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Full Length Research Paper

Effects of exercises on bone mineral density of proximal femour region among athletes of different branches

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This study was carried out to evaluate and determine the differences in T and Z values of proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region bone mineral density (BMD) among high level male athletes of different branches. The study was completed with the voluntary attendance of a total of 42 uninjured male national athletes in different branches (taekwondo 12, wrestling 8, judo 10 and runners 12) whose ages vary between 18 to 25 and whose athletic carrier is intact with at least 8 to 10 years of regular exercise. BMD measurements of athletes were completed with the dual energy x-ray absorbtiometric (DEXA) technology using Hologic QDR 4500W device on proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region. The recorded BMD and the T and Z values after measurements of the proximal femour region were completed and have been used for calculations of the statistical data. Comparison of the BMD and T and Z values in different athletic branches has indicated that the highest BMD and T and Z values are found in wrestlers, followed by judo, runners and lastly taekwondo. Between the different athletic branches, the statistical comparison of the proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region of BMD and T and Z values was carried out and the differences were detected ($P < 0.05$). Generally, the values of BMD and T, Z among wrestlers are found to be higher than athletes of judo, taekwondo and runners ($P < 0.05$), but these values show statistical similarity with athletes of judo, while showing differences with runners and taekwondo ($P < 0.05$). Athletes of judo, taekwondo and runners are statisticaly similar to each other ($P > 0.05$), and it is seen that the lowest value of BMD has been found in athletes of taekwondo, while the lowest value of T and Z has been found in runners. The reason why the values of BMD, T and Z are recorded higher among wrestlers than other athletes is thought to be the exercises that add more mechanical weight onto the bone as a matter of their athletic branch. These indicators show that there can be differences in the formation of proximal femour bone mineral density between different athletic branches, especially among the high level male athletes whose activity is mainly composed of intense weight loading exercises on the bones.

Key words: Athletes, proximal femour, bone mineral density, exercises.

INTRODUCTION

Bone tissue is a lifelong active metabolic tissue (Compston, 2001). Physical activities or mechanical add-ups onto bones are the important factors that affect the structure and durability of bones (Peterson et al., 1991). In cases of bone fragility, to reduce the risks of fragility of bones, it is important to maintain or strengthen the bone durability as well as reducing the applied weights on bones (Günaydin et al., 2007). In formation of bones, to achieve a high level bone mass and to be unaffected by malformations of bone structure and osteoporosis in later years (Fricke et al., 2005 ; Tamaki et al., 2008), it is imperative to carry out regular exercises throughout adolescence and early adulthood (Valimaki et al., 1994). It is stated that physical activities done throughout childhood and adolescence enhance the bone mass, especially if these exercises are carried out at the beginning of adolescence, they will be more effective (Lima et al., 2001). It is also stated that proper exercises applied throughout adolescence enhance the bone mineral density (BMD), especially the physical activity, which is a crucial indicator of the proximal femour BMD (Nordström et al., 1997).

While there is a common aggreement in literature for the necessity of physical exercises for formation of peak bone structure and its maintanence along lifespan, there are still indefinitenesses about the type, level, duration and frequency of the exercises (Rutherford, 1999). To increase the bone mass of the skeletal regions that are carrying weight, it is reported that the high level exercises have been more effective than the low leveled ones (Heinonen et al., 1996; Nelson et al., 1994). Several studies that have been conducted were about its effects on the bodily composition (Andreoli et al., 2001; Morris et al., 1997); however the data referred to male athletes and girls before pubertas (Ulivieri et al., 2005). The increasing amount of bone throughout the developmental age can be a crucial indicator for risks of bone fragility in later years (Mark et al., 2006). Physical activity of weight load is an adjustable indicator of the increase in peak bone mineral level (Bailey et al., 1999; Heaney et al., 2000).

To attain the enhancing effects of exercises on bone mass, it is necessary to apply exercises that has weight load on bones. Athletics with no weight loading on bones such as swimming and cycling have not had much effect on BMD levels. On the other hand, it is reported that the dynamic exercises (short distance sprint, gymnastics, etc.) have a more major effect on bone mineral density because of more weight load on bones rather than endurance exercises (for example long distance runners) (Gölünük and Ocak, 2007).

