Original Article

Effects of Weight Bearing Exercises on Bone Mineral Density of the First-Year Privates by Quantitative Ultrasound

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Objective: To study the results of weight bearing exercises during the first year of the active military service before and after training by using quantitative ultrasound.

Materials and Methods: The authors measured bone mineral density [BMD], broadband ultrasonic attenuation [BUA], and speed of sound [SOS] in which the measurement was focused in the right calcaneus by using quantitative ultrasound [QUS]. The sample population was the first-year draftees privates in the military service of the Service Company, Service Division, Directorate of Army Transportation, Second group, in the year 2016. Measurement were taken twice, the first one before the beginning of practicing physical integrity and strength on the first day of reporting and the second one was after six months of weight bearing exercises by QUS, the Sahara Clinical Bone Sonometer; Hologic Inc., Bedford, MA, which have been verified for reliability.

Results: Forty-eight first year privates in the military service of Service Company, Service Division, Directorate of Army Transportation, second group, in 2016 had an higher average BMD (1.08±0.18 g/cm^2) as compared to before training (0.49±0.18 g/cm^2) (*p*-value <0.001). This was consistent with the higher average BUA after training (after: 88.58±2.17 dB/MHz, before: 84.19±2.79 dB/MHz) (*p*-value 0.039), and the higher average SOS after training (after: 1,577.62±24.09 m/s, before: 1,569.69±27.52 m/s) (*p*-value <0.001).

Conclusion: After six months training, the first-year privates had higher BMD than before training. This indicates that the new army private training program has a positive correlation with increased BMD, especially weight-bearing exercises such as running, training exercise, playing football, and Sepa takraw, etc.

Keywords: Weight bearing, Privates, Training exercise, Bone mineral density

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Osteoporosis is a bone disease affecting the bone structure and strength of bone, raising the risk of fractures. The World Health Organization [WHO] reported that the statistics of worldwide osteoporosis patients have been increasing and it has become a public health issue, ranking second only after cardiovascular diseases. Osteoporosis is the vital cause of brittle bone and consequent fracture especially in elderly population causing hip fractures, which, in turn would increase the rate of death, disability, and contribute to excessive treatment fee. The WHO[(1)] also reported that there are more than 75 million osteoporosis patients in Europe, Japan, and the United States of America. It is the major cause of fractures in the European and American continents affecting more than two million people, occurring more frequently in females than males.

The cause of higher frequency of osteoporosis in females when compared to males is because females have lower values of their highest bone mineral density [BMD] as compared to males and that their estrogen levels decrease after menopause. However, the incidence of osteoporosis in males is also high especially in those with low testosterone levels, cigarette smoking, and higher alcohol consumption. These are significant factors that contribute to the reduction of BMD. Therefore, osteoporosis is an important condition that affect the male population as well[(2)].

To prevent osteoporosis to reduce the incidence of fracture, life style and behavior modification are required including regular exercise[(3)], smoking and alcohol consumption cessation, and adequate calcium intake or supplementation.

Exercising regularly, especially running, which is considered as a weight-bearing exercise[(4)] increases BMD and prevents osteoporosis. This is because the bone is a dynamic organ that is constantly changing to adjust to the intensity of the mechanical forces that is exerted on it by the muscles. The forces sustained by the

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musc les due to physical activity is directly proportional to the number of bone-forming cells (osteoblasts). In contrast, the level of muscle activity is conversely proportional to the number of bone-resorbing cells (osteoclasts). Therefore, if the muscles undergo high levels of exertion, their cells would increase bone formation instead of resorption. However, low intensity exertion against bone would result in more bone resorption. Consequently, the physical activities that build bone mass must be performed on that part of the bone by causing it to bear weight. Usually, the complete cycle of bone resorption and forming is about three to four months[5].

Normally, the human bone grows and accumulate bone mass from birth until the peak bone mass occurs, which is at about 30 years of age. The BMD will plateau for a certain period of time. Then, the process of resorption will be more active than the process of bone formation, resulting in rapid depletion of bone minerals density, causing weakening of the bone eventually resulting in osteoporosis. Osteoporosis may present as severe back pain, compression fractures of the spine (or vertebral body collapse), kyphosis or hunchback, and decrease in height. Therefore, the higher the BMD, the lower the risk of osteoporosis.

