Iranian Journal of Health and Physical Activity (2013) 4 (2), (31-36)

Comparing the Biological Markers of Bone Metabolism in Female Athletes Engaged in Weight Bearing Sports, and Non-athletes

Asra Askari [1]*, Babisan Askari[2], Zynalabedin Fallah[3], Mohammad Ali Samavati Sharif[4]

[1] *Department of Physical Education,Gorgan Branch, Islamic Azad University, Gorgan, Iran*
[2] *Department of Physical Education,Qaemshahr Branch ,Islamic Azad University,Qaemshahr,Iran*
[3] *Department of Physical Education,gorgan Branch, Islamic Azad University, Gorgan, Iran*
[4] *Department of Physical Education and Sport Sciences, Bu-Ali Sina University, Hamedan,Iran*

Received 27 May 2013 Accepted 24 July 2013

Abstract

Purpose: Serum Alkalin phosphatase (ALP) is an osteoblastic protein whose levels may be affected by exercise. Research has shown that exercise may increase bone density through increasing the level of bone constitute markers such as calcium, phosphor, and ALP. The aim of the present research was to compare the markers of the bone metabolism (calcium, phosphor, and ALP) between 20-35 year-old female basketball players and non-athletes in Golestan province.

Material and Methods: 12 female, professional basketball players and 15 non-athletes participated in this study as the experimental group and the control group respectively. To study the intended markers, 5 cc of blood was collected from the archival vein of the participants in a sitting position. To analyze the data, shapiro wilk, mann whitney u and independent T-test were used. SPSS software version 18 was used to analyze the data. The significance level was set at $p<0.05$.

Results: Data showed a significant increase in the ALP level of the experimental group ($p=0.001$) but no significant difference was observed in the calcium ($p=0.792$) and phosphor ($p= 0.905$) levels between the two groups.

Discussion and Conclusions: According to the results, different intensities of exercise may improve and maintain the level of bone osteoblastic proteins and bone formation stimulating factors such as ALP.

Key words: ALP, Calcium, Phosphor, Osteoporosis

Introduction

Osteoporosis has been one of the main human health problems in the last three decades and is known as one of the four social enemies of human, and an important problem in general health. It is a systematic bone problem in adults in which bone intensity and the levels of the bone minerals in bone matrix decrease, leading to more frequent bone fractures [1]. This problem develops in different people, indicating that it has different reasons. Different factors influence bone density: genetics, gender, race, age, hormones, nutrition, calcium intake, exposure to sunlight, physical activity and weight [2]. Analyzing the level of biochemical markers of bone formation is an important clinical measure to study the reasons of this problem [3]. According to the literature, some of the serum markers of bone metabolism such as ALP, calcium, and phosphor can be used to study dynamic changes in bones and their metabolic response to physical activity [4]. ALP-B is one of the bone formation markers and acts in PH between 4-10. It is found in many tissues such as bone, liver, intestine, and kidney.

Osteoblasts are a great source of ALP and their serum levels reflect osteoblastic activity. ALP also plays an important role in calcium sediment in long bones. It also hydrolyses ester phosphates and transfers them to the matrix of developing bones. ALP becomes significantly active after bone fractures and breaks [5, 6]. Physical activity makes ALP exert anabolic effects on bone metabolism on one hand, and on the other, increases calcium reserves in bones [7, 8]. Lester et al (2009) observed that a combination of aerobic and weight training for 8 weeks stimulated bone formation

* Corresponding author E-mail:
asra_askari@yahoo.com

markers [6]. Roodberg et al reported an increase in Alp levels after 30 -40 minutes of moderate running [8] and Valsse et al found the same results after 2 hours of pedaling at 80% of VO2 max [9]. However Ashizava et al observed a decrease in ALP-B, 2 to 3 days after weight training [10].

