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Acute Effects of Plyometric Exercises Performed on Land and in Water on the Parameters of Bone Metabolism in Middle-Aged Males

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Abstract

Objectives: This study was performed to investigate the acute effect of plyometric exercise in water and on land on some indices of bone metabolism in middle-aged males.

Methods: In this quasi-experimental study, 10 middle-aged disabled people were selected. Participants exercised on two separate weeks, on one week only recorded water-based exercise and the other week reported their land-based plyometric exercise. The blood sample was initially taken 10 minutes before starting plyometric workout on land or in water and 10 minutes after a week of intervention. Serum levels of alkaline phosphatase (ALP) and calcium were measured. Student's t-test was used and $P < 0.05$ was considered as significant.

Results: There was no significant difference in mean serum calcium level both before ($P = 0.322$) and after exercise ($P = 1.0$) between the 2 groups. Mean serum calcium level changes were also similar between the 2 groups ($P = 0.300$). Serum alkaline phosphatase (ALP) level was similar between the 2 groups both before ($P = 0.337$) and after exercise ($P = 0.147$); yet its changes was significantly higher in individuals, who exercised on land than in water ($P = 0.003$).

Conclusions: It seems that land-based plyometric exercise increases serum ALP more than water-based plyometric exercise in middle-aged males.

Keywords: Serum, Calcium, Alkaline Phosphatase, Plyometric Exercises

1. Background

Osteoporosis, a disease related to the human skeletal structure, is characterized by bone loss and high risk of bone fracture. Osteoporosis is a threat to public and individual health and has been recognized as a factor of disability in daily functioning (1). In America, more than 50% of males above 85 years are affected by this disease (2). Also, it has been reported that 10% to 15% of mortality in people over 50 years is associated with hip fractures in the first year (3). This shows that the potential risk of osteoporosis is higher in older people. In America, it has been predicted that by 2020, about 14 million people will be affected by osteoporosis and about 47 million people will be at the risk of this clinical problem (4). According to estimations, about 200 million female around the world suffer from this disease. The high prevalence of osteoporosis and related fractures would be one of the reasons for high costs of treatment and mortality in the coming decades. Accordingly, this disease is an important issue for the health system of Iran (5, 6).

The bone regeneration process is significantly affected by mechanical stress exerted on the bone. Mechanical stresses induced by exercises are important factors leading to the growth and development of skeletal tissue (7). Recent data have shown that jerking exercises are associated with an increase in bone mineral density (BMD) and may play an important role in preventing osteoporosis (8), and it is well known that early prevention is important in preventing this disease (9). According to the American college of sports Medicine (ACSM) recommendations, generally, two exercise methods are useful for bone health, one of these methods is impacting intense workout (such as jumping and landing), which is the result of an increase in ground reaction force and another method is high-intensity strength exercises (10). One of the enzymes affecting bone metabolism is alkaline phosphatase (ALP), which is a marker of bone formation; the activity of this bone marker is a sign of formation and absorption of bone minerals (11). In bone, osteoblasts are a great source of alkaline phosphatase, whose rate in the cells, indicates the

ability of bone formation in osteoblasts (12). Rudberg et al. in their study concluded that 20 minutes of moderate-intensity running for 30 to 40 minutes was effective in increasing ALP (13). Vini Simas et al. showed that aerobic exercises in shallow water helped postmenopausal females maintain and improve BMD in the femur (14). Minerals, especially calcium and phosphorus, play an important metabolic and structural role in bone growth and are considered as initial indicators of the risk of fracture due to osteoporosis. Sports could maintain and increase bone mass by increasing bone mineral density (particularly calcium and phosphorus) (15). Some studies have reported that performing acute exercises for a period of time cannot be enough for changing bone metabolism (16). However, some evidence has shown reduction in bone formation markers while increases in the bone reported markers (17). These changes may be dependent on the type and duration of exercise or even the fitness condition or the age of participants. Floating on water reduces the extraversion and tensile reflex of plyometric exercises and in contrast, the surface tension of water increases resistance to contraction of introversion (18). Available studies have documented the direct effect of plyometric exercises on bone markers. Despite all benefits of plyometric exercises, plyometric exercises could also lead to muscle damage due to an extrovert phase of contraction (18). Although plyometric exercises can increase the risk of damage to traditional resistance exercises (19), a series of studies have reported the beneficial effects of these types of exercises on the structure and mineralization of bone (20). Since many of these studies have only been limited to land, we compared the effects of these exercises on land with those performed in water. To this purpose, the effects of a session of water-based and land-based plyometric exercises on bone metabolic indicators were assessed in disabled middle-aged people.

2. Methods

In this applied quasi-experimental study, 10 middle-aged disabled people with an average age of 36.9 $\pm$ 1.59, height 175.4 $\pm$ 2.75 cm, weight 69.2 $\pm$ 2.93 kg, body mass index (BMI) of 22.45 $\pm$ 0.74 kilograms per square meter were selected. Passive people were defined as those, who did not have any regular exercise in the past two years.

All the necessary explanations were given to the trainers based on any risk as well as the purpose of the research and all the contestants were given a testimonial letter to sign and agree in order to cooperate in this research. At pretest, weight, height, and body composition were measured 5 days before the intervention. The height was measured using a wall stadiometer and weight was measured using a digital scale.

Participants exercised on two separate weeks; on one week only recorded the water-based plyometric exercise and the other week reported on the land-based plyometric exercise. For each intervention, subjects began to warm up by stretching large muscles for 5 minutes (especially the twin muscles, quadriceps, hamstrings, and lumbar and chest muscles) and also warmed up their joints for 3 minutes. For the training program, the model of Miller et al. was used (20). After warming up, the participants were requested to perform plyometric exercises based on the guidelines specified in Table 1 (20). The exercises in water were performed at a depth of 110 to 120 cm. The guidelines for the plyometric exercises in water and on land are detailed in Table 1.