In the Thai military service, all privates are between 18 to 30 years old healthy males recruited for training in both discipline and physical fitness. To serve in the military, they join the armed forces in May or November, referred as the first and second group, respectively. Each group will be trained daily for 10 weeks according to the regulations and basic training. Every military service will have to train regularly, especially running, which is a weight bearing[6] activity that could contribute to the increase in BMD and prevent osteoporosis.

In Thailand, few studies have been reported regarding osteoporosis. Only one published paper by Rangsipat et al[7] was found. They reported the comparison of the BMDs of the new military recruits with the second-year recruits by using ultrasound for measuring the density of the bone at the heel (calcaneus).

The authors, as researchers, were interested in studying the results of weight bearing exercise on the second group of the first-year military recruits, before and after physical training by using quantitative ultrasound [QUS] to measure their BMDs[8,9]. If it had evidence that physical training could increase BMD, it could be incorporated into the guideline for setting up a healthy campaign to prevent osteoporosis in the future. Moreover, the present study could create awareness to the rest of the military, which is another benefit of physical training. It is not only an honor to serve the country by joining the military service for the national security, but be able to strengthen their fitness and increase their BMD to prevent osteoporosis are some of the additional benefits.

Objective

To compare the results of weight bearing exercise on the second group of the first-year military recruits, before and after physical training for six months by using QUS.

Materials and Methods

The present research was a cohort study in which the target population was the second group of first-year of military service. The sample population included the first-year privates of the second group of military service from the service company, the service division, the directorate of army transportation. The authors used simple random sampling by drawing up chits.

Inclusion criteria for the samples

All participants were the military service from service company, service division, directorate of army transportation, 2016, in the age group between 18 and 25 years, who did not suffer from congenital diseases and were not on medications.

Exclusion criteria for the samples

Participants who did not undergo continuous physical training for any amount of time, those taking calcium supplements, alcohol consumption, cigarette smoking, those who were previously athletes, or regularly trained for at least four hours per week before or during service were excluded. The calculated sample size (BMD was calculated as primary outcome)[7] was 48 privates. We used a calculated sample size of BMD from the military service of the service company, service division, directorate of army transportation, the second group, in 2016.

The authors obtained the relevant data and used QUS[10,11], the Sahara Clinical Bone Sonometer; Hologic Inc., Bedford, MA, qualified by the expert engineering from this company, to measure the BMD, broadband ultrasonic attenuation [BUA], and speed of sound [SOS] in which the measurement was focused in the right calcaneus. The statistical method for analyzing the data was paired t-test. In this case, using the theory based on the movement or reflection of sound wave

depended on its components and the density of bone as high BMD, BUA, and SOS correlated with high density of bone. The authors measured these values twice, once at first appearance of the privates on November 4, 2016 before beginning any physical fitness training. The second time was six months after, also recording the general data, age and any issues that effected the alteration of the bone density. The statistical analysis was done using the SPSS (Statistic Package for Social Science for Window) and the hypothesis testing accepted a statistical significance of 0.05.

Results

The present study indicated that the sample population, the military service of the service company, service division, directorate of the army transportation, second group, in 2016, had the average age of 21.40±1.16 years, average weight was 64.46±12.06 kilograms, and an average height 170.48±6.07 centimeters, as shown in Table 1.

According to the comparative analysis of the mean difference for the BMD, BUA, and SOS for the 48 active military service of the service company, the service division, Directorate of Army Transportation, second group of 2016, before and after six months of training, Paired t-test showed significant differences (p<0.05) that the mean BMD after six months of training with weight bearing exercises (1.08±1.28 g/cm^2) had statistically significant increased when compared to the mean BMD prior to undergoing training (0.49±1.24 g/cm^2), with the p-value <0.001. Likewise, we found that the mean of BUA, after six months of training (88.58±14.66 dB/MHz) was statistically significant more than before physical training with the p-value <0.039. Lastly, we also found that the SOS after six months of physical training (1577.62±24.09 m/s) was statistically significantly higher than before training (1569.69±27.52 m/s) with the p-value <0.001, as shown in Table 2.

