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Comparison of Biometric Measurement Values of Ossa Antebrachii in Weightlifters and Sedentary Individuals

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Abstract

This study aims to investigate the biometric effects of weightlifting on antebrachium. Study group was composed of 9 adult male weightlifters and 9 sedentary male individuals between the ages of 20-25. Body weight and height of participants were measured. Left arm radius distal terminus bone mineral density (BMD) was measured via dual-energy x-ray absorptiometry (DEXA) method and recorded as gr/cm^2. Two dimensional (2D) images of right and left antebrachium bones were obtained through multi detector computed tomography (MDCT). 2D images were converted to 3D images with the help of Mimics-13.1 software program and bone volume, length and thickness were measured with the same programme. Weightlifters' radius distal terminus bone mineral density (BMD) was recorded to be higher compared to data obtained from sedentary individuals. Taken as a whole, results of this study presented high values in weightlifters' ossa antebrachii mass. This magnitude was identified to be in bone width instead of bone length and distributed in the periosteal direction. High values in the radius and ulna bone volumes, radius cortex thickness and BMD values of the radius distal terminus can be regarded as indicators of bone quality and strength. Existence of numerical value differences especially in sedentary individuals in the comparison of data for right forearm and left forearm mass may be related to the fact that right hand is more dominant in daily life and effects of working with heavy loads may decrease this effect in weightlifters.

Keywords: 3D modelling, BMD, ossaantebrachii, volume, weightlifting

INTRODUCTION

Despite its high degree of resistance and stiffness to pressure, withdrawal and bending, and reduced potential with aging; the bone is a continuously reshaped tissue due to the destructive activity of osteoclasts and constructive activity of osteoblasts in it (Allori et al., 2008). Bone structure; besides genetic factors, is also associated with nutrition, hormones, environmental factors and physical activity (Stewart et al., 2005).

Several studies have examined the effecting mechanisms of exercise on bone quality and quantity, the functional adaptation of bone in exercise and injury (Wohl et al., 2000; Judex et al., 2008). It has been reported that physical activity and mechanical loading caused by exercise positively contribute to construction of bone, formation of peak bone mass and maintenance of existing mass (Haapasalo et al., 2000). Suitable resistance exercises have been reported to have the ability to increase both bone mass and bone strength in humans and animals. The increase obtained in bone mass during growth prevents age-dependent osteopenia or osteoporosis (Joo et al., 2003). Based on this, bone mass and strength increased by exercise can be considered to significantly reduce bone injuries in possible accidents in daily life.

Researchers involved with sports science have analyzed the physical character of athletes for more than a century, and implemented various measurement methods to determine the impact of exercise on morphological structure (Duquet and Carter, 1999). Dual Energy X-Ray Absorptiometry (DEXA) devices, a radiological imaging method, measure bone mineral content and bone mineral density (BMD). Another method is the computed tomography, which plays a dominant role in the diagnosis and evaluation of numerous diseases. Various evaluations and measurements such as density, size and reformation can be made with the images obtained from method (Hu et al., 2000). Multi-detector computed tomography (MDCT) produces the hundreds of two-dimensional (2D) images in seconds and the obtained images can be converted into three-dimensional (3D) ones with the help of advanced computer programs (Krupa et al., 2004).

Some structural changes are likely to occur in the skeletal system of the weightlifters, who require maximal strength training with heavy weights. As a result of the literature review, we have reached a very limited number of resources related to the implementation of 3D modelling programs to determine the effects of exercise on bone structure (Kalayci, 2008;

Yıldız and Beşoluk, 2013). No study has been found on three-dimensional geometric modelling of forearm bones of weightlifters.

The weightlifting bar directly impresses on the forearm bones, therefore; in this study, this effect has been investigated in detail. The ratio of the radius bone over ulna bone with respect to length and volume are also considered to provide significant clues about the effect of weightlifting on the bones. The osteological data obtained by the method used in this study can shed light on the work to be done in the future, is thought to be useful in determining the biometric differences and deformities in bones according to different sports.

