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Bone Mineral Density in Weight Bearing and Non-weight Bearing Sports

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Abstract:

The purpose of this study was the comparison of Bone Mineral Density (BMD) in lumbar spines and the neck of femur among sportsmen.

***Method**: 25 volleyball players (age 23 ± 2.1 years, height 189.73 ±1.7cm, weight 79.76 ± 7.15kg; mean ± SD), 25 throwers (age 20.14 ± 1.86 years, height 186.08 ± 4.16cm, weight 97.37 ± 12.67kg; mean ± SD), 25 swimmers (age 22.75 ± 1.5 years, height 183.76 ± 3.92 cm, weight 83.58 ± 4.51 kg; mean ± SD) and 25 body builders (age 22.86 ± 2.19 years, height 180.21 ± 3.78 cm, weight 87.66 ± 8.87 kg; mean ± SD) participated in this study. BMD of lumbar spines (L2-L4) and the neck of femur were assessed by Dual Energy X-Ray Absorptiometry (DEXA, Norland Excell).*

***Results**: The throwing group were younger in age, heavier in body weight ($p\leq .000$) and higher in lean body mass (LBM) values ($p\leq .000$). The volleyball players were taller ($p\leq .000$) and the swimmers were higher in body fat percentage ($p\leq .008$) than other sportsmen. Throwing and volleyball groups had significantly higher BMD at lumbar bones (L_2-L_4) and neck of the femur compared to swimming and bodybuilding groups. ($p\leq .000$)*

***Conclusion:** This study concludes that mechanical loads have strong effects on bone adaptation. Weight bearing activity effects have to be taken into account for evaluation of osteogenic effects of exercise. Particularly dynamic sports with short, high, and multidimensional loads have the strongest effects on bone formation, independent of training quantity.*

Key words: Body composition, Bone Mineral Density (BMD), Dual Energy X-Ray Absorptiometry (DEXA), weight bearing activity and non-weight bearing activity

Introduction

Both men and women are at risk for osteoporotic fractures. As osteoporosis is more common in females, most exercise-related research has focused on reducing the risk of osteoporotic fractures in women (1). However, as osteoporosis is a growing problem also in males (13), more information is needed about factors influencing bone mass in this gender. Studies in males have reported that athletic training leads to an increase of bone mineral density (BMD), particularly in the highly stressed parts of the skeleton, such as in the playing arm of tennis players (10). It is not known whether these adaptations are induced by muscle pull or by mechanical or other factors.

Physical activities, particularly weight-bearing exercises are believed to provide the mechanical stimuli or 'loading' importance for the maintenance and improvement of bone health, whereas physical inactivity has been implicated in bone loss and its associated health costs. Both aerobic and resistance training exercise can provide weight-bearing stimulus to bones, yet research indicates that resistance training may have a more profound site specific effect than aerobic exercises. High-intensity resistance training, in contrast to traditional pharmacological and nutritional approaches for improving bone health in older adults, have the added benefits of influencing multiple risk factors for osteoporosis, including improved strength, balance and increased muscle mass. (9) Mechanical loads are important for the growth and maintenance of bones.

Hence, the present study was interested to investigate of bone mineral density at two sites of the skeleton in male athletes of different high-intensity sports i.e. non-weight bearing and weight bearing exercises - athletes who chronically train in different sports and thus have differing amounts of mechanical loading on the skeleton - and to compare these values together (volleyball, swimming, Throwing and body building).

Methods

Subjects

One hundred Iranian male athletes participated in this study. Subjects were recruited from the national, local as well as regional high level sport clubs and teams. The athletes were divided into 4 groups: volleyball (n=25), throwing (n=25), swimming (n=25) and body building (n=25). All athletes had been training regularly 4-6 days per week for at least 5 years playing experiences in their specific sport. They were on national and, partly, international performance levels.

All athletes were free of any illness such as diabetes, hyperthyroidism, hyperparathyroidism, cardiovascular disease and were not taking any medication viz. anti-seizure drugs, cortone consumption, and alcohol and smoking cigarette.

Body Composition

Body Composition was made on each subject. Height was measured in the upright position to the nearest millimeter (Seca, Germany). Body mass (weight), lean body mass (LBM) body fat percentage were determined using a body composition analyzer (X-scan plus II model).

Bone mineral density

BMD was measured with dual-energy X-ray-absorptiometry (DXA) using Norland Excell (made in USA) instrument. BMD was measured at L_2–L_4 of lumbar spines, the neck of femur and dominant wrist.