In loading exercises that are applied to enhance the bone mass, it is necessary to have a more weight on bones than common weights that occured in daily life. These exercises are triggering an osteogenical response by their tensions on skeleton. It is seen that the osteogenical effect is specific to the region of mechanical stress (Haapasalo et al., 1994; Tommerup et al., 1993), and it is experimented on test animals that exercises which form a mechanical weight on bones are stimulating the osteogenesis and increasing the bone mineral density (BMD) (Akhter et al., 1998; Umemura et al., 2002). Particularly, the weight load exercises indicated that such exercises are reducing the regressions of bones and even increasing the osteogenesis (Dalsky et al., 1988).

Researches done by scientists indicated that body mass and physical activities are positively increasing the bone mass (Tamaki et al., 2008; Gölünük and Ocak, 2007), while athletes with active athletic life have higher bone mass and lower bodily fat levels (Dana et al., 2001; Dook et al., 1997; Calbet et al., 1999; Alfredson et al., 1997; Viola et al., 2004). Also, to attain the peak bone mass, it is reported that the physical activity has a notable effect on proximal femour BMD (Nordstrom et al., 1996).

This study has been carried out to evaluate and determine any differences found in the proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region's BMD, T and Z values between distinct athletic branches with male athletes of similar age that are applied to different loading exercises in wrestling, taekwondo, judo and running.

MATERIALS AND METHODS

This study has been applied on the subject athletes that are studying in Konya Selçuk University Physical Education Highschool with the approval of the ethic commitee on subject athletes.

Qualifications of the subject athletes

A study has been completed with the voluntary attendance of a total of 42 uninjured male national athletes in different branches whose ages vary between 18 to 25 and whose athletic carrier is intact along with at least 8 to 10 years of regular exercise. Athletes have been divided into groups according to the athletic branches. The groups of the study comprised athletes of different branches, which are followed as runners (n = 12), athletes of taekwondo (n = 12), judo (n = 10) and wrestlers (n = 8) in total of 4 distinct athletic branches. As such, measurements are done in challenge seasons of athletes.

In the beginning of this study, the contents of the study were explained to the athletes and those who were voluntary and without any health issues were elected. This study was carried out to evaluate and determine the differences of the proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region BMD and T and Z values of male athletes between distinct athletic branches.

Measurements of height, weight and bone mineral density

Heights (as cm) of the subject athletes were measured by using antropometric set with sensitivity of 1 mm, while athletes were standing firm and bare footed on a flat line, heels adjacent and with tight knees. Weights (as kg) of the subject athletes were measured using electronic bascule with a sensitivity of 100 gr, while athletes were outfitted as light as possible. Measurements of BMD were completed in the Department of Nuclear Medicine, Konya Selcuk University Medicine School of Meram with the technology of dual energy x-ray absorbtiometric (DEXA) using a device called Hologic QDR 4500W on the proximal femour region of the right leg. Each athlete has been accepted into the imaging room one by one. Radiology technician of the imaging room has executed the measurement after the athlete was properly placed on the DEXA table. The athlete has been warned to lie flat and still for 7 to 8 min, until the measuremet was completed. Afterwards, the measurement process procedure was followed by the cautious standing of the athlete and his outfitting. This procedure has been applied to each subject athlete. By doing so, caution was taken to prevent athletes from having metals. The right proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region has been measured and the values of BMD and T and Z are used for the statistical evaluation. The value of T means the case when a comparison with the normal early adult average of BMD is between -1 to -2,5 SD, while the value of Z means the case when a comparison with the referance value of BMD according to age and

Table 1. Summarization of the recorded data according to athletic branches as mean and standard deviation.