Table 1. Characteristics of the military service of the service company, the service division, the directorate of the army transportation, 2nd group (n = 48)

Data	Mean	SD	Max	Min
Age (years)	21.40	1.16	25	20
Weight (kg)	64.46	12.06	98	43
Height (cm)	170.48	6.07	190	160

Table 2. The comparison of the differences between the BMDs, BUAs, and SOSs; before and after 6 months of training (n = 48)

Data	Mean ± SD		p-value
	Before training	After 6 months training	
BMD (g/cm^2)	0.49±0.18	1.08±0.18	<0.001
BUA (dB/MHz)	84.19±2.79	88.58±2.17	0.039
SOS (m/s)	1,569.69±27.52	1,577.63±24.09	<0.001

BMD = bone mineral density; BUA = broadband ultrasonic attenuation; SOS = speed of sound

Discussion

The present study found that six months of weight bearing physical activities of the first-year privates resulted in the increase of the mean BMD from 1.08±1.28 g/cm^2 to 0.49±1.24 g/cm^2 with statistical significance. This is likely due to the physical activity training program that is mandatory for any new recruits to undergo regular daily physical training with weight bearing exercises for 10 weeks. The training program includes a 2 km run, 12 body weight exercises and comprises of various sports such as football, volleyball, table tennis, and sepak-takraw. The mean BUA and SOS values also showed statistically significant increase post six months training program.

The principle of regularity was used for this training program, which included a variety of activities and alternated between training and rehabilitation and light and intense activities. The privates gradually increased the time and intensity of exercise to keep in good shape. The period of training was adjusted in accordance with the weather conditions to avoid casualties and ensure safety as well as having adequate portions of the five food groups, which is consistent with the research of Yung et al[6], and Tenforde and Fredericson[12]. They found that weight bearing exercise could increase the density of bone more than swimming, biking, and no exercise. Scofield and Hecht[13] also found that running increased BMD more than biking.

With the consistency in exercising during the training program, the increase in bone density is in line with Lorentzen et al[14] research. He found that athletes who underwent regular exercise had higher increase in BMD than the those who previously exercised but had ceased to continue. Due to the time factor for training, he found that those who exercised daily for more than six months could increase the alteration rate of bone mass. This is because three or four months are required to complete one cycle of bone turnover. It was also noted that the least amount of time required to cause changes in the bone density is approximately six to eight months. This is also in accord with Nordström et al's research[15], which found that military medical students and second-year medical

students at Phramongkutklao College of Medicine, had an average BMD of 0.63 gram per cm^2 of body surface area. Then, after six months of performing weight-bearing exercises, their average BMD increased to 0.74 gram per cm^2, which is significantly higher than prior to training. Moreover, it is also supported by Valimaki et al[16] research that found that after six months of exercise, the BMD of army active military significantly increased by 21%.

It was apparent that the first-year of the military service that underwent six months physical training with weight bearing exercise, would have higher BMD than prior to training. There were many factors in the training program that contributed to increment of the BMD for the privates. However, the training program for new active military service of the army is specially designed to have a lot of weight bearing exercises such as running, exercising, playing football and Takraw, to improve and maintain the health of the privates.

It could be concluded from the present study that the training program for new active military service was able to increase the BMD, thus, reduce the risk of osteoporosis at a younger age. Accordingly, it must also be emphasized that regular exercise was very important and must be carried on even after being decommissioned. The researcher had suggested and explained that maintaining and increasing BMD is a necessity to maintain strong physique and fitness as well as being mentally and physically willing to serve the army, and in turn, the country. The guidelines derived are as follow, presenting the importance of exercise, specifically those that increase the bone density, to create awareness in the general population so that they realize the value of bone strength that lead to a good physique and is vital in preventing osteoporosis; providing the knowledge of preventative and risk factors for osteoporosis, information about the required nutrition, weight bearing, and resistance exercises that make up bodyweight exercises. They should also be provided an area to exercise and some sport gears as required.

What is already known on this topic?

Regular exercise, especially weight-bearing exercise will result in increasing of bone density. Smoking cigarettes and drinking alcohol is a risk factor of decreasing BMD.

What this study adds?

Weight bearing exercise in the military service for new private training program that includes a two-kilometer run and a 12-gestures exercise including playing sports such as football, volley ball, table tennis, takraw, increase the bone density. The army should pay attention to the importance of setting up the program to exercise correctly and appropriately as well as providing enough sports equipment for the personnel.

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Potential conflicts of interest

The authors declare no conflict of interest.

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