The blood sample was initially taken 10 minutes before starting plyometric workout on land or in water and 10 minutes after a week of intervention. Subjects had a rest time for about 20 minutes before blood sampling. Serum ALP and calcium were measured photometrically using affiliated kits (Parsazmoon, Karaj, Iran). The ALP or calcium changes following exercise was calculated. For statistical analysis, student's t-test was used.

3. Results

There was no significant difference in mean serum calcium level both before (P = 0.322) and after exercise (P = 1.0) between the 2 groups (Table 2). Mean serum calcium level changes were also similar between the 2 groups (P = 0.300; Table 2).

Serum ALP level was similar between the 2 groups both before (P = 0.337) and after exercise (P = 0.147). However, its changes were significantly higher in individuals, who performed land-based than water-based exercises (P = 0.003; Table 2).

4. Discussion

The effects of a session of water-based and land-based plyometric exercise on bone metabolic indicators (calcium and ALP) were assessed in disabled middle-aged people. Both exercises had no effect on serum calcium level. However, land-based plyometric exercise increased serum ALP more than water-based exercise. Serum ALP increased after both water-based and land-based plyometric exercises. It is estimated that the reason behind this significant change on the amount of ALP in water and on land training is due to the excessive pressure that has been caused on the joints and bones during the exercise in these two conditions.

Previous studies showed that short-term exercises had no effect on serum calcium levels (21, 22). However, regular

Table 1. Plyometric Exercises in Water and on Land

Drills	Repetition Set *	Definition
Pogo	3*8	Jump up and down pairs on the chest of legs when knees are slightly bent
Squat Jump	3*8	Jump pairs up and down when knees are completely bent
Knee tuck	3*6	Hands stretched forward and jump up so that the palms touch the knees
Heel kick	3*8	Kick your heels up to the buttocks while jumping
Fast skipping	4*6	Skipping and jumping
Lateral bounds	3*6	Opening legs more than the shoulder, sitting on one leg by bending the knee and changing the direction of movement.

Table 2. The Mean Levels of Serum Calcium and Alkaline Phosphatase (ALP) Were Increased in Both Groups Following Exercise[a]

Variables	Before Intervention		P Value	After Intervention		P Value	Changes		P Value
	Water-Based	Land- Based		Water-Based	Land- Based		Water-Based	Land- Based	
Calcium, mg/dL	9.25 ± 0.08	9.36 ± 0.07	0.322	9.43 ± 0.07	9.43 ± .0.07	1.0	0.18 ± 0.10	0.07 ± 0.03	0.300
ALP, U/L	113.7 ± 9.0	127.8 ± 11.1	0.337	118.5 ± 9.0	140.1 ± 11.0	0.147	4.8 ± 1.5	12.3 ± 1.6	0.003

[a] Data are expressed as mean ± SEM, and analyzed by student's t-test.

exercise in the long-term increases 25OH vitamin D3 and calcium levels, and bone density and facilitate the process of bone formation (23). Hence, it could be concluded that a session of exercise has no significant effect on the serum calcium levels and more time should be allocated to exercise for drastic changes.

The effects of a session of land-based plyometric exercise on values of ALP was significant. However, water-based exercises couldn't create significant changes in the levels of ALP. The result of this study is consistent with other researches (23, 24). A reason for consistency probably could be the intensity and pressure of exercise in bone density formation. However, Tanya et al. showed that aerobic exercises in shallow water on hip bone density in postmenopausal females leads to maintenance and improvement of bone density in the hip bone (14). The lack of consistency could be due to the type of exercise (aerobic), duration of exercise (long-term), and estimation severity (aerobic exercises compared with plyometric). Bone structure is maintained through a feedback system so that an increase of dynamic or mechanical stress leads to simulation of the bone and occurs along with growth and bone formation. This theory is known as the theory of mechanical condition. According to this theory, mechanical pressure should be at a specific level to overtake bone formation in the process of bone reabsorption. This mechanical pressure is called minimum effective pressure threshold (25). Performing exercise plays a key role in bone density. Such density helps the area to better cope with the mechanical load or dynamic pressure. In addition, it should be noted that different bones have a great difference in bone formation, or bone formation responses to mechanical or dynamic pressures (26). The bone formation rate is higher in cortical bones, such as the femur, while in the bony bones, such as the lower back, this rate is followed by a lower rate. The results of the research showed that the response of the brain bones, such as the femur, to mechanical or dynamic pressures, is greater than unformed bones, such as the lumbar vertebrae. Hence, for this type of bone more time is required to show a positive response to the mechanical or dynamic pressures of exercise (27). Moreover, the mean concentrations of alkaline phosphatase are influenced by exercise and time and the interaction between exercise and age. In the present study, exercise intensity seems to have a positive correlation with alkaline phosphatase levels, so that the increase of alkaline phosphatase enzyme in this study leads to transfer of mechanical stresses to biochemical signals. Future work could be carried out with a different exercise period in terms of severity and duration or the type of exercises and specific group of subjects.

4.1. Conclusion

It seems that land-based plyometric exercise increases serum ALP more than water-based plyometric exercise in middle aged males.

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2016. Therefore, the authors appreciate all athletes, who voluntarily participated in this study and adhered to their commitments by moral considerations.

Footnotes

Ethics Research: This research was part of a master's thesis, and was approved by the sports physiology department and the graduate committee of the faculty of sport sciences, and the graduate committee of Shahid Chamran University of Ahvaz on December 12th, 2015 (number 94/3/30/90228).

Conflict of Interest: The authors declare no conflict of interest.

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