Parameter	Wrestler N = 8		Judo N = 10		Taekwondo N = 12		Runner N = 12	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age (year)	22.25	0.707	22.20	1.135	21.25	1.138	21.33	1.154
Height (cm)	177.75	7.324	172.40	7.260	170.83	7.895	176.41	8.016
Weight (kg)	77.12	11.630	72.80	13.381	60.50	12.109	63.66	7.831
Neck BMD (g/cm^2)	1.216	0.172	1.129	0.188	0.010	0.174	0.018	0.092
Neck T value	2.158	1.569	1.601	1.426	0.834	1.544	0.573	0.966
Neck Z value	2.231	1.555	1.684	1.463	0.873	1.535	0.541	1.062
Trochanter BMD (g/cm^2)	1.022	0.155	0.919	0.146	0.844	0.139	0.853	0.094
Trochanter T value	2.046	1.415	1.255	1.198	0.930	1.194	0.735	0.971
Trochaner Z value	2.078	1.410	1.401	1.044	1.050	1.181	0.787	0.985
Intertrochaner BMD (g/cm^2)	1.399	0.220	1.294	0.177	1.182	1.174	1.201	0.120
Intertrochaner T value	1.042	1.465	0.524	0.968	0.012	1.064	-0.109	0.862
Intertrochaner Z value	1.081	1.457	0.591	0.958	0.093	1.047	-0.066	0.867
Ward's Triangle BMD (g/cm^2)	1.369	0.381	1.075	0.151	1.006	0.235	0.930	0.162
Ward's Triangle T value	3.437	2.824	2.147	1.138	1.751	2.056	0.914	1.399
Ward's Triangle Z value	3.537	2.801	2.276	1.185	1.815	2.012	0.997	1.346

Table 2. Comparisons of the BMD, T and Z values of femour regions of athletes of different branches according to athletic branches.

Parameter		Sum of squares	df	Mean square	F	Sig.
Neck BMD	Between Branches	0.278	3	0.093	3.675	0.020
Neck T value	Between Branches	15.279	3	5.093	2.685	0.060
Neck Z value	Between Branches	17.293	3	5.764	2.937	0.045
Trochanter BMD	Between Branches	0.186	3	0.062	3.491	0.025
Trochanter T value	Between Branches	9.162	3	3.054	2.188	0.105
Trochanter Z value	Between Branches	8.765	3	2.922	2.230	0.100
Intertrochaner BMD	Between Branches	0.279	3	0.093	3.158	0.036
Intertrochaner T value	Between Branches	7.912	3	2.637	2.270	0.096
Intertrochaner Z value	Between Branches	7.732	3	2.577	2.251	0.098
Ward's Triangle BMD	Between Branches	0.998	3	0.333	5.957	0.002
Ward's Triangle T value	Between Branches	31.416	3	10.472	2.935	0.046
Ward's Triangle Z value	Between Branches	32.124	3	10.708	3.081	0.039

gender is between -1,1 to -2,4 SD. The reason why this measurement was done using DEXA device is its low radiation rate and considerations about the fact that it is the best criterion in the evaluation of BMD.

Statistical analysis

Determinations have been done with the oneway anova test, using SPSS 12 package program with a significance level of 0.05 in comparisons of the recorded data. In the groups having differences between each other, the Tukey test was used to determine the groups where the difference was present ($P<0.05$).

RESULTS

Here, the results of the whole tables are shown. Table 1 shows the summarization of the recorded data according to athletic branches as mean and standard deviation. When Table 2 was inspected, it was seen that there were statistical significant differences between wrestling, judo, taekwondo and running according to comparisons of the BMD, T and Z values of athletic branches ($P<0.05$).

In Table 3, while the BMD values of the femour neck region of wrestlers were recorded higher than athletes of taekwondo and runners, they showed similarity with athletes of judo, although femour neck region bone mineral density values of athletes of judo, taekwondo and runners are similar to each other ($P<0.05$). However, there was no statistical significant difference between wrestlers and judo and between taekwando, judo and running, but there were differences between the BMD values of wrestlers when compared to taekwondo and running ($P<0.05$). When compared, there was no statistical significant difference between T, Z values of

Table 3. The multiple comparisons of the BMD, T and Z values of the femoral neck regions of athletes of different branches.