Procedure

Body Composition measurements were conducted after a light breakfast and without exercise for 12 hours.

BMD test is a quick and painless procedure. The person lays on the whole body scanner, with the x-ray sources mounted beneath a table and a detector overhead. The persons were scanned with photons generated by two low-dose x-rays at different energy levels. The body's absorption of the photons at the two levels is measured. The ratios can be then used to predict total body fat, fat-free mass and total body bone mineral. The procedure could take about 10 - 20 minutes. On the day of the exam the person may eat normally, but should not take calcium supplements for at least 24 hours before exam.

To assess the spine, the patient's legs were supported on a padded box to flatten the pelvis and lower (lumbar) spine. To assess the hip, the patient's foot was placed in a brace that rotates the hip inward- “pigeon-toed” position to rotate the hips and provide the largest projected area to measure.

In all cases, the detectors were slowly passed over the area, generating images on a computer monitor. The person must be hold very still and may be asked to keep from breathing for a few seconds while the x-ray picture is taken to reduce the possibility of a blurred image. The person should wear comfortable clothing, avoiding garments that have zippers, belts or buttons made of metal. Objects such as keys or wallets etc., which would be in the area being scanned, should be removed since they might interfere with the x-ray images. (7)

Protocol

All tests were conducted after a medical investigation, a standardized questionnaire assessing information regarding the family history or personal history of bone fractures, exercise training history, dietary preferences, weekly intake of certain food, and supplementation of vitamins and minerals were applied to exclude risk factors or medications that might interfere with bone metabolism. Intake of drugs like anabolic steroidal hormones or growth hormones was an exclusion criterion.

The study was conducted according to the ethical principles for clinical research involving human subjects in accordance to the Declaration of Helsinki and all data were collected in the forenoon (8 to 12 am) in the Moosavi Hospital, Gorgan, Iran.

Statistics

All group results are expressed as the mean and standard deviation. Descriptive statistics for the tested variables were computed for each group. One way analysis of variance (ANOVA) with scheffe post hoc analysis was used to compare age, body composition and bone mineral density among sportsmen. Significance was set at $p<0.05$ for all tests. Analyses were carried out using SPSS v18.0 (SPSS 2009).

Results

Age and body composition of each group are reported in Table 1. The Throwing group was significantly younger in age, significantly heavier in body weight and significantly higher in lean body mass (LBM) values ($p \leq .000$) than the other groups. The volleyball players were significantly taller in the body height than other sportsmen ($p \leq .000$). And the swimmers were significantly higher in body fat percentage than other groups ($p \leq .008$).

Table 1: Characteristics of sportsmen (Mean ± SD)

	Volleyball	**Throwing**	**Swimming**	**Body Building**
Age (yrs)	23 ± 2.10	20.14 ± 1.86	22.75 ± 1.50	22.86 ± 2.19
Weight (kg)	80.63 ± 6.75	97.71 ± 12.61	83.58 ± 4.51	88.58 ± 9.15

Height (cm)	189.73 ±1.70	186.43 ± 4.20	183.76 ± 3.92	180.21 ± 3.78
PBF (%)	12.85 ± 4.94	13.23 ± 8.05	18.63 ± 2.28	17.60 ± 4.08
LBM (kg)	70.05 ± 2.83	84.81 ± 9.46	70.18 ± 2.67	71.74 ± 6.53

Bone Mineral Density values are shown in Table 2. As shown in Table 2 the mean BMD at Lumbar bones (L_2-L_4) in the throwing and volleyball groups is significantly higher compared to swimming and bodybuilding groups ($p \leq .000$). Mean BMD values at neck of the Femur Throwing and volleyball groups had significantly higher BMD as compared to swimming and bodybuilding groups ($p \leq .000$). (See Figure 1)

Table 2: BMD (g / cm²) values in sportsmen (Mean ± SD)

Subject	Lumbar bones L2-L4		Neck of the Femur	
	Mean	SD	Mean	SD
Volleyball	1.327	0.074	1.415	0.142
Throwing	1.341	0.061	1.336	0.196
Swimming	1.093	0.044	1.167	0.131
Body Building	1.130	0.088	1.081	0.148

