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Comparison of Femoral Bone Mineral Density in Elite Track and Field Athletes

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ABSTRACT

Introduction: physical activity contributes to increasing and maintaining bone mineral density (BMD). Research has shown that increased BMD in athletes primarily result from training and is independent of increased muscular strength. The present study aims to investigate femoral BMD in elite track and field athletes.
Materials and Methods: the research adopted a causal-comparative method. The participants consisted of a number of 30 elite male athletes ranging in age from 20 to 30 years who practiced endurance running, throwing and jumping. They had at least five years of athletic experience, held both national and international championship titles and participated in Iran's Athletics League. The femoral BMD was measured in the athletes. The data was analyzed using one-way ANOVA ($P<0.05$).
Results: the analysis of the data revealed that jumpers had higher BMD across the whole femur as well as femur head, neck and trochanter comparing with runners and throwers ($P=0.001$). Although jumpers had higher femoral BMD than throwers, the difference was not significant between them ($P=0.663$). The results also showed that throwers had higher femoral BMD comparing with runners ($P=0.006$).
Conclusion: the results indicated that jumpers had higher femoral BMD comparing with other athletes, which may relate to the nature of jumping events since they are considered as strength sports that mobilize the greatest amount of energy within minimal time courses. Moreover, explosive moves, jumps and landings exert high pressures on the femur and its different parts in jumping events comparing with throwing and endurance running.
KEYWORDS: femoral bone mineral density, elite athletes, track and field

INTRODUCTION

Osteoporosis is the most prevailing metabolic disease of the bone in most societies and is one of the most urgent problems posed to the world health organization (WHO). It is referred to as the silent disease that symphonizes quite late [1, 2]. Research has shown that physical exercise increases BMD so that the athletes of weight-bearing sports such as tennis, volleyball and gymnastics have higher BMD comparing with the athletes of non-bearing sports such as swimming and cycling [3, 4, 5, 6]. Rico et al. (1993) reported that athletes who performed weight-bearing sports such as gymnastics and football had higher BMD due to mechanical pressures comparing with their swimmer and cyclist counterparts [7]. Exercise may transmit power to the bone via two mechanisms: muscular stretch and stimulation pressure applied to body. Either mechanism may increase BMD. Track and field, which is referred to as the mother of sports, may help prevent osteoporosis as it is a weight-bearing activity - as in throws, jumps, endurance runs and sprints – that increases the load on the skeleton.

Moreover, strength training such as throwing and jumping May significantly contribute to increased lumbar spine BMD, femur and the whole body because it exerts variable load to different bones so that it facilitates stimulation threshold of bone formation. According to Wolff's law, the bones adapt to variations in mechanical loads so that with increased load on bones, skeletal cells increase; however, when the load is dropped, skeletal cells degenerate [8, 9]. Therefore, athletes of throwing and jumping events have higher BMD comparing with other athletes. Sprint athletes have significantly higher levels of BMD comparing with endurance runners. Specifically, endurance runners have the lowest BMD in lumbar spine and femur comparing with sprinters because fast races require intensive muscular contractions that transmit to bones as a mechanical load. Besides, bone response to increased density depends on the mechanical load placed on it, which may account for higher BMD in sprinters comparing with endurance runners. In research on endurance runners was determined that there was a negative correlation between BMD and the running distance so that runners who ran longer distances had lower BMD [10]. In a similar research, Hind et al. (2006) studied a number of 109 male and female endurance runners and reported a negative correlation between the weekly distance runners covered and their BMD [11]. In other research reported that explosive and strength exercises such as weight lifting and wrestling contributed more significantly to BMD increase comparing with endurance exercises [12]. Kun et al. (2001) contend that higher BMD in weight-bearing extremities relates to the mechanical load placed upon bones during exercise

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training. They observed that increased mechanical load induced stretch and variations in bone. When the stretch exceeds bone capacity, it stimulates skeletal cells resulting in increased BMD [13]. Considering the research findings, there is consensus that weight-bearing strength and speed workout increases BMD in the respective extremities. Thus, since runners and throwers perform strength and sprint exercises, they have higher BMD comparing with endurance runners who perform aerobic training.

The present study aims to compare femoral BMD among the athletes participating in different track and field events in order to determine what athletes have higher BMD.