Dependent variable	(I) Branches	(J) Branches	Mean difference (I-J)	Std. error	Sig.
Neck BMD g/cm^2	Wrestler	Judo	0.087	0.075	0.661
		Taekwondo	0.206	0.072	0.034*
		Runner	0.198	0.072	0.045*
	Judo	Wrestler	-0.087	0.075	0.661
		Taekwondo	0.120	0.068	0.309
		Runner	0.112	0.068	0.369
	Taekwondo	Güreş	-0.206	0.072	0.034*
		Judo	-0.120	0.068	0.309
		Runner	-0.008	0.065	0.999
	Runner	Wrestler	-0.198	0.072	0.045*
		Judo	-0.112	0.068	0.369
		Taekwondo	0.008	0.065	0.999
Neck T value	Wrestler	Judo	0.558	0.653	0.828
		Taekwondo	1.325	0.629	0.169
		Runner	1.585	0.629	0.072
	Judo	Wrestler	-0.558	0.653	0.828
		Taekwondo	0.767	0.590	0.568
		Runner	1.028	0.590	0.316
	Taekwondo	Wrestler	-1.325	0.629	0.169
		Judo	-0.767	0.590	0.568
		Runner	0.261	0.562	0.966
	Runner	Wrestler	-1.585	0.629	0.072
		Judo	-1.028	0.590	0.316
		Taekwondo	-0.261	0.562	0.966
Neck Z value	Wrestler	Judo	0.547	0.665	0.843
		Taekwondo	1.358	0.639	0.164
		Runner	1.690	0.639	0.055
	Judo	Wrestler	-0.547	0.665	0.843
		Taekwondo	0.811	0.600	0.537
		Runner	1.142	0.600	0.243
	Taekwondo	Wrestler	-1.358	0.639	0.164
		Judo	-0.811	0.600	0.537
		Runner	0.332	0.572	0.938
	Runner	Wrestler	-1.690	0.639	0.055
		Judo	-1.142	0.600	0.243
		Taekwondo	-0.332	0.572	0.938

*The mean difference is significant at the 0.05 level (P< 0.05).

athletic branches (P<0.05).

In Table 4, while the BMD values of femour trochanter region of wrestlers were recorded higher than athletes of taekwondo and runners, they showed similarity with athletes of judo. However, the femour trochanter region bone mineral density values of athletes of judo, taekwondo and runners were similar to each other (P<0.05), and as such, there was no statistical significant difference between wrestlers and judo and between taekwondo, judo and running, but there were differences between the BMD values of wrestlers if compared to taekwondo and running (P<0.05). When compared, there was no statistical significant difference between the T and Z values of athletic branches (P<0.05).

In Table 5, the BMD values of femour intertrochanter region of wrestlers showed statistical similarity with the values of athletes of judo and runners, but found different values for athletes of taekwondo (P<0.05). Consequently, no statistical difference was found for the BMD values of femour intertrochanter region between judo, taekwondo and athletism (P<0.05), and when it was compared, no statistical significant difference for the T and Z values was found between athletic branches (P<0.05).

In Table 6, while the BMD values of femour ward's triangle region of wrestlers were recorded higher than athletes of taekwondo and runners, they showed similarity with athletes of judo, although the femour ward's triangle region bone mineral density values of athletes of judo, taekwondo and runners were similar to each other (P<0.05). As a consequence, no statistical significant difference was found between wrestlers and judo and between taekwondo, judo and running, but there were differences for the BMD values of wrestlers if compared to taekwondo and running (P<0.05). When the values of T and Z were compared, it was seen that the wrestlers showed statistical similarity with judo and taekwondo, while showing differences with runners (P<0.05). As such, there was no statistical difference between taekwondo, judo and running (P>0.05).

DISCUSSION

This study was carried out to evaluate and determine if there are any differences in the proximal femour (femoral neck, trochanter, intertrochanter and ward's triangle) region BMD, T and Z values between distinct athletic branches with male athletes of similar age that are applied to different loading exercises in wrestling, taekwondo, judo and running. When the findings of this study are inspected, it is seen that generally, the bone mineral density (BMD) values of proximal femour neck, trochanter, intertrochanter and ward's triangle regions of wrestlers are recorded higher than athletes of taekwondo and runners, but they show similarity with athletes of judo. The BMD values of proximal femour neck, trochanter and ward's triangle regions of athletes of judo, taekwondo and runners are shown to be statistically similar to each other (P>0.05), and as such, there is no statistical significant difference between wrestlers and athletes of judo and between athletes of taekwondo, athletes of judo and runners, but it is seen that the BMD values of wrestlers are different from that of judo and runners (P<0.05). When the T and Z values of femoral neck and trochanter regions are compared, it is seen that there is no statistical significant difference between athletic branches (P>0.05), whereas when the T and Z values of the ward's triangle region are compared, it is seen that the values of wrestlers show statistical similarity with judo and taekwondo, while showing difference with runners (P<0.05).

