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The comparison whole body bone mineral density in elite athletes of athletic

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Abstract

Sports and physical activity are considered as synthesis stimulator and bone density maintainer. Activity through accumulation of minerals, muscle improvement, and individual's balance improvement result in less bone fracture. People, who start physical activities before maturity, tend to increase the mineral contents and diameter bone growth. The current study aims to compare bone mineral density (BMD) in total body bones of elite athletes in athletics. The examinees of this comparative-scientific research consist of 30 male elite athletes of age 20 to 30 years old, involved in endurance, throwing and jumping. These examinees had championship titles and they were active in Iran athletics league. The BMD of total body bones were measured by DEXA method, and the data were compared by the UNIVARIATE ANOVA ($P \leq 0.05$). Data analysis showed that no significant difference exists in examinees' total body bone mineral density in different types of athletics ($P=0.124$). But BMD in throwers' hand bones was more than two other groups ($p=0.002$). Also BMD in jumpers' ribs, spine, pelvis and legs was more than the throwers and runners ($p=0.001$). Based on the non-significant difference of athletics athletes' total body bone minerals it could be concluded that all three types of athletics have positive effect on the total body bones. Possibly the higher BMD of hand in throwing type is due to the more effect of exercise pressure compared to running and jumping types. Jumpers have more BMD in rib, pelvis, leg, and spine bones, because jumping is considered as one of the strengthening exercises. On the other hand explosive movements in jumpers are more than two other groups, which put more pressure on the pelvis, rib, leg, and spine bones.

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Introduction

Bone tissue, joints and levers formed from it are resistant toward many pressures, and on the other hand, muscle contraction also has good elasticity. Similarity of many bones to man artificial levers, supporting columns, arches and scaffolding depend on the movement and action of each bone (Creghton, 2001). If the range of motion is wide and vast, more bones can participate in activity. In between, the athletics sport which is the base of natural movements such as running, jumping, and throwing, could impose a wide range of body bones to move and exercise.

People, who start physical activities before maturity, tend to increase the mineral contents and diameter bone growth (Barrcra, 2004). In many researches it has been reported that body exercises result in increase of bone mineral density; Researchers believe that bone cells react to mechanical stimuli caused by sports and body exercising, and significantly increase the ossification (Karlsson, 2001 and Vicente-Rodriguez, 2004). Borrer (2005) research results showed that body exercises and sports are considered as maintainer and stimulator of bone-forming tissues, and they result in increase of bone mineral contents and transverse bone growth. Based on the nature of the mechanical pressures exerted on the bone tissue, body exercises are put into two general groups: 1-Contact sports: exercises in which the mechanical pressure exerted on the bone is imposed through external mechanical stimuli (Fehling, 1995). Such as: Gymnastics, track and field, soccer and volleyball (Grimiston, 1993 & Maimoun, 2005). 2- Non-contact sports: exercises in which the mechanical pressure exerted on the bone is caused by muscle contraction (Fiore, 1996). Such as: Swimming, cycling, and boating (Maimoun, 2005).

Conducted studies show that contact sports athletes have more bone mineral density in their body bones (Kemmler. 2006). While, non-contact sports are less OSTEOGENIC (bone builder) (Heinonen, 1993). According to Kun *et al* (2001), higher bone mineral density in organs bearing the body weight is due to the mechanical load imposed on the bone during the exercise, and it more stimulates the bone cells of that part (Chandran, 2003). Thus, the load effects on the bone could be a result of gravity on body weight or the force caused by the muscle contractions which result in creation of dynamic pressure on the bone, and ultimately the reaction of bone to this pressure through osteoplastic stimuli is increase of its density (Nicholas, 2007). Kelli *et al* (1998) stated that high-pressure exercises result in the high tension of muscle connected to the bone and it imposes the bone toward more tension and pressure, and this stimulates the ossification, followed by the increase of bone density (Kelly, 1998). Mechanical pressures along with weight bearing on the bone through tendons and muscle have a direct effect on the ossification (Binbridge, 2004).