METHODS

Participants

In this study, two groups of male aged 20-25 were participated. First group consisted of 9 adult weightlifters (study group) who have been doing weight lifting at least for five years. The weightlifters participating in national and international competitions in Turkey declared that they had no orthopedic injuries. The weightlifters have been training for 5 days in week since 7.5 years. The weightlifters were not in the off-season. Second group were composed of 9 sedentary adult (control group) who did not attend to any sporting activity. By the way, both group of participants were university students in Turkey.

The required disclosures were made to the volunteers before measurements, and the 'Informed Consent Forms' were filled in and recorded. This study protocol was approved by the decision of Selçuk University, Selçuk Non-Drug Clinical Research Ethics Board, Numbered 2012/24 dated 03/05/2012.

Data Collection Procedures

Body weight measurements of the participants were taken in kg, and height measurements in m. Body Mass Index (BMI) was calculated from the obtained height and weight measurements (BMI = weight (kg) / height^2 (m)). All of the people in weightlifting and sedentary group stated that they were dominantly right-handed. Left arm distal radius bone mineral density of the participants was measured using a Lunar absorptiometry device (Lunar DPX-NT) with DEXA method. Measurements were recorded in g/cm^2.

Right and left arm bones of weightlifters and sedentary individuals were scanned with the MDCT device (Somatom Sensation 64, Siemens Medical Solutions, Forchheim, Germany) device. Scans of tomography were performed in prone position with arms extended forward. The parameters of the MDCT device were set as; physical detector collimation, 32 x 0.6 mm; final section collimation, 64 x 0.6 mm; section thickness, 0.75 mm; gantry rotation time; 330 mili-seconds; kVp; 120; mA, 300; resolution of image 512 x 512 pixels; resolution range, 0.92 x 0.92.

After recording the resulting 2D axial images on CD in DICOM (Digital Imaging Communications in Medicine) format, they were transferred to a computer with Mimics (Materialise's Interactive Medical Image Control System, Mimics 13.1 Materialise Group, Leuven, Belgium), which is a 3D modelling program. Bone images were modelled in this software by processing separately. Bone volume and length values were obtained automatically. In the same software; cortex bone thickness of radius and ulna bones on corpus level, cavum medullare diameter of these bones (in anterior-posterior direction) on corpus level were measured manually with the help of a computer mouse (Figure 1). Measured values were recorded in millimeters. Image processing and measurement of each bone took about 1 hour.