Although genetics determines maximum bone intensity to 80%, environmental factors such as physical activity play an important role in reaching that threshold. Maximum bone density and age-related bone erosion are important factors in osteoporosis in adults. Bone fracture risk in old age increases with the decrease in bone density [11]. According to a mechanical theory bones increase their mineral density in response to the load they bear. The unit of exposed load to bone is micro-strain and 1000 micro-strain is a force that increases bone length to 0.1% as a result of mineral absorption. The amount of stress on the bone may lead to four conditions. There would be no bone formation where the amount of load is less than 50 to 200 micro-strain. In this case the amount of bone minerals decreases which is a case seen in people who have had long rests or were hospitalized for a long time. 200 to 2000 micro-strain is enough to maintain bone density, 2000 to 3000 micro-strain stimulates bone formation, growth, and increases bone density while loads greater than 4000 micro-strain are not safe for bones and usually lead to malapropos bones [12, 13]. Weight bearing activities (activities with lots of jumps and springs) which demand overcoming the gravity [14] put more mechanical stress on the bones, increasing their mineral content. Grikton et al [2001] studied the relationship between the exerted stress on the bones and their mineral density in female athletes. The participants were classified into four groups: high weight bearing basketball and volleyball], moderate weight bearing (football and track and field), non-weight bearing (swimming), and control group. Results showed that participants in the high weight bearing group had higher mineral density in neck femoral. Also mineral density of those in the moderate weight bearing group was higher compared to non-weight bearing and control groups. These findings show that athletes involved in high weight bearing sports have higher BMD compared to other athletes such as swimmers and non-athletes [15]. In general, nearly 120 million people suffer from osteoporosis 80% of whom are women. Osteoporosis development is slow and irreversible, and speeds up with aging. Unfortunately there is still no effective and safe cure for osteoporosis [16]. Understanding bone metabolic responses to physical activity would help in developing beneficial strategies to maintain and increase bone density. As exact mechanisms of interaction between physical activity and bone metabolic markers are still unknown on one hand, and on the other, not enough attention has been paid to studying bone metabolic markers in young women before menopause, the present research aims at comparing the effects of weight bearing exercises on calcium, phosphor, and serum APL levels in 20 to 35-year old, female, basketball players and non-athletes in Golstan province.

Material and Methods

The statistical population and sample of the study

The statistical population of this semi-experimental study included all the female basketball players in the Golestan Super League among whom 12 players, aged between 20 to 35 years, with at least 3 years of basketball training, volunteered to participate in this study. 15 individuals from the qualified people were also randomly selected as the control group. Participation criteria included cardiovascular health, lack of any disease, lack of hormonal disorders, and taking no medications at least one month before the study.

Data collection

5 cc of blood was collected from the archival vein of the participants while they maintained a sitting position. After plasma separation (containing EDTA) the samples were processed for further analysis. All the analyses were done using the Selectra and auto analyzer device and ELISA kits (made in France).

Data analysis

Descriptive statistics was applied to summarize and classify the characteristics of the participants. Then shapiro wilk test was used to examine the homogeneity of the data and mann whitney u and independent T-test were applied to compare the two groups. All the analyses were done using SPSS software version 18 and the significance level was set at $p<0.05$.

Results

Table 1 shows the demographic characteristics of the participants. Table 2 demonstrates the results of mann whitney u test for calcium and phosphor and those of the independent t-test for the APL. As shown in table 2, APL levels in the experimental group were significantly higher in comparison to the control group (p=0.001). Calcium (p=0.792) and phosphor (905 .0=p) levels were also higher in the experimental group but this differences were not significant.

Table1 : Demographic characteristics of the participants

mean ± sd	No	variables	
25.25 ± 4.827	12	experimental	Age (year)
25.67±4.467	15	control	
173.75 ± 5.065	12	experimental	Height (meter)
161.67 ± 5.790	15	control	
66.33±8.105	12	experimental	Weight (kg)
60.80±9.329	15	control	

Table 2: Comparison of mean changes (ALP, Ca, P) in the control and experimental groups

P value	mean ± sd	No	variables	
.001	128.67±20.656	15	control	ALP
	165.42 ±32.506	12	experimental	
.792	9.4533 ±.47188	15	control	Ca
	9.5583 ±.21515	12	experimental	
.905	3.2933 ± .46823	15	control	P
	3.3917 ±.3872	12	experimental	

