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# Comparison of the Levels of Bone Metabolic Markers between Young Female Basketball Players and Non-Athlete Females

**Asra Askari**
PhD) Department of Physical Education and Sports Science, Gorgan Branch, Islamic Azad University, Gorgan, Iran

**Boby Sun Askari**
(PhD) Departments of Physical Education and Sports Sciences, Ghaemshahr Branch, Islamic Azad University, Ghaemshahr, Iran

**Saqa Faraj Tabar Behrastagh**
Assistant Professor, Department of Physical Education and Sport Sciences, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran
**Tel:** +989111566028

**Email:**askari.asra@gmail.com

**Corresponding author:** Asra Askari

**Address:** Faculty of Humanities, Islamic Azad University, Gorgan Branch, Gorgan, Iran

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## ABSTRACT

**Background and objectives:** Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue. It is the most common chronic metabolic bone disease. The purpose of this study was to compare the level of bone metabolic markers including parathyroid hormone (PTH), alkaline phosphatase (ALP), calcium, and phosphorus between female basketball players and non-athlete females.

**Methods:** Twelve female professional basketball players (aged 20-35 years) of the Super League of Golestan Province (Iran) were enrolled as the experimental group. Fifteen age-matched non-athlete females were also selected as the control group. Plasma levels of PTH, ALP, calcium, and phosphorus were compared between the study groups.

**Results:** The levels of PTH ($p=0.004$) and ALP ($p=0.001$) were significantly higher in the experimental group than in the control group. The levels of calcium and phosphorus did not differ significantly between the study groups ($p>0.05$).

**Conclusion**: Based on the results, it could be stated that performing weight-bearing sports activities such as basketball can improve the density of bone minerals and the factors stimulating bone formation.

**Keywords**: Parathyroid hormone, alkaline phosphatase, calcium, phosphorus, osteoporosis.

## INTRODUCTION

Osteoporosis is characterized by a decrease in bone mass and bone minerals, resulting in bone tissue destruction and finally bone fractures (1). According to research, the lifetime risk of bone fracture is about 40% among women (2). The high prevalence of osteoporosis (3) and the subsequent fractures are thought to be a main causes of high therapeutic costs and deaths in the future decades. Around 200 million women all over the world are estimated to suffer from osteoporosis. The disease is also of utmost importance for Iran's health system, the ubiquity of which has already begun to emerge (4,5).

Bone is an active metabolic tissue, which continually restores during the lifetime, and can change its structure under existing pressures. This organ contains living cells, blood vessels, and nerves. A lack of activity or pressure will gradually make the bones weak and fragile (6). Skeletal homeostasis depends on the balance between bone construction by osteoblasts and its re-absorption by osteoclasts (7). A constructive cell called osteoblast and a destructive cell called osteoclast bring about such effects. Both cells are formed in the bone marrow. When one gets older, osteoclasts become more active osteoblasts less active, which ultimately results in a decrease in bone mass (8,9). Decreased bone mineral density depends on many factors, including age, gender, race, decreased muscle strength, inactivity, impaired calcium intake and absorption, amount of phosphorus, smoking, alcohol consumption, and hormonal disorders. Minerals, especially calcium and phosphorus, play a crucial structural and metabolic role in bone growth and are regarded as the first indicators of osteoporosis. Calcium is the main substance of bone (3) and the source of calcium storage in the body, and it creates the mechanical stability of the bone and can be used in times of need and changes in the serum calcium level (10).

Normally, a very small portion of stored calcium is available for exchange in the serum (11).

Research shows that physical activity has a considerable effect on the development and maintenance of bone density because constant physical pressure stimulates osteoblasts, leading to bone calcification sediment (12). Based on this, the density of bone minerals has a high correlation with the activities involved in weight-bearing and muscle tension (13). In this regard, it has been stated that sports requiring dynamic pressures, such as jumping and military activities, are considered the most efficient type of physical activity for the storage of bone mass. This would be particularly beneficial for increasing bone stability peak and preventing osteoporosis in the younger population (14,15). Moreover, Torstveit et al. (2004) showed that the bone density of the femoral neck, femoral trochanter, and spine of athletes participating in high-intensity sports is higher compared with low- and moderate-intensity sports (14,16).

In addition, another study showed that running at a speed of 4.2 m/s for 50 minutes, which increased by 0.25 m/s with 5 steps in 8 minutes, produced more parathyroid hormone compared with running at an even speed (17).

Hence, as a non-medical intervention, sports activity is very important for bone health and the prevention and improvement of osteoporosis. Exercises recommended by the World Health Organization have both direct and indirect osteogenic effects on skeletal tissue and can increase bone density through the maintenance of the balance between bone formation and reabsorption (17, 18). Accordingly, measuring some hormones, cytokines (19), and bone biochemical markers can show inner cellular metabolism and the relationship between physical activity and bone metabolism. Some of these markers include the parathyroid hormone (PTH), alkaline phosphatase (ALP), calcium, and phosphorus (20,21).