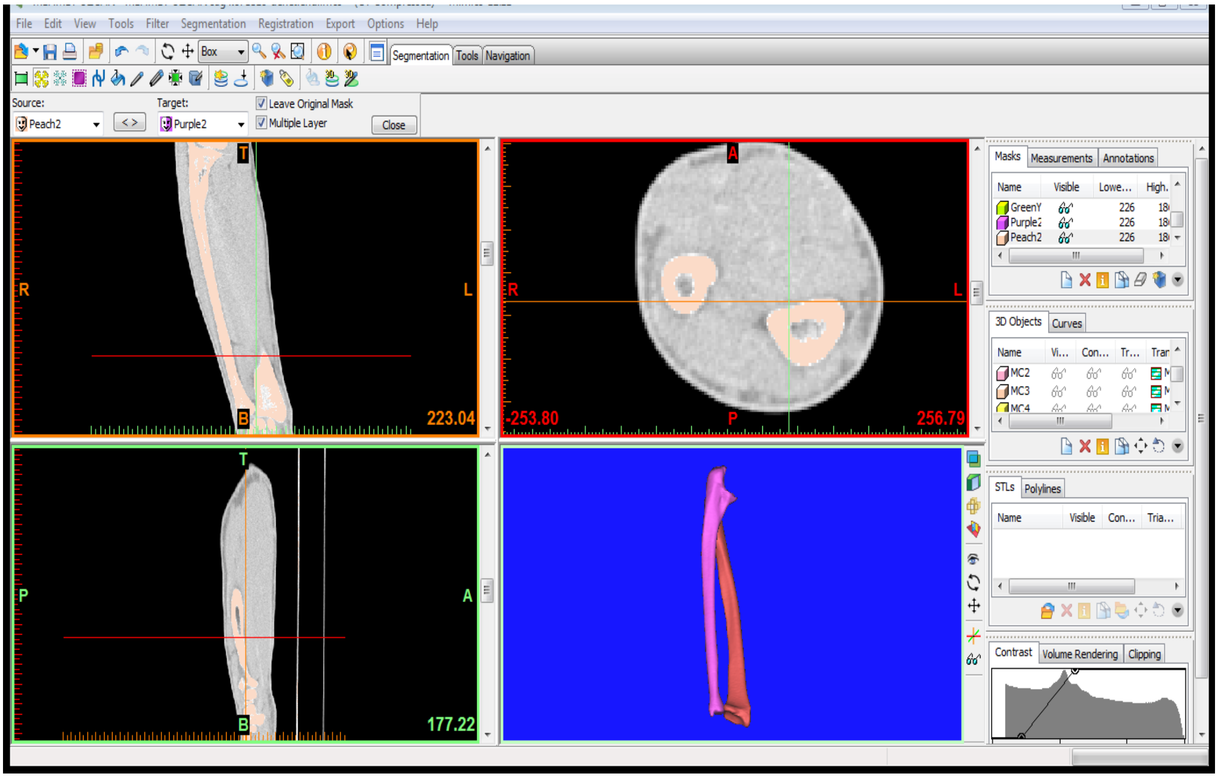

Figure 1. Processing radius and ulna bone images in Mimics

Mimics software is a medical imaging and control system developed by Materialise in conjunction with the University of Leuven in Belgium with computer-aided design software. The most important feature of this software is that it makes segmentations using Hounsfield values (Materialise, 2012). In a comparative study made with three methods, including Mimics and using Computed Tomography (CT) images; the methods were found to give highly consistent results with each other (Poeschl et al., 2013).

Statistical Analysis

All measurement data obtained from weightlifting and sedentary groups were transferred to Minitab-14 package software. In the between-group comparison; the statistical analysis was performed with two-sample t-test. In the intragroup comparison of right and left arm data; statistical analysis was performed with paired-sample t-test. In tests, the value $p<0.05$ was considered statistically significant. Arithmetic average, standard error, and p values of the group data are shown in statistical tables (mean ± SE).

RESULTS

No statistical differences were determined between the groups in terms of age (22.33 ± 0.67 and 21.78 ± 0.52 years), height (1.69 ± 0.01 and 171.00 ± 0.01 m), weight (70.30 ± 3.60 and 72.20 ± 3.40 kg) and BMI (24.29 ± 0.82 and 24.62 ± 0.84 kg / m^2) of weightlifters and sedentary individuals ($p> 0.05$).

Table 1. Comparison of the average volume of the right and left forearm bones of weightlifters and sedentary individuals (mean ± SE).

Skeleton Antebrachii	Groups	Volume (mm^3)		p
		Right	Left	
Radius	Weightlifter	50738±2591	50449±2903	0.731
	Sedentary	42619±1833	40504±1348	**0.014**
	p	**0.009**	**0.003**	-
Ulna	Weightlifter	55301±2412	55507±2822	0.841
	Sedentary	50471±2317	48766±1712	0.071
	p	**0.048**	**0.029**	-

Table 2. Comparison of the average length of the right and left forearm bones of weightlifters and sedentary individuals (mean ± SE).

Skeleton Antebrachii	Groups	Volume (mm^3)		p
		Right	Left	
Radius	Weightlifter	231.8±3.6	227.3±3.7	
	Sedentary	237.8±4.1	232.9±4.1	**0.003**
	p	0.287	0.329	**0.004**
Ulna	Weightlifter	257.0±4.3	254.1±4.4	**0.008**
	Sedentary	261.8±3.9	258.6±3.7	**0.020**
	p	0.424	0.443	-

According to the statistical analyzes, radius and ulna bone volumes in both right and left arms of weightlifters were found to be higher than those of sedentaries ($p<0.01$, $p<0.05$, respectively). Ulna and radius bone volumes in the right arms of weightlifters were not significantly different from the data obtained from the left arm ($p>0.05$). Right arm ulna and radius bone lengths of the weightlifters were significantly different from the left arm data ($p<0.05$). Right arm radius bone volumes and lengths of sedentaries were found to be higher than those of the left arm ($p<0.05$, $p<0.01$). In addition, significant differences were determined between the right arm and left arm ulna bone length data of sedentaries ($p<0.05$, Tables 1 and 2).