However, there is no statistical significant difference between taekwondo, judo and running (P>0.05), in that the BMD values of the intertrochanter region of wrestlers are shown to be statistically similar with the athletes of judo and runners, while showing difference with the athletes of taekwondo (P<0.05). Consequently, there is no difference in the BMD values of intertrochanter region between taekwondo, judo and runners (P>0.05). When the values of T and Z are compared, it is seen that there is no statistical significant difference between athletic branches (P>0.05). Nonetheless the value of T means the case when a comparison with the normal early adult average of BMD is between -1 to -2,5 SD., while the value of Z means the case when a comparison with the reference value of BMD according to age and gender is between -1,1 to -2,4 SD (Bozkurt, 2010).

In this study, it is seen that the highest proximal femour BMD values are measured in wrestlers which is then followed by judo, running and lastly taekwondo. This case is an indication of the probable effect of mechanical loading exercises on localised osteogenesis. It is seen that the lowest proximal femour BMD values are measured in athletes of taekwondo, while the lowest values of T and Z are measured in runners. The reasons why the T and Z values of runners have been measured lower than athletes of taekwondo are thought to be the similarity of the BMD values of these two branches and the differences between height and age of athletes, whereas the reason why the BMD, T and Z values of wrestlers are measured higher than other athletic branches in our study is thought to be the necessity of weight loading on bones as a nature of this athletic branch. Studies carried out by scientists have proved that the bodily weight and physical activity have a positive effect on increasing the bone mass (Lima et al., 2001).

Recently, progressive studies (Tamaki et al., 2008; Yung et al., 2005) indicated that high level of aerobic or physical activities, having weight load on bodily weight, can enhance the BMD levels among pre-adolescence infants. It is observed that athletics with heavy loads on the skeleton and which are known to have high level of athletics present higher bone mineral density levels than athletics without mechanical loading against gravity such as swimming among adolescence and adulthood. Grimston et al. (1993) experimented the effect of add-ups on BMD in their research, while a total of 34 similar subjects have been used in this study. In their study, the BMD values of the subjects' spine and femour were measured by using the Dual Phontom Absorbtiometry device. As a result of their study, it was stated that subjects exercising athletics that require more loading on the bones have higher BMD values than subjects exercising athletics that require low loading on the bones such as swimming. According to this conclusion, it was stated that the loading levels of varying exercises on the bones enhanced the BMD levels of particular skeletal regions. Fiore et al. (1996) reported that the BMD values of the total body, spine and buttocks of canoers were signifcantly higher than cyclists and those in control.

Table 4. The multiple comparisons of the BMD, T and Z values of the femoral trochanter regions of athletes of different branches.

Dependent variable	(I) Branches	(J) Branches	Mean difference (I-J)	Std. error	Sig.
Tochanter BMD g/cm^2	Wrestler	Judo	0.103	0.063	0.375
		Taekwondo	0.178	0.061	0.029*
		Runner	0.169	0.061	0.040*
	Judo	Wrestler	-0.103	0.063	0.375
		Taekwondo	0.075	0.057	0.565
		Runner	0.066	0.057	0.657
	Taekwondo	Wrestler	-0.178	0.061	0.029*
		Judo	-0.075	0.057	0.565
		Runner	-0.008	0.054	0.999
	Runner	Wrestler	-0.169	0.061	0.040*
		Judo	-0.066	0.057	0.657
		Taekwondo	0.008	0.054	0.999
Tochanter T value	Wrestler	Judo	0.791	0.560	0.500
		Taekwondo	1.115	0.539	0.182
		Runner	1.310	0.539	0.088
	Judo	Wrestler	-0.791	0.560	0.500
		Taekwondo	0.324	0.506	0.918
		Runner	0.519	0.506	0.735
	Taekwondo	Wrestler	-1.115	0.539	0.182
		Judo	-0.324	0.506	0.918
		Runner	0.195	0.482	0.977
	Runner	Wrestler	-1.310	0.539	0.088
		Judo	-0.519	0.506	0.735
		Taekwondo	-0.195	0.482	0.977
Tochanter Z value	Wrestler	Judo	0.678	0.543	0.601
		Taekwondo	1.028	0.522	0.218
		Runner	1.291	0.522	0.081
	Judo	Wrestler	-0.678	0.543	0.601
		Taekwondo	0.350	0.490	0.891
		Runner	0.613	0.490	0.599
	Taekwondo	Wrestler	-1.028	0.522	0.218
		Judo	-0.350	0.490	0.891
		Runner	0.263	0.467	0.942
	Runner	Wrestler	-1.291	0.522	0.081
		Judo	-0.613	0.490	0.599
		Taekwondo	-0.263	0.467	0.942

*The mean difference is significant at the 0.05 level ($P<0.05$).