MATERIALS AND METHODS

The study adopted a causal-comparative method. The participants consisted of 30 elite male track and field athletes: 10 endurance runners (Age: 23.80±3.08 yrs; Height: 177.10±5.10 cm; Weight: 68.2±4.75 kg), 10 jumpers (Age: 24.30±2.89 yrs; Height: 181.8±5.15 cm; Weight: 77.30±8.23 kg) and 10 throwers (Age: 23.70±4.08 yrs; Height: 179.30±5.39 cm; Weight: 79.30±7.13 kg). The subjects had no history of bone fracture, diabetes, Hyperthyroidism, cardio-respiratory diseases and smoking as well as Anticonvulsant and Corticosteroids use. The participants had at least five years of athletic experience in their respective fields and participated in Iran's Athletics League. All participants were holding championship titles in national and international levels. The data was collected using a scale, wall-mounted stadiometer, medical data sheet and Dual Energy X-ray Absortiometry (DEXA).

DEXA is a bone density scanning device that uses advance X-ray technology, which was used to measure the participants' BMD. The DEXA machine uses a source with two types of high and low energy transmission that is variably absorbed in soft tissues and bone. It uses X-ray as the source of energy that, despite radioactive sources, does not attenuate over time so that it increases the accuracy of measurements up to 99 percent [14, 15]. BMD was automatically measured and recorded by DEXA machine. Then color prints were made for every bone segment. Kolmogorov-Smirnov and Levene's tests were run to examine the normality of the data and homogeneity of variances, respectively. The data was analyzed using one-way ANOVA (F test) ($P<0.05$).

RESULTS

The results showed a significant difference in femoral BMD among track and field athletes participating in different events (Table1 and Figure1).

Table1. Comparison of BMD across different femoral sections in the participants

Femur Area	***Group***	***M±SD (g/cm²)***	***F-Val P-Val***	***P-Value in Tukey's test***		
				Runners with throwers	Runners with jumpers	jumpers with throwers
total	Runners	1.115±0.14	F=10/041 P=0/001*	0.006*	0.001*	0.663
	throwers	1.30±0.12				
	jumpers	1.35±0.10				
trochanter	Runners	0.777±0.13	F=8/970 P=0/001*	0.011*	0.001	0.645
	throwers	0.935±0.12				
	jumpers	0.980±0.08				
neck	Runners	0.938±0.13	F=8/161 P=0/002*	0.095	0.001*	0.0167*
	throwers	1.041±0.11				
	jumpers	1.13±0.06				
head	Runners	0.805±0.15	F=3/705 P=0/038*	0.229	0.031*	0.577
	throwers	0.901±0.13				
	jumpers	0.959±0.09				

**** = Significant in %5***

As shown in Table 1, jumpers had higher BMD across the whole femur as well as femur trochanter, femur head and femur neck comparing with other athletes ($P<0.05$).

DISCUSSION

Higher femoral BMD in jumpers may relate to their frequent landings on hard surfaces. Creighton et al. (2001) reported that exercise training on hard surfaces with recurrent jumping and shear movements exerts greater load on skeleton [15]. Although endurance runners use their legs to run long distances, they have lower femoral BMD comparing with jumpers and throwers. The reason may be that endurance running does not impose enough loads to provide appropriate mechanical stimulus for bones. Therefore, leg pressure and impact is not significant enough to stimulate the remodeling of skeletal cells. Besides, endurance runners tend to run at a consistent volume of load so that bones adapt to this consistent load. However, jumpers apply variable, accumulative pressure to bones in strength exercises so that their recurrent landings on hard surfaces stimulate skeletal tissue. Zanker (2003) reported that the minimum load required to stimulate bones is twice as much as body weight or a little more so that the threshold limit would be provided for bone cell stimulation [16].