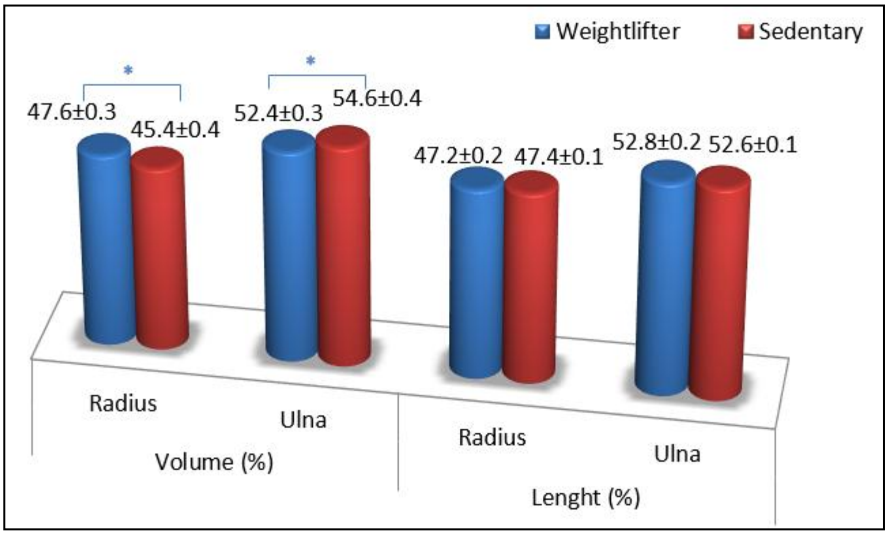

Figure 2. Comparison of mean percentage (%) rates of left forearm bone volumes and lengths of weightlifters and sedentaries (mean ± SE).

*: $p<0.01$ indicates the significance between the means of different groups.

Weightlifters' ulna bone volume percentage rate was found to be lower than that of the sedentaries, however, it was found higher in radius ($p<0.01$). Length percentage rates of both bones in the groups were similar ($p>0.05$, Figure 2).

Table 3. Comparison of averages of the left arm radius and ulna bones cortex thickness, medullary diameter and distal radius bone mineral density of weightlifters and sedentaries (mean ± SE).

Variables	Weightlifter	Sedentary	p
Radius Cortex Thickness (mm)	6.96±0.32	5.61±0.17	**0.001**
Spinal Radius Diameter (mm)	2.76±0.20	3.00±0.36	0.575
Distal radius BMD (gr/cm^2)	0.703±0.03	0.507±0.02	**0.000**
Ulna Cortex Thickness (mm)	5.00±0.17	4.68±0.11	0.070
Ulna medullary diameter (mm)	2.90±0.25	2.77±0.54	0.824

Upon comparing the averages of intergroup the cortex thickness of left arm radius bone in the corpus level and the measured values of distal radius BMD; the data obtained from weightlifters were found to be extremely higher than those of sedentaries ($p<0.01$). There were no statistical differences between the groups in terms of medullary diameter at the left arm radial corpus level, cortex thickness at ulna corpus level and medullary diameter measurement values ($p>0.05$, Table 3).

DISCUSSION

The mechanical loading caused by physical activity and exercise has been determined to be one of the best stimuli to improve the adaptation of the skeleton structure and bone strength as well as to improve bone mass. Physical activity provides skeletal benefits that can be saved during the entire growth. There is also evidence that the benefits in bone mass and structure, obtained by mechanical loading during growth, may be maintained in older ages. Findings showing that former male athletes have a lower fracture risk than expected support this view (Karlsson and Rosengren, 2012).