Table 5. The multiple comparisons of the BMD, T and Z values of the femoral intertrochanter regions of athletes of different branches.

Dependent variable	(I) Branches	(J) Branches	Mean difference (I-J)	Std. error	Sig.
Intertrochanter BMD (g/cm^2)	Wrestler	Judo	0.105	0.081	0.575
		Taekwondo	0.217	0.078	0.041*
		Runner	0.197	0.078	0.073
	Judo	Wrestler	-0.105	0.081	0.575
		Taekwondo	0.112	0.073	0.434
		Runner	0.092	0.073	0.594
	Taekwondo	Wrestler	-0.217	0.078	0.041*
		Judo	-0.112	0.073	0.434
		Runner	-0.019	0.070	0.992
	Runner	Wrestler	-0.197	0.078	0.073
		Judo	-0.092	0.073	0.594
		Taekwondo	0.019	0.070	0.992
Intertrochanter T value	Wrestler	Judo	0.518	0.511	0.742
		Taekwondo	1.030	0.492	0.174
		Runner	1.152	0.492	0.107
	Judo	Wrestler	-0.518	0.511	0.742
		Taekwondo	0.511	0.461	0.687
		Runner	0.633	0.461	0.524
	Taekwondo	Wrestler	-1.030	0.492	0.174
		Judo	-0.511	0.461	0.687
		Runner	0.122	0.440	0.992
	Runner	Wrestler	-1.152	0.492	0.107
		Judo	-0.633	0.461	0.524
		Taekwondo	-0.122	0.440	0.992
Intertrochanter Z value	Wrestler	Judo	0.490	0.508	0.769
		Taekwondo	0.988	0.488	0.198
		Runner	1.148	0.488	0.105
	Judo	Wrestler	-0.490	0.508	0.769
		Taekwondo	0.498	0.458	0.700
		Runner	0.658	0.458	0.486
	Taekwondo	Wrestler	-0.988	0.488	0.198
		Judo	-0.498	0.458	0.700
		Runner	0.160	0.437	0.983
	Runner	Wrestler	-1.148	0.488	0.105
		Judo	-0.658	0.458	0.486
		Taekwondo	-0.160	0.437	0.983

* The mean difference is significant at the 0.05 level ($P<0.05$).

Table 6. The multiple comparisons of the BMD, T and Z values of the femoral ward's triangle regions of athletes of different branches.

Dependent variable	(I) Branches	(J) Branches	Mean difference (I-J)	Std. error	Sig.
Ward's Triangle BMD g/cm^2	Wrestler	Judo	0.293	0.112	0.059
		Taekwondo	0.362	0.108	0.009*
		Runner	0.439	0.108	0.001*
	Judo	Wrestler	-0.293	0.112	0.059
		Taekwondo	0.069	0.101	0.903
		Runner	0.145	0.101	0.485
	Taekwondo	Wrestler	-0.362	0.108	0.009*
		Judo	-0.069	0.101	0.903
		Runner	0.076	0.096	0.858
	Runner	Wrestler	-0.439	0.108	0.001*
		Judo	-0.145	0.101	0.485
		Taekwondo	-0.076	0.096	0.858
Ward's Triangle T value	Wrestler	Judo	1.290	0.896	0.483
		Taekwondo	1.686	0.862	0.223
		Runner	2.523	0.862	0.028*
	Judo	Wrestler	-1.290	0.896	0.483
		Taekwondo	0.395	0.809	0.961
		Runner	1.233	0.809	0.433
	Taekwondo	Wrestler	-1.686	0.862	0.223
		Judo	-0.395	0.809	0.961
		Runner	0.837	0.771	0.700
	Runner	Wrestler	-2.523	0.862	0.028*
		Judo	-1.233	0.809	0.433
		Taekwondo	-0.837	0.771	0.700
Ward's Triangle Z value	Wrestler	Judo	1.261	0.884	0.491
		Taekwondo	1.722	0.851	0.197
		Runner	2.540	0.851	0.024*
	Judo	Wrestler	-1.261	0.884	0.491
		Taekwondo	0.460	0.798	0.939
		Runner	1.278	0.798	0.390
	Taekwondo	Wrestler	-1.722	0.851	0.197
		Judo	-0.460	0.798	0.939
		Runner	0.818	0.761	0.706
	Runner	Wrestler	-2.540	0.851	0.024*
		Judo	-1.278	0.798	0.390
		Taekwondo	-0.818	0.761	0.706

* The mean difference is significant at the 0.05 level ($P<0.05$).