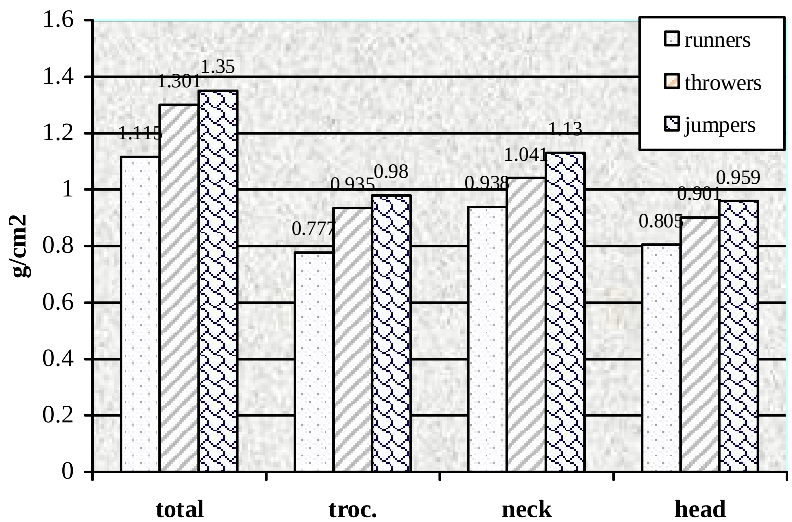

Figure1. Mean femur BMD in the participants

Furthermore, endurance runners are lighter than jumpers and throwers. Since weight is one of the determinants of BMD [17, 18, 19] higher weight increases osteogenesis via applying extra load on skeleton [20, 21]. In this regard, Gjesdal et al. (2008) investigated the relationship of fat mass and fat-free mass with BMD. They reported that increased lean mass (fat-free mass) as much as one kilogram was associated with increased BMD in both males and females [21]. Considering the relationship of body weight, lean mass, fat mass and body mass index with BMD, Shabani (2007) reported a significant positive correlation of body weight with the T-score of femoral, spinal and ulnar areas in cyclists [22]. Endurance runners consume great amounts of energy in running long distances. In endurance activities, recurrent muscular contractions to continue the activity and generate energy require calcium. However, body loses a great volume of minerals such as calcium through cutaneous perspiration during endurance activities so that the calcium levels drop in the blood circulation. These factors influence calcium balance in the blood. It is likely that bones, as the mineral bank of body, sacrifice during long-term endurance workout in order to compensate for calcium loss [12]. Therefore, endurance runners have low BMD across femur and its different sections.

As shown in Table 1, jumpers had higher femoral BMD than throwers though the difference was not statistically significant. Although throwers appear to use their hands primarily, they significantly use their legs, particularly thighbone, in throwing activities so that femur and its different sections bear the majority of body weight pressure. Indeed, the throwing power is transmitted from the lower extremity (legs) to the body and eventually to hands. Therefore, throwers have higher femoral BMD than endurance runners as they perform rotational moves, landing, jumping and anchoring legs. However, they have lower femoral BMD comparing with jumpers, which may relate to the differences in the nature of throwing and jumping events. Jumps are considered as strength workouts in which the athletes engage their maximum muscular and skeletal power in minimal time while throwing requires less muscular and skeletal engagement. Although throwing is considered as a strength activity, it follows a reverse mechanism in power transmission comparing with jumping. While landing, the jumpers place all the power, used for jumping, on the legs and femur that are the main locus of power accumulation and transmission so that, based on the law of action-reaction, the gravity exerts an extra load on their femur [23]. Moral et al. (2001) studied a number of 704 athletes and reported that BMD variations among different athletes referred to different tensile force and gravity that athletes experienced in different sports [24]. In throwing sports, the power transmission pathway starts from lower extremities (legs) and leads to upper extremities (lumbar spine). Then the power is transmitted from torso to shoulders and hands; thus, less pressure applies to femur. In other words, while landing, the jumpers have a vertical movement vector so that all kinetic energy and body weight applies to legs and femur. However, in throwing sports, legs first bear potential energy that turns into kinetic energy and transmits to the arm and hand. The kinetic energy together with body mass is conveyed to weight, discus or hammer at the moment of throwing [14]. Therefore, jumpers experience more intense pressure and load on their femur. According to a commonly-held theory, bone is considered as a piezoelectric crystal in which mechanical pressure converts into electrical energy so that electrical potential stimulates the osteogenesis. According to this theory, it is evident that higher mechanical load applied to jumpers' femur induces greater osteogenetic stimulation comparing with throwers. Magkos (2007) and Torstveit (2005) reported that positive changes in BMD are subject to the magnitude and recurrence of load applied to bones [25, 26]. The present findings revealed that endurance runners had the lowest femoral BMD comparing with other athletes. This is consistent with the findings of Hind (2006) who reported a negative correlation between the distance covered by endurance runners and their BMD [11]. Maypx (1999) reported that short-term, strength sports were more osteogenetic than endurance sports [27].

CONCLUSION

Considering the present findings, we may conclude that track-and-field athletes have variable femoral BMD based on the specific events in which they specialize. Since endurance runners have lower femoral BMD, they are recommended to perform strength and sprint exercises in addition to endurance training. Throwing athletes have higher BMD in shoulders, arms and hands; still, femur plays a crucial role in transmitting power from lower extremities and legs to upper extremities. Therefore, throwers are recommended to perform special training in order to improve femoral and crural BMD. Although jumpers have high femoral BMD, they are recommended to perform special training to improve their lumbar spine BMD.

The present study suffered limitations. First, the effect of genetic factors on BMD was not addressed. Second, the researcher did not control the participants' diet. Besides, a variety of other factors such as the bone structure, shape and size as well as sexual hormones concentration, which may contribute to bone strength, were not examined in the present study. Therefore, it is recommended that further studies be conducted to address these factors.

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