Also based on the nature of the sports activities, nature of speed power and endurance, and energy systems which are impose on the athlete during the activity, they have different effects on the bone mineral density (Nicholas, 2007). Findings of Colletti (1981), Davee (1996), Grand Hed (1984), Barbeny and linder (1995) are based on the increase on bone mineral density in strengthening athletes (Bennell, 1997). Strengthening sports and their related exercises put excessive pressure or resistant load on the bones, and the threshold for ossification is simply provided. Each activity or exercise that could increase the power, mass and muscle strength, could activate the bone-building stimuli (Ljunghall, 1992). Speed activities also require severe muscle contraction, and the force is imposed through the muscles to the bones, as a mechanical pressure. On the other hand, the response to the density increase depends on the mechanical load exerted on it (Nicholas, 2007). Thus, speed activities could also result in increase of bone density. About the endurance activities research results of Kerr (1996), MaddaLozza (2000), Hind (2006), and Burrows (2003) confirmed the low bone density in endurance athletes. There are a few possibilities for justifying the low bone mineral density in endurance athletes. The first possibility: the long-term activity in these athletes requires calcium for nerve stimulation and performing muscles' contractions. In addition to the need for calcium for contractions and stimulations, some part of the calcium is excreted through sweat and urine, and these factors affect the blood calcium balance. It is probable that during long-term activities, bones that are considered as salts bank be sacrificed for balancing the blood calcium. PARATORMONE is one of the hormones that have the role of blood calcium regulator, and it is probably activated during endurance exercises, because the decrease of blood calcium concentration is the most important stimulating factor of PARATORMONE. For preventing HIPOCALSI (decrease of blood calcium), PARATORMONE constantly destroys the bone tissue in order to balance the calcium in blood to maintain the activity continuation (Guyton, 2004).

The other option is the weight loss that endurance athletes endure compared to the speed and strengthening athletes, since weight is one of the effective determining factors in bone mass (Glauber, 1995. Edelstein, 1993 & Felson, 1993) the higher body weight through the increase of extra load imposed on the bone; result in the increase of OSTEOGENIC stimuli (Beck, 2001 & Langdon, 2006). In this regard in a research studying the relationship of fat mass and lean mass with bone mineral density, Increase of 1 kg of LM (fat-free tissue) is related to the increase of BMD in both genders (Gjesdal, 2008). Also, according to Beck (2007), excessive body weight makes the bone tissue resistant by increase of mechanical pressures through muscle or through adsorption effect of bone tissue from exerted loads on the skeleton, where the stimulation of osteogenesis increases (Beck, 2001). Since athletics include different types of throwing, jumping, and different types of running, it covers a wide range of skills and qualities, and in this sport, all of the energy systems are used by the athlete according to the type of activity. On the other hand, athletics is one of the sports that in all of its types the athlete skillfully moves or endures his/her body weight. This is why athletics is known as the pro sports (Ballesteros, 2002) and it is called blonde mother. In this research the effort is made to compare the BMD of all of the male elite athletes' bones and to determine that the BMD of which group of these athletics athletes (throwing, jumping, and endurance running) is more.

Materials and methods

Subjects

This research is a comparative-scientific research, and the examinees consist of 30 male elite athletics athletes. 10 endurance runners with age range of: 23.8±3.08, height: 177.10±5.1 cm, weight: 68.2±4.75 kg. 10 jumpers with age range of: 24.30±2.82, height: 181.8±5.15 cm, weight: 77.30±8.23 kg. 10 throwers with age range of: 23.70±4.08, height: 179.30±5.39 cm, weight: 79.30±7.13 kg. The examinees did not have any history of smoking, anticonvulsants and corticosteroids. These athletes had at least 5-year activity background in their specific field, and all of them had championship titles in national and international competitions, and currently they are active in Iran athletics league. In order to collect the required information Scales and wall Height Gauges (made in Burer company, Germany), standard sports medical questionnaire and Dual energy X-ray Absortiomery (DEXA) (Made in Halogic Inc., USA with Discovery model, production no. 510-1547, 2011) were used.

Research plan

For running the measuring test of BMD of whole body, the examinees laid down on the bed sets. Hands were adjusted beside legs. At first the panel device was placed on the fourth lumbar vertebra, then it moves toward the head, and it does the reciprocating action. It also does the reciprocating action from the fourth lumbar vertebra toward lower body parts (legs). In addition to measuring the bone density in whole body, the mentioned photography also measured the fat mass and lean mass weight in whole body. It also separately recorded the BMD in hand, leg, body, pelvis, ribs and lumbar vertebra. The time of this test per each examinee was about 10 minutes. The bone density was ready to be printed by the calculating and color photo device of each part of the body. The bone density scanning device known as

DEXA is an advanced type of X technology which is used for measuring and estimating the bone minerals. The base for estimating the mineral density in this device is usage of a resource with two types of high and low energy that have different types of absorption in soft and bone tissues, The energy source of DEXA device is X ray, that in contrast with radioactive, it does not decrease during time (Kemmler, 2006 & Frost, 2000).

Statistical methods

Based on the establishment of assumptions of normality and homogeneity of variances acquired by K-S and Levene's test, the data were analyzed by the use of F test (one-way ANOVA) ($p < 0.05$).

Results

As it is shown in table1, according to the amount of F, and the significance level, there was no significant difference in BMD of the examinees' whole body in different types of athletics ($p>0.05$). But BMD in throwers' hand bones was more than two other groups ($p=0.002$). Also BMD in jumpers' ribs, spine, pelvis and legs was more than the throwers and runners ($p=0.001$). By the use of Tukey's test the significant difference between the groups is determined (table1, figure1). Tukey's test show`s that there were significant difference in BMD of hands, spine, ribs and pelvis between runners with jumpers and throwers and between runners with jumpers in legs BMD ($p<0.05$).

