$) and significant differences compared to the second group ($p < 0.05$). As shown in Table 2 and Figure 3, the Z-scores of bone mass increase progressively with higher physical activity levels, revealing a positive correlation with a correlation coefficient of approximately 0.6. The variation in Z-scores of bone mass associated with physical activity levels was observed to be greater in male subjects than in female subjects.

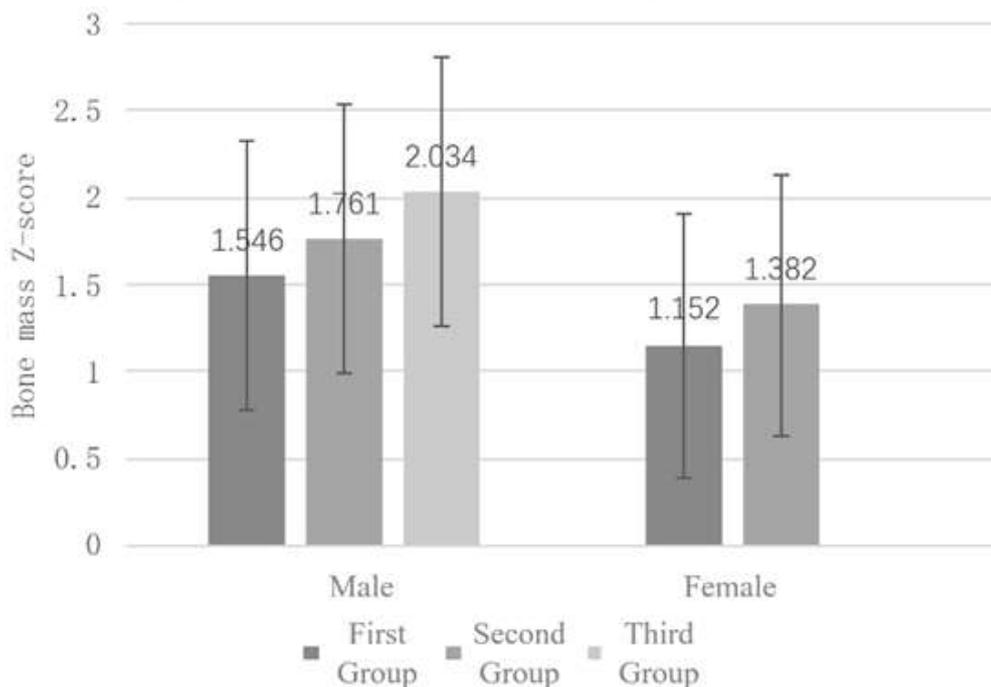


Figure 3. The impact of different physical activity levels on the Z-scores of bone mass among Shenyang Sport University students.

Analysis and discussion

This study examined the impact of physical activity on bone mass by comparing bone mineral density (BMD), T-scores, and Z-scores among Shenyang Sport University students under different physical activity levels. The results indicate a positive correlation between physical activity and bone mass indicators. The increase in bone mass with higher physical activity was significantly greater in male students than in females, suggesting that physical activity has a more pronounced effect on bone health in males.

The impact of physical activity level on bone mineral density

This study found that as physical activity levels increased, bone mineral density showed an upward trend among both male and female college students. Specifically, male participants with physical activity exceeding 2,000 MET·min had significantly higher bone mineral density than the low-activity group ($p < 0.05$), while females in the 1,000-2,000 MET·min group also showed significant differences ($p < 0.05$). This aligns with the findings of Zhang et al. in their study on obese children and adolescents, indicating that increased physical activity contributes to improved bone mineral density [7]. Hu et al. also noted a significant correlation between bone mineral density and physical activity levels, further supporting the results of this study [8].

The improvement in bone mineral density may be related to mechanical load stimulating bone formation. During exercise, muscle contractions and gravitational loads create stress on bones, activating bone cell signaling pathways and promoting the deposition of bone minerals. Therefore, maintaining appropriate physical activity levels during adolescence helps accumulate more bone mass before peak bone mass formation, reducing the risk of future osteoporosis.

The impact of physical activity level on T-score and Z-score of bone mass

As key indicators for evaluating bone mass, T-scores and Z-scores reflect comparisons with peak bone mass in young adults and age-matched populations, respectively. In this study, all participants had positive T-scores and Z-scores, indicating that the bone mass of Shenyang Sport University students was generally higher than normal levels. Notably, males with physical activity exceeding 2,000 MET·min showed highly significant

differences in Z-scores compared to the low-activity group ($p < 0.01$), suggesting that high-intensity physical activity has a more pronounced effect on bone mass improvement.

It is worth noting that females in the 1,000-2,000 MET·min group also had significantly higher T-scores and Z-scores than the low-activity group ($p < 0.05$), but data for higher activity groups were unavailable, possibly due to smaller female sample sizes or uneven activity level distribution. Wang found in a study of elderly individuals that physical activity significantly improved T-scores in males but had no significant effect on females, which differs from the current findings [9]. This discrepancy may be related to factors such as participant age, sex hormone levels, and exercise types, warranting further investigation in future studies.

Influence of gender differences on bone mass response

In this study, the increase in bone mass among male college students with higher physical activity levels was significantly greater than that among females, suggesting that males are more sensitive to bone formation responses stimulated by exercise. This may be related to higher testosterone levels in males, which have a dual effect of promoting bone formation and inhibiting bone resorption [10]. Additionally, differences in exercise intensity, frequency, and type among males may further influence bone mass accumulation.

After puberty, bone mass growth in females tends to plateau, and changes in estrogen levels may affect bone metabolism. Therefore, exercise interventions for female college students should consider their physiological characteristics and select appropriate load types and intensities to maximize bone health benefits.

Practical implications and recommendations

The findings of this study indicate that appropriate physical activity levels have a positive effect on bone health in college students, particularly more pronounced in males. It is recommended that universities strengthen health education and encourage students to participate in diverse physical activities, such as strength training and jumping exercises, to enhance bone density [11]. At the same time, attention should be paid to the bone health of female college students, with gender-specific exercise programs designed to improve their bone mass reserves. Furthermore, schools can foster an active exercise environment through physical education curriculum

reforms, extracurricular activity organization, and health lectures [12]. This helps students achieve peak bone mass during the critical period of skeletal development and lays the foundation for preventing osteoporosis in middle and old age.

Conclusion

The bone density level of students at Shenyang Sport University is higher than that of normal adolescents. The bone density of college students at Shenyang Sport University increases with higher physical activity levels, and the increase is more pronounced in male students than in female students. Physical activity has a greater impact on bone health in males. The T-score of bone mass among college students at Shenyang Sport University increases with higher physical activity levels, and the increase is more pronounced in male students than in female students. Physical activity has a greater impact on the T-score of bone mass in males. The bone mass Z-score of Shenyang Sport University students increases with higher physical activity levels, and the increase in bone density is more pronounced in male students compared to female students. Physical activity has a greater impact on bone health in males.

Recommendations

It is recommended to increase lectures on health-related theoretical knowledge to enhance students' awareness of health and encourage them to voluntarily increase physical activity during leisure time. Teachers should reinforce the knowledge students acquire in sports health theory courses while promoting the practical application of this knowledge. Schools should strengthen scientific research in physical education, refine teaching methods, and boost student participation in physical activities. Society should also increase its emphasis on fostering a social environment that encourages more sports activities, thereby enhancing adolescents' physical activity levels through multiple approaches.

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Conflicts of Interest

The authors declare no conflict of interest.

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