Discussion and Conclusion

Results from the present study showed that APL levels were significantly higher in the experimental group who participated in basketball league of Golestan province at least for 3 years , as compared to the control group (p=0.001). These findings were in line with those of Beekley et al (2005) [17], Kemmler et al (2007) [18], Bagheri et al (1388) [19], Tartibian et al (2009) [20] and Lester et al (2009) [6] but contradicted the findings of Beije et al (1390) [21], khorshidi et al (2011) [22], and Magkos et al (2007) [23] APL is one of the main markers of bone formation, sensitive to physical activity, illness and menopause. This enzyme catalyses the hydrolysis of organic phosphates in alkaline PH and is strongly related to bone calcification. This enzyme is also a marker of osteoblastic activity, and is necessary for bone mineralization. APL level represents the amount of osteoblastic activity and this can be used as a marker of bone formation [17, 24, 25]. The results of the present study indicated that exercise training in the experimental group positively correlates with the ALP serum levels and may increase bone calcification, bone formation or mineralization (mechanical stress theory). On the other hand results from the present study supports the theory that bone markers reflect different phases of osteoblasts proliferation and reaction [26].

In their study Kevin et al (2002) found a significant increase (7.1 %) in the APL level after 24 weeks of intense weight training. Magkos et al (2007) also reported that swimmers had lower BMD as compared to other athletes and the control group. They also reported that bone density of the sprint runners group was not very different from that of the control group but was significantly higher compared to the endurance group.

In general they claimed that endurance athletes had lower bone mineral density compared to the control group [23]. Lack of consensus in this regard could be due to differences in type, intensity, and duration of the physical activity, and the participants' gender. Factors such as intensity, type and duration of the physical activity affect calcium serum levels. In the present study calcium serum levels were higher in the experimental group as compared to the control group but the difference was not significant. This is in line with the findings of Beije et al [21], Maimoun et al [28], Guillemant et al [29], but contradicts those of Ebrahim et al [30], Tofighi et al [31], and Barry et al [32]. The effect of calcium as an important marker of bone metabolism in increasing bone density could be related to the decrease in bone turnover and osteocalcin (as a marker of bone turnover), that may increase bone density [33,34].

In general long term, regular physical activity at an appropriate intensity, leads to bone stimulation through increasing calcium absorption in intestine, and decreasing its urine excretion, leading to increased levels of this ion in the serum. On the other hand according to increase in ALP, calcium transfer from extra cellular fluid to bone osteoids, increases and leads to building new bone cells [20,33].

Kemmler et al (2007) studied the effects of long-term exercise, stretching, and intense aerobic exercise on the BMD of pelvic and cervical vertebrae of 40 women and observed an increase in the BMD and a decrease in the rate of bone density loss, in the experimental group as compared to the control group [35]. Some research has shown that, exercise-induced, regular pressure on bones stimulates osteblasts and leads to bone calcification [7,33].

The results of the present study showed an insignificant increase in the phosphor levels of the experimental group as compared to the control group. This is in line with the findings of Tofighi et al [31], and Ryan et al [37], but contradicts those of Ashizawa et al [38]. One reason for the contradicting results regarding phosphor levels could be calcitonin hormone release which decreases absorption of calcium and phosphorus from the bones. On the other hand, paratormone causes re-absorption of calcium and phosphorus from bone to circulation [21].

In general, researchers believe that different types of sports and exercise exert different effects on bone formation, as bone reconstruction is to a great extent under the influence of mechanical stress which is an important factor in skeletal development. Weight bearing physical activity is a bone osteogenic stimulant and is more influential in formation of new bone cells and bone mineralization increase, as compared to non-weight bearing exercises such as swimming. Mineral content of the bones is higher in women who started exercising before the age of puberty and have consumed enough calcium in their diet [15, 39, 40]. However further research is needed to clarify bone metabolic responses to exercise training, and to find out the appropriate type, duration and intensity of training to optimize bone formation responses to exercise and training programs.

Acknowledgment

The authors would like to express their appreciation of Islamic Azad University, Gorgan, Iran, and all the participants of this study for their participation.

References

1-Genat HK, Cooper C, Poor G (1999). Interim Report and Recommendation of the WHO taskforce for osteoporosis. Osteoporosis Int: 10:259-264.

2-Fujiwara S(2005). Epidemiology of osteoporosis. Clin Calcium:15:577-582.