The major physiological function of parathyroid hormone is protecting plasma calcium ions and inorganic phosphorus homeostasis through stimulation of osteoclasts and calcium re-absorption from the bones as well as renal cells, as well as increasing indirect calcium absorption from the intestines and stimulating the production of active forms of vitamin D (21, 22). QI et al. (2016) showed that the levels of blood parathyroid hormone increase right after exercising, and if this exercise continues, these levels reach balance and exert osteogenic effects. Exercise can adjust the secretion of this hormone in proportion to the content of bone initial minerals, gender, age, exercise conditions, and metabolic factors (23). A study reported that intensive exercise can increase parathyroid hormone secretion (24), while other studies showed that short-term exercise can only increase serum calcium concentration and has no effect on parathyroid hormone secretion (25). Furthermore, in a study by Lester et al., 8 weeks of resistance and mixed aerobic exercise had no significant effect on the levels of parathyroid hormone (26,27). In another study, 6-12 months of intensive exercise significantly decreased parathyroid hormone (28). Alkaline phosphatase (ALP) is one of the most important indicators of bone formation and can reflect bone changes (29). Osteoblasts are rich sources of ALP, and ALP serum levels indicate osteoblast activities (30). In a study conducted by Alghadir et al. (2014), cyclical aerobic training with treadmills, bicycles, and stairs increased the levels of bone formation biomarkers including ALP among healthy men and women (31,32). In other studies, bone formation biomarkers decreased after a period of intensive alternate exercise (33,34). In a study by Bagheri et al., 8 weeks of jogging and aerobic exercise with an intensity of 70-60% in postmenopausal women caused a significant increase in serum parathyroid hormone and ALP (35). Similarly, another study reported that 8 weeks of aerobic training at 65-75% of maximum heart rate was effective in increasing serum calcium, phosphor, estrogen, and parathormone (PTH) in women with premature menopause (36). The present study aimed at comparing the levels of parathyroid hormones, ALP, and bone minerals (calcium and phosphorus) among non-athlete women and female basketball players in the Super League of Golestan Province, Iran.

## MATERIALS AND METHODS

The study included 12 female basketball players (aged 20-35 years) playing in the Super League of Golestan Province and 15 healthy women. The players have been practicing 5 sessions a week, 90 minutes a session, for 3 years.

The athletes and control subjects were matched in terms of ethnicity and age. Written informed consent was taken from all participants, and the study received approval from the local ethics committee. To measure the intended blood variables, blood samples (5 ml) were taken from the participants' arms in the sitting position.

Then, plasma levels of hematologic phosphorus, calcium, and ALP were measured by using an autoanalyzer and commercial kits (Selectra, Elitech, France).

In addition, PTH was measured by using an ELISA reader and a commercial kit (IBL, Germany).

Descriptive statistics were used to describe the data. The normality of data distribution was assessed using the Shapiro–Wilk test. Intergroup changes were evaluated using the independent t-test and Mann–Whitney U test. All analyses were carried out in SPSS software (version 18), with the significance level set at 0.05.

## RESULTS

Table 1 shows the demographic characteristics of subjects in the experimental and control groups.

There was a significant difference between the experimental group and the control group in terms of PTH (p=0.004) and ALP (p=0.001) levels (Tables 2 and 3).

**Table 1- Demographic characteristics of subjects in the experimental and control groups**

| | Statistical Indices of the Variable | Age (Years) | Height (cm) | Weight (kg) | ALP (U/l) | PTH (n/l) | Calcium (mg/dl) | Phosphate (mg/dl) |
|---|---|---|---|---|---|---|---|---|
| Groups | Experimental (n=12) | 25,25±4, 827 | 173.75±5.0 65 | 8.105 ±66.33 | 165.42 ± 32.506 | 47.625±28.4 5903 | 9.5583± .21515 | 3.3917±.3872 |
| | Control (n=15) | 25.67±4. 467 | 161.67±5.7 90 | 9.329 ±60.80 | 128.67±20.6 56 | 22.9400±14. 32574 | 9.4533±.4 7188 | 3.2933±.46823 |

**Table 2- Comparison of the mean level of PTH, calcium, and phosphorous between the experimental and control groups**

| | Groups | Ranking Mean | U-value | P-value |
|---|---|---|---|---|
| PTH (pg/ml) | Control (n=15) | 10.20 | 33.000 | 0.004 |
| | Experimental (n=12) | 18.75 | | |
| Phosphorous (mg/dl) | Control (n=15) | 13.83 | 87.500 | 0.905 |
| | Experimental (n=12) | 14.2 | | |
| Calcium (mg/dl) | Control (n=15) | 13.60 | 84.000 | .792 |
| | Experimental (n=12) | 14.50 | | |