Many partial (Heinrich et al., 1990; Heinonen et al., 1995) and progresive (Snow-Harter et al., 1992) studies, done with the attendance of athletes and non-athletes, indicated that a mechanical loading via an endurance application (for example, exercises while carrying a weight) or increase in the physical activities that require weight lifting (for example, sprinting) can greatly increase the bone mass (Taaffe et al., 1997). Lohmann et al. (1995) indicated in their study which was applied on young females that after 18 months of weight lifting exercises, major increases were seen in the BMD values of Lumbar spine and proximal femour regions, whereas Wu et al. (1998) indicated in their study that the measured BMD values of the rhythmic gymnasts' left buttock were found to be higher than the BMD values of their right buttock. This was as a result of the fact that one leg was chosen as the jumping leg by rhythmic gymnasts. However, Duncan et al. (2002) studied the effects of different exercises and loading types on BMD levels. The groups comprised 15 female subjects of cycling, running and swimming, while sedantary subjects were applied into their study. The BMD values of the total body, spine and femour of the subjects were measured with DEXA. As a result of these measurements, it is seen that the BMD values of femour, spine and the total body of runners are found to be higher than the sedantary subjects, while the BMD values of the total body and femour are found to be higher than swimmers. The reason why the BMD values of the specific regions of runners are higher than swimmers and cyclists is the nature of running as an activity that loads weight on the bones.

Another study which adds weightlifting into the high level loading exercises indicated major increases in the bone masses of buttock, spine and the total body (Kohrt et al., 2004). Different athletic branches have loadings on different skeletal regions; for example, weightlifting generally loads on lumbal spine and lower extremities along with wrists, while running loads mainly on lower extremities. It is stated that weightlifting and similar athletics that require weight loadings on the bones have a better osteogenical response, and in line with the male and female athletes of such athletic branches, it presents higher BMD values than equal athletes of other branches (Heinonen et al., 1993). Bennell et al. (1997) carried out a similar study to examine the differences of BMD levels between athletes of impact athletics and athletes of endurance. After 12 weeks of a long exercise period, it is seen in the measurements that the athletes of impact athletics have more enhanced BMD levels than athletes of endurance. Similar to this case, Janowiak et al. (2002) carried out a study to determine the differences of the BMD levels of females engaged in exercising athletics with weight load on the bones and athletics without weight loadings on the bones. In conclusion, it is stated that different physical activities have varying effects on the BMD levels of different skeletal regions, while in another study, Bozkurt (2010) has examined the effects of different athletic branches (wrestling, judo, taekwondo and running) on bone mineral density levels of the lumbar spine region. At the end of the measurements, for each lumbal spine zone, it was found that the highest BMD levels were of wrestlers and this was followed by athletes of judo, taekwondo and runners.

However, these findings are important as they supported our findings in this particular study. The findings of this study are comfirmed by the findings of other authors whose theses are the reasons of the increase in the BMD levels. These are specific to the region and are related to the muscle tensions of the exercises on particular regions, where high tensions are created by gravity and weight loading on the bones. Studies that are presented in the literature are generally related to cases where the athletics which are not affected by gravity (for example, swimming, cycling, etc.) are ineffective to increase the bone mass even if exercised intensively. Among different physical activities, those of weight carrying exercises, dynamic intermittant loading and high endurance athletics (weightlifting, wrestling, etc.) positively affect the osteogenesis and the bone mass. According to the athletics and the type of physical activity, BMD levels can be different between skeletal regions. By carrying out this study, our conclusion was is in line with the studies that were carried out with male and female athletes in literature and it indicated that athletes of branches which require more weight loading on the bones have higher BMD values.

CONCLUSION

As a result of this study, it is seen that the highest BMD values of proximal femour region is found among wrestlers, followed by athletes of judo, runners and taekwondo. This indicates that the physical activity has a significant effect on the bone mineral density of the proximal femour region, and it indicates that there are regional differences in the formation of bone mineral density of proximal femour region according to athletic branches, especially among the high level male athletes of athletic branches which require weight loadings on the bones and an intense physical activity.

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