Table 1. Comparison of BMD body different sections in the participants.

Body Area	Group	M±SD (g/cm²)	F-Val P-Val	P-Val in Tukey's test: Runners with Throwers	Runners with Jumpers	Jumpers with Throwers
Body total bones	Runners	1.280±0.192	F=2/253 P=0/124	---	---	---
	Throwers	1.353±0.084				
	jumpers	1.412±0.117				
Skull bones	Runners	1.913±0.212	F=2/151 P=0/136	---	---	---
	Throwers	2.135±0.304				
	jumpers	2.128±0.289				
Ribs bones	Runners	0.746±0.035	F=12/39 P=0/001*	0.001*	0.001*	0.810
	Throwers	0.861±0.072				
	jumpers	0.879±0.077				
Upper limb	Runners	0.828±0.060	F=7/617 P=0/002*	0.005*	0.007*	0.987
	Throwers	0.922±0.059				
	jumpers	0.918±0.061				
Vertebrae column	Runners	0.976±0.094	F=13/69 P=0/001*	0.009*	0.001*	0.145
	Throwers	1.124±0.103				
	jumpers	1.220±0.117				
Pelvis	Runners	1.170±0.118	F=9/976 P=0/001*	0.007*	0.001*	0.624
	Throwers	1.377±0.129				
	jumpers	1.435±0.166				
Lower limb	Runners	1.415±0.130	F=8/846 P=0/001*	0.078	0.001*	0.149
	Throwers	1.544±0.109				
	jumpers	1.653±0.138				

** = Significant in %5*

Discussion

According to the table 1 data, no significant difference exists in BMD of whole body bones of elite runners, throwers, and jumpers ($P= 0.124$). In other words, the elite athletes of all types of athletics are equal in bone density of the whole body bones. Probably we could relate this to the nature on athletics. Athletics is a dynamic sport. Movement is the result of force versus a resistant factor. In humans' movements, body or its different parts are considered as resistance and force muscle contractions. When the force becomes dominant on the resistance, the movement occurs (Ballesteros, 2002). In movement both negative and positive movements involve. The reason for formation of positive forces is muscle contraction and the reason for formation of negative forces is "friction", "air resistance", "gravity" and "body weight". Thus, in athletics, which movement has the main role, and forces such as muscle contractions, friction, air resistance, gravity and body weight impose pressure on the athlete's bones, excessive mineral density forms in the whole body bones of athletes of athletics.

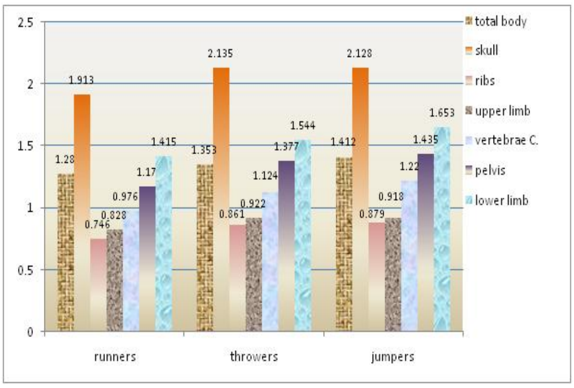

Fig. 1. Mean of body different aera BMD (g/cm^2) in the participants.

On the other hand, in athletics the movements are formed on hard surfaces, and it is along with shearing movements, jumps, take off, start, change of direction and change of speed. These movements put pressure on the whole body bones. According to the research of Creighton *et al* (2001), if the sport exercises are done on hard surfaces, and if there are several jumping and shearing movements, the pressure on the bone increases (Vicente-Rodriguez, 2004). Also in athletics all of the body parts start to move. For example: According to the table 1 and figure 1 data, BMD of hand bones of throwers is more than two other groups. Maybe we could consider the reason to this matter due to the excessive use of hands in different types of throwing. But, regarding the fact that hand plays the main role in throwing, the main power for throwing is delivered from different parts of the body to the hands. In all kinds of throwing, principle of accumulation of powers is at the center of attention (The instantaneous power). The initial velocity resulted from running, spinning and gliding is complimentary to explosive power which is created for effective throwing. In throwing moment, the maximum speed is delivered to the hand, and the movement of each member starts when the previous member has reached its maximum speed (Ballesteros, 2002). In other words, the principle of accumulation of powers is delivered from legs to the body, ribs, and elbow and ultimately to the hand wrists (delivery from the organs having more mass to the organs having less mass), and the transmission of power and motion from the lower body member to the upper body member, which is the point showing the movement in all parts of the athletes' body in different types of athletics which justifies the equality of BMD in their whole body bones (Ballesteros, 2002).