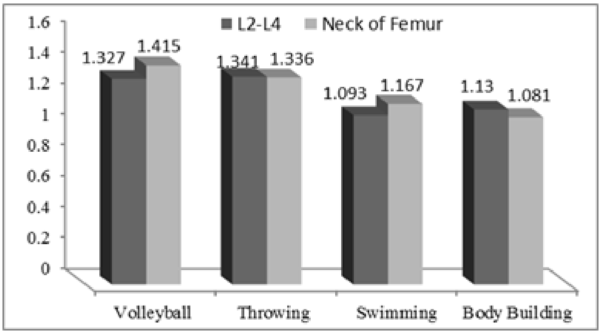

Figure 1: BMD (g/cm²) at Lumbar bones (L_2-L_4) and Neck of Femur

Discussion

The study of top-level athletes may help to reveal the relationships between different kinds of physical activity and the specific changes induced in skeletal regions. So the present study has compared four groups of athletes, volleyball, throwing, body building and swimming together.

This study found that bone mineral density of volleyball players was similar to throwers. Moreover bone mineral density of swimmers and body builders was similar together. But the volleyball and throwing groups had higher bone mineral density at lumbar bones and neck of femur than the swimming and body building groups. These findings suggest that swimming and body building activities may not be effective for mechanical loading of central skeletal sites such as lumbar bones and neck of femur bone. In contrast, volleyball and throwing activities clearly load the central skeletal sites.

Accordingly, several authors have reported that the type of exercise most likely to lead to an increase in BMC and BMD is that of high impact or weight-bearing activity (6, 12). Volleyball combines both these types of activity. Furthermore, ground reaction forces equivalent to 6-7 times body weight have been measured at landing in volleyball players during ordinary jumps of only 60 cm height (4). Much greater ground reaction forces may be generated by smashing jumps (80–90 cm height) and polymeric training.

Results of this study show that BMD of swimmers and body builders is not higher than other sportsmen. Therefore even with extensive time spent in swimming and body building exercises over a long term basis, there are no positive effects on bone mineral density, especially at clinically related sites, the lumbar spines and neck of femur. Moreover, even at sites that are subject to the action of muscles employed in training, there was no significant difference. Therefore, this suggests that swimming and body building exercises are not osteogenic.

As peak bone mass is a determinant of future fracture risk, maximizing bone mineral acquisition during adolescence and early adulthood may aid in the prevention osteoporosis. (14). Certain activities, such as gymnastics (14) and weightlifting (6) that load the skeleton via various strain magnitudes, rates and distribution patterns have been shown to augment peak bone mass.

It has been accepted that weight bearing forms of vigorous exercise are associated with greater levels of BMD (3), and weight-bearing activities seem to be more effective than endurance or non-weight bearing activities to enhance bone density (8).

However, the potential benefits of non-weight bearing activities, such as swimming, on bone density are controversial (15). Stress applied to a skeletal segment affects the geometry of the bone, the micro architecture, and the composition of the matrix (5). The stimulatory effect occurs when the skeleton is subjected to strains exceeding habitual skeletal loads; under these conditions the intensity of load is more important than the duration of the stimulus. Physical activity leads to greater bone density in children and adolescents and, to a minor extent, in adults (5). Weight bearing activities, such as walking, have a greater effect than non weight bearing activities, such as cycling and swimming, whereas a reduction in mechanical loading, i.e., bed rest or space flight, leads to bone loss (11). It has been previously suggested that the type of physical activity necessary to build and maintain bone density must be weight bearing, in part, because the loss of ambulation or weightlessness results in marked skeletal atrophy. Research conducted on astronauts suggests that a loss of bone mass could be driven by a lack of gravity. Therefore, weight bearing activity has been widely recommended as a possible prophylaxis for age related bone loss. (2)

Explanations for these results can be given when analyzing the sport-specific loads: The strain on a bone is mainly determined by mechanical forces. Dynamic forces depend on body mass and acceleration. In volleyball and throwing, movements correspond to high maximal strength and power. Besides forces induced muscular activation, high accelerations and therefore high forces, as well as varied patterns of strain, occur when falling. Furthermore, special strength training with heavy weights is a typical and regular training method in these sports. Therefore, high bone formation can be expected in volleyball and throwing. Movements in the investigated ball games induce mechanical forces on the whole body. Sport-specific movements are uncyclic and multidimensional. Demands in jumping, during short sprints, and stopping are of very short duration, inducing very high accelerations and, therefore, strains.

In conclusion, physical activity appears to have a beneficial effect on bone mass; physical activity with greater mechanical loading appears to result in a greater bone mass than non-weight bearing activities, and there appears to be a site-specific skeletal response to the type of loading at each BMD site.

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