3-Garnero P, Borel O, Delmas PD (2001). Evaluation of a fully automated serum assay for C-terminal cross-linking telopeptide of type I collagen in osteoporosis. Clin Chem:47:694–702.

4-Komnenou A, Karayannopoulou M, Polizopoulou ZS, Constantinidis TC, Desasiris A (2005). Correlation of serum alkaline phosphatase activity with the healing process of long bone fracture in dogs. Veterinary Clinical Pathology: 34:35- 8.

5-Volpin G, Rees JA, Ali SY, Bentley G(1986). Distribution of alkalin phosphatase activity in experimentally produced callus in rats. The journal of bone and joint surgary: 68-B:629- 34.

6-Lester ME, Urso ML, Evans RK, Pierce JR, Spiering BA, Maresh CM, Hatfield DL, Kraemer WJ, Nindl BC (2009). Influence of exercise mode and osteogenic index on bone biomarker responses during short-term physical training Bone: 45:768–776.

7-Brahm H K, Piehl Aulin S, Ljunghall (1997). Bone metabolism during exercise and recovery: the influence of plasma volume and physical fitness. Calcif Tissue Int: 61:192 – 198.

8-Rudberg AP, Magnusson L, Larsson H, Joborn (2000). "Serum Isoforms of bone alkaline phosphatase increase during physical exercise in women". Calcif Tissue Int: 66:342 – 7.

9. Wallace JD, Cuneo RC, Lundberg PA, Rosen JOLL Jorgensen, Longobardi et al (2000). "Responses of markers of bone and collagen turnover to exercise, growth hormone (GH) administration, and GH withdrawal in trained adult males". J Clin Endocrinol Metab: 85:124 – 33.

10. Ashizawa, NG, Ouchi R, Fujimura Y, Yoshida K, Tokuyama M, Suzuki (1998). "Effects of a single bout of exercise on calcium and bone metabolism in untrained young males". Calcif Tissue Int: 62:104 – 8.

11- Hemayattalab R, Nikravan A, Rashidi Rostami

L(2010). Comparison of the effects of weight bearing exercises and calcium supplement on mineral density of vertebral column bones of pre-school children. Scientific-Research Journal of Shahed University Seventeenth Year, No.87 .

12. Winzenberg TM, Shaw K, Fryer J, Jones G(2006). Calcium supplementation for improving bone mineral density in children. Cochrane Database of Systematic Reviews. Am J Clin Nutr, Feb: 87(2):455-62.
13. Dianne S, Ward, Ruth P,Sanders, Russell Pate R (2007). Physical Activity Interventions in Children and Adolescents. Human kinetic.
14. Rowlands AV,Ingledew DK,Powell SM, & Eston R.G(2004). Interactive effects of habitual physical activity and calcium intake on bone density in boys and girls. Journal of Appl physiol: 97: 1203-1208.

15-Creighton DL, Morgan AL, Boardley D, Brolinson PG(2001). Weight bearing exercise and markers of bone turnover in female athletes. Journal of Appl physiol: 90(2): 565-570.

16- LIU Meng, ZHONG Cheng, HE Rong-xin and CHEN Li-feng (Chin Med J 2012). Icariin associated with exercise therapy is an effective treatment for postmenopausal osteoporosis:125(10):1784-1789

17- Beekley MD, Sato Y, Abe T (2005). KAATSU-walk training increases serum bone-specific alkaline phosphatase in young men. Int. J. KAATSU Training Res: 1: 77-81

18- Kemmler W, Engelke K, von Stengel S, Weineck J, Lauber D, Kalender WA(2007). Long-term four-year exercise has a positive effect on menopausal risk factors: the Erlangen Fitness Osteoporosis Prevention Study. J Strength Cond Res: 21:232-9.

19-Bagheri, L, et al (1388). Effects of aerobic exercise on the hormone levels of estrogen, parathyroid, calcium, alkaline phosphatase and serum albumin levels in elderly women. Iranian Journal of Ageing. Year IV, No. 12: pp. 35-26.

20- Tartibian B, Moutab Saei N(2009). Effects of 9-weeks high intensity aerobic exercises on parathyroid hormone and marker of metabolism of bone formation in young women. Olympic:16(4):79-88.