About the high bone density in throwers' hands maybe the reason is excessive use of hand in throwing and to be put under the pressure of exercise which results in increase of bone mineral density in throwers' hands compared to two other groups. This result is similar to the research result of Kannus *et al* (1995) that measured the effects of mechanical load on the superior and non-superior member of tennis players and they found out that the BMD of tennis players' hands is more than their non-superior member, because they use their superior hand more for hitting the balls, and they also hold the racket with their superior hand (Kannus, 1995).

According to table 1 data, spine, and ribs of the jumpers have higher bone density compared to two other groups, and probably the reason is due to the pressure that spine endures during the jumping and landing. For example, if we carefully look at the jumps (length, triple, and pole vault) we figure out that spines and ribs locating at the center of the body endure the most pressure during jumping, hanging in the air and landing on the ground (Yunat, 2001). In high jump, converting the horizontal running speed and running-off to the vertical speed is the most important factor in increasing the height of jump, and based on the Newton's third law, the gravity applied by the earth puts excessive pressure on the spines and ribs of the jumper in action and reaction on the body (Yunat, 2001), and also in high jump Fosbury technique, curved back movement of the jumper results in the delivery of too much force on the spines.

In triple jump, the moment of hanging in the air and landing put too much pressure on the athlete's ribs and spines. Also in pole vault, the moment of passing the barrier, displacement of the center back caused by non-contact of body with the rod puts too much pressure on the athlete's ribs and spine (Ballesteros, 2002).The mentioned items confirm the increase of bone density of spine and ribs in jumpers compared to two other groups. Also in pelvis bone the mineral density of jumpers is higher, and perhaps the reason is due to the fact that this part of the jumpers' body is under more pressure. Pelvis has an important role in all types of jumps. Movement of the jumpers depends on the irritability of the hip joint especially in movements related to opening the foot twist corrosive, and ability to straighten the leg muscles. Therefore, doing jumping movements puts a lot of pressure on the jumpers' pelvis. Table 1 data show the increase of mineral density in jumpers' leg bone compared to the throwers and endurance runners. In jumping the leg bones, especially femur and different parts of it are exposed to extreme pressure. In jumping, legs work as a lever and all of the pressure and body weight during jumping and landing are put on the legs. And this pressure is doubled by the exertion of gravity to the athlete's legs (Mc Ardle, 2004). Regarding table 1 and low level of bone density in endurance runners compared to other two groups we understand that maybe one of the reasons of low bone mineral density in endurance runners is their lower body weight. A research indicates that increase of body weight is due to the increase of muscle mass and fat tissue and mechanical pressure formation on the bone tissue and production of sex hormones which result in stimulation of ossification (Castro, 2005). In the research of Cobayashi a significant relationship exist between the increase of BMI and high bone density (Cobayshi, 2005). On the other hand, although endurance runners are exposed to impacts and forces exerted on the leg, the pressures and impacts caused by them are not that much extreme to stimulate the bone cells. In addition to that, the less mechanical load also does not result in increase of their bone mass (Burrows, 2003). Because the endurance runners run with similar volume of constant and uniform load, and after a while the bone is adapted to that condition. But in strengthening-speed sports, the pressure is applied on the bone by different and excessive load and the stimulation threshold is easily provided. These findings were in consistent with the results of Mack Dogall (1999) reporting that bone mineral density is not observable by running 20 miles per week. On the other hand, by increasing the time of running the amount does not change either, although the endurance runners are exercising and doing activities for more period of time, their skeleton are adapted to the common and uniform activity, and increasing the time of activity to more than the standard level does not have any benefit for them (SalehiKia, 2006). These results are based on the theory of Frost indicating that: the minimum basic force is required for new bone formation (Frost, 2000), and the other possibility is that the endurance runners are more often engaged with constant running movements, and they seldom use explosive movements, take-off, and change of direction, start and jumping.

Conclusion

Based on the research results, whole body bones of athletes of different types of athletics have equal BMD. Also based on the activity in different types of athletics such as: jumping, throwing, and different types of running, since the athletes improve and train one specific part of the body, and they use one or a few bones more than others, the bone density in the higher pressure area is more. On the other hand, the energy resource of strengthening and powerful activities is PHOSPHAGEN system. The energy resources of power-endurance sports are ATP-CP and acid lactic. The energy resources of endurance sports are acid lactic and oxygen and ultimately the energy resource of high endurance sports is oxygen (Ballesteros, 2002). Based on the type of activity, different types of athletics athletes use different energy systems. Athletes of different types of athletics are characterized as powerful, high power, power, power-endurance, endurance and high endurance. Thus it is recommended to the athletes of different types of athletics to use a combination of powerful, speedy, power and endurance activities. Especially it is recommended to the endurance athletes to use more powerful, speedy and high power activities in order to help their body in formation of BMD.

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