**Table 3- Comparison of mean changes of ALP in the experimental and control groups**

| | Alp (IU/l) | Mean Differences | Standard Deviation | T | P-value |
|---|---|---|---|---|---|
| Groups | Control | 36.750 | 20.656 | 3.577 | 0.001 |
| | Experimental | | 32.506 | | |

## DISCUSSION

Based on the results of this study, the serum levels of PTH, ALP, calcium, and phosphorus in professional, female basketball players were higher than those in their non-athlete counterparts. This is in line with the findings of most previous studies (36-39), all of which reported an increase in the level of PTH after sports activities. In line with our findings, some studies found no change in calcium levels after exercise training (39-41), while others reported a significant change in calcium levels after exercise training (38, 42, 43). Examining the results obtained from clinical research indicates that not all kinds of sports programs had positive effects on bone metabolism indices. Many factors such as exercise type, intensity, and duration as well as the physical status and age of participants can impact the changes in the levels of PTH and bone minerals. Various studies indicated a strong inverse relationship between calcium ion concentration changes and PTH secretion (37). Another possible reason for the increased levels of PTH during physical activity is metabolic acidosis (40), which increases urinary calcium excretion but decreases calcium renal reabsorption (10). The principal physiological function of PTH is protecting calcium ion and inorganic phosphate hemostasis through PTH receptors in the kidney, bones, and intestines. This hormone can increase plasma calcium levels by stimulating calcium reabsorption in the intestines and increasing bone reabsorption. It also increases calcium reabsorption in the kidneys by producing 25-hydroxy vitamin D. Regular sports activities increase the level of plasma calcium, and in long term, increase bone density and bone formation (44).

In the present study, the level of blood phosphorus did not differ significantly between the study groups, which is in line with the findings of a previous study (45). However, Ashizawa et al. reported a decrease in blood phosphorus after resistance exercise (46). This inconsistency might be related to the increase in the levels of the calcitonin hormone as it decreases the absorption of calcium and phosphorus from the bone. On the other hand, PTH release can increase bone resorption, which causes the release of calcium and phosphorus into the blood; with the increase in the levels of phosphate ion plasma and PTH, excess phosphate will be excreted via the kidneys (22). In a study by Khajehlandi et al., selected aerobic exercise increased PTH, osteocalcin, and ALP levels (2). Alghadir et al. also reported that aerobic exercise caused an increase in the levels of bone formation biomarkers, including ALP, among healthy men and women (31).

According to the Wolff's Law, the process of bone restoration directly depends on the mechanical pressures exerted on the bone (47). Given the mechanical pressures stemming from the activities involving weight-bearing, such as basketball, participation in this type of activities can improve the level of bone biochemistry markers, whereas this osteogenic adaptation is not gained through other sports such as swimming (48). On the other hand, osteogenic effects of exercises with weight bearing could be influenced by the differences in mechanical pressures related to the ground reaction force. In this research, the mechanical forces resulting from the running and jumping movements among basketball players caused changes in the biomarkers of bone formation and resorption, indicating an optimal bone metabolic response. Based on a previous study, the forces on the ground during walking and running are 1.1 and 2.5 times the body weight, respectively, while in jumping activities, this force reaches 6 times the body weight (32). Previous studies have shown that exercise can enhance osteoblast differentiation, inhibit osteoclast activity, and improve bone regeneration by regulation of multiple signaling pathways, such as Wnt/beta–catenin , basic metabolic panel (BMP) and osteoprotegerin (OPG)/the receptor activator for NF-κB ligand (RANKL)/RANK signaling pathways.

The Akt-glycogen synthase kinase-3β (GSK-3$\beta$) pathway, or PI3K / Akt / GSK-3$\beta$ / $\beta$-catenin, is also important in the positive regulation of bone metabolism. Recent studies have shown that non-coding RNAs, small interfering RNAs, microRNAs, lncRNAs, and circular RNAs are widely involved in the regulation of various stages of bone metabolism, including the proliferation and differentiation of osteoblasts and osteoclasts.

Laboratory findings suggest that mechanical stress during exercise stimulates increased blood flow to the brain and bones.

Laboratory findings suggest that mechanical stress during exercise increases blood flow to the brain and bones. In addition, mechanical loads exert forces on specific areas of the bones, and interstitial fluid can flow down from the pressure area (1, 19).

As Frost (1992) stated in his theory, bone structure is protected through feedback systems so that the increase in mechanical or dynamic pressure can stimulate bone growth and formation (48).

## CONCLUSION

Based on the results of the present study, it could be stated that performing sports activities with weight bearing like basketball can improve the density of bone minerals and the factors stimulating bone formation.

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## DECLARATIONS

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## Ethics approvals and consent to participate

Written informed consent was taken from all participants, and the study received approval from the local ethics committee.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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