In young rats, on which endurance exercises were implemented; the femur bone volume of the running group was found to be significantly higher than the values of the control group (Joo et al., 2003). In the study conducted by Yıldız and Beşoluk (2013) on carpal bones, no differences were observed between weightlifters and sedentaries in terms of volume. In the present study, radius and ulna bone volume in both right and left arms of weightlifters was significantly higher than in sedentaries. The weight-lifting bar influences on the long bones more than short bones.

In Kalayci's (2008) study conducted on judoists, it was reported that there were differences in terms of volume percentages of metacarpal bones II and IV compared to sedentaries, however, there were no differences between the groups in terms of length percentages of the bones. Yıldız and Beşoluk (2014), however, found no difference between weightlifters and sedentaries in terms of both length and length percentages of the metacarpal bones. In the present study also, the radius lengths and length percentages of weightlifters were not so different from those of sedentaries. In light of these data, we can say that the bar weight does not influence bone length in weightlifters. Examining the percentage ratios of the groups' forearm bone volume, the fact that radius bone volume ratio of weightlifters is higher than that of sedentaries is thought to arise from the fact that heavy bar load on the forearm is carried by radius more.

In a study done by Akman et al (2006), humerus bone morphometric measurements were made in adults, and the right upper arm length values were significantly higher than those of the left upper arm length. In Yıldız and Beşoluk's (2014) intragroup comparison of right hand and left hand metacarpal bone lengths, they found differences only in one bone of both weightlifters and sedentaries. In this study, radius and ulna bone lengths of the right arms of both weightlifters and sedentaries were higher than those of the left arms.

In Yıldız and Beşoluk's (2014) intragroup right and left hand comparison; there were differences in the volumes of many metacarpal bones of sedentaries, while there were no differences in weightlifters. In this study; differences were found between right and left arms radius bone volume in sedentaries, while no volume differences were observed in both bones of weightlifters.

In comparisons of right and left forearm volume data, it is seen that there are more numerical value differences especially in the sedentaries than weightlifters. This is thought to arise from the fact that the right arm is used dominantly in everyday life and that the effects of the exercises done with heavy weights reduce this difference. However, comparing the values of weightlifters and sedentaries, the highest differences in values are found in the left arm.

It is known that body bone mineral density varies according to sports disciplines and sedentaries. According to the studies, BMD was found higher in weightlifters (Eren et al., 2003). In a study conducted on arm bones of tennis athletes, BMD was significantly higher in the dominant arm (Haapasalo, 2000). In a study conducted on female athletes dealing with cross, skiing, orienteering, cycling and weightlifting sports; distal radius, distal femur and patella BMD measurement values were found higher in weightlifters (Heinonen et al., 1993). In another study, distal radius BMD measurements from 46 healthy adults were found as 0.49 ± 0.05 kg/cm^2 (Lapauw et al., 2008). In this study, sedentary BMD results were obtained close to the above values (0.50 ± 0.02 kg/cm^2). In accordance with the literature, the distal radius BMD measurements of weightlifters were found to be considerably higher than those of sedentaries.

In a study investigating the effect of exercise on bone, a significant increase was observed in the metatarsus dorsal cortical bone thickness of the rats that exercised 5 days a week for 24 weeks (Wohl et al., 2000). According to another study, it was reported that the width of the upper extremity bones of runners and gymnasts were the same as in the control group, while the cortical cross-sectional area in the lower limbs of young runners and gymnasts was higher by 12 % (Duncan et al., 2002). In this study; the radius and ulna medullary diameter measurements in corpus level were found to be similar in weightlifters and sedentaries, while radial cortical bone thickness of the weightlifters were significantly higher than that of sedentaries.

CONCLUSION

The osteological data taken from the forearms sedentaries and the weightlifters withstanding heavy mechanical loading were found highly consistent with the other osteological study findings in the literature. The presence of high distal radius BMD and radial cortical thickness values in weightlifters can be considered as an indicator of good bone quality. The results obtained in this study generally indicate higher values were gained in the ossa antebrachii volumes of the weightlifters. It was found that the growth did not disperse in bone length or width but in a periosteal direction.

Due to the benefits of weightlifting training on bone health, bone diseases such as osteoporosis or osteopenia, and possible injuries likely to be encountered in daily life are expected to significantly reduce.

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Note:

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