21-Bijeh, N , et al (2011). Effect of aerobic exercise on markers of bone metabolism in middle-aged women. Kowsar Medical Journal: 16(2):129-135.

22-Khorshidi D, Matinhomaee H, Azarbayjani MA, Hossein-nezhad A. Effect of one period of aerobic exercise on serum levels of alkaline phosphatase and osteocalcin in patients with type 2 diabetes. J Shahid Sadoughi Univ Med Sci: 19(5): 676-85.

23-Magkos, FM, Yannakoulia and LS, Sidossis(2007).The type and intensity of exercise have independent and additive effects on bone mineral density. J sports Medicine:[Epub ahead of print].

24-Fernandez NJ, Kidney BA(2007). Alkaline phosphatase: beyond the liver. Vet Clin Pathol: 36(3): 223-33.

25-Raman K. Marwaha et al (2011). Effects of sports training & nutrition on bone mineral density in young Indian healthy females. Indian J Med Res 134, September: pp 307-313

26-Stein, GS, JB, Lian (1993). "Molecular mechanisms mediating proliferation/ differentiation interrelationships during progressive development of the osteoblast phenotype". Endocrine Rev. 14:424 – 442.

27-Kevin R, Vincent T, Randy WB (2002). Resistance exercise and bone turnover in elderly men and women. American College of Sports Medicine: 0195-9131/02/3401-0017.

28- Maimoun L, Sultan C (2011). Effects of physical activity on bone remodeling. Metabolism: 60(3):373-88.

29-Guillemant J, Accarie C, Peres G, Guillemant S (2004). Acute effects of an oral calcium load on markers of bone metabolism during endurance cycling exercise in male athletes. Calcif Tissue Int:74 (5): 407-14.

30-Ebrahim K, Ramezanpoor M, Rezaee Sahraee A (2010). Effect of Eight Weeks of Aerobic and Progressive Exercises on Changes of Estrogen Hormone and Effective Factors on Bone Mass in Menopaused Sedentary Women. Iranian Journal of Endocrinology and Metabolism: 12 (4).401-408.

31-Tofighi A, Hefzollesan M (2011). Effect of 12-weeks selective aerobic and resistance water training on femoral and lumbar spine bone density in obese postmenopausal women. Olympic: 18(4) Serial 52) : 153-164.

32-Barry DW, Kohrt WM (2007). Acute effects of 2 hours of moderate intensity cycling on serum parathyroid hormone and calcium. Calcif Tissue Int; 2007:80 (6):359-65

33-Andreoli T, Carpenter CH, Griggs R, Benjamin I(2007). Cecil essential of medicine: Diseases of bone mineral metabolism and connective tissue. Heshmati P, translator. Tehran: Andisheh Rafi Publication; [Persian]

34-Mafazi SH, Moshtagh E, Montazeri M(1998). Metabolic and endocrine disorders. Tehran: Arjmand Publication: [Persian]

35-Kemmler W, Engelke K, von Stengel S, Weineck J, Lauber D, Kalender WA(2007). Long-term four-year exercise has a positive effect on menopausal risk factors: the Erlangen Fitness Osteoporosis Prevention Study. J Strength Cond Res: 21:232-9.

36-Palmas S , Hinton R, Scohrector T, Thomas R(2006). weight-bearing aerobic exercise increase markers of bone formation during short term weight loss in overweight and oboes men and woman. J Metabolism:p.1616-1618.

37-Ryan, Alice S, Nicklas, Barbara J and Dennos Karen

E(1998). Aerobic exercise maintains regional bone mineral density during weight loss in postmenopausal women. J Appl Physiol:84(4):1305-10.

38-Ashizawa N, Fujimura R, Tokuyama K, Suzuki M (1997). A bout of resistance exercise increases urinary calcium independently of osteoclastic activation in men. J Appl Physiol: 83(4): 1159-63.

39-Robling AG, Castillo AB, Turner CH(2006). Biomechanical and molecular regulation of bone remodeling. Annu Rev Biomed Eng: 8: 455-98.

40-Huang TH, Lin SC, Chang FL, Hsieh SS, Liu SH, Yang RS(2003). Effects of different exercise modes on mineralization, structure, and biomechanical properties of growing bone. J Appl Physiol: 95(1):300-7.