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Full Length Research Paper

Analysis of bone mass density of lumbar spine zone of athletes

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This study was carried out to evaluate T-Z scores of lumbar spine zone (L1, L2, L3, L4, L1-L4) bone mass density (BMD) of elite active male athletes in different branches and to determine the differences between them. 42 healthy male athletes aged 18 - 25 competing in different branches (Taekwondo 12, wrestling 8, Judo 10, Running 12) volunteered to take part in the study during the competition period. The measurements of the athletes were taken from lumbar spine zone (L1, L2, L3, L4, L1-L4) with Dual energy X-Ray Absortiometry (DEXA) through Hologic 4500W QDR apparatus. The BMD values obtained by the measurements taken from each lumbar spine zone and T and Z scores were used in calculating statistical data. In the comparison with regard to BMD and T, Z scores, it was determined that the highest BMD and Z, T score belonged to the wrestlers and judo, taekwondo competitors, and runners followed them in the same order. Lumbar spine zone BMD values (L1, L2, L3, L4, L1- L4) and T and Z scores between the branches were compared with regard to statistics, and it was determined that there were statistically significant differences between the branches ($p < 0.05$). In general, lumbar spine BMD and T and Z scores of the wrestlers were higher than the athletes in judo, taekwondo competitors, and runners ($p < 0.05$), it was the same in judo and taekwondo competitors, and the lowest in the runners ($p < 0.05$). The reason why lumbar spine zone BMD and T and Z scores of the wrestlers were higher may be due to the fact that the wrestlers have to do exercises putting more mechanical load on the bones, a special activity their branch requires.

Key words: Athletes, different sport branches, bone mass density, exercise.

INTRODUCTION

It is known that the skeleton starts growing and developing in the uterus and keeps on growing for approximately 20 years. The more the bone mass density obtained in this period, the lesser the influence in the decrease of minerals in older period. Therefore, it should not be forgotten that the activities done for bone development until twenty is extremely important to avoid osteoporosis (Jonsson et al., 1992; Eryavuz, 1999; Rittweger, 2006; Karlsson, 2006; Uçan et al., 2007). Strengthening exercises, together with walking and aerobic exercises (Ryan et al., 1998), increase the bone mass density both in the spine and femur (Nelson et al., 1994; Cindaş, 2001).

The mechanical factors affecting the bone reformation are muscle contraction and gravitation. Physical activity decreases loss in bone and increases endurance (Yaraman et al., 2002). In studies carried out on the matured and old, it was determined that the bone mass density (BMD) of more active individuals is higher (Bozkurt and Nizamlıoğlu, 2006). It is known that the starting age for the exercise affects the bone formation positively. A study showed that the level of physical activities done during childhood affects the bone mass density positively (Tüzün, 1998).

During puberty, load carrying exercises increases the bone mass density and decrease the risk of osteoporosis (Barkai et al., 2007). Bone density of males and females increases continuously until the age of 20 - 30, and it reaches the highest point at the age of 25 for females and 30 for males (Gölünük, 2007). It was determined that more than 90% of mature bone mass is acquired during late puberty, and exercises before and during the puberty affect BMD positively more than the ones done after puberty (Mc Kay et al., 2004).

According to the data collected by the scientists, it was determined that physical activities have a positive relationship to BMD in children and adults doing exercises; and, as a result of scientific studies, it was accepted that physical activities play an important role in increasing BMD (Silvaı et al., 2003). In order to obtain the useful effects of exercises on bone mass, the exercises putting load on the bone should be applied.

This study was carried out to evaluate BMD of lumbar spine (L1, L2, L3, L4, L1- L4) zone, T, Z scores of active male athletes competing in different branches in the same age group and to determine the differences between the branches.

MATERIALS AND METHODS

The participants in the study

This study was carried out on the athletes being trained in the Physical Education and Sport College of Selcuk University. Forty two (42) healthy male athletes aged 18 - 25 competing in different branches (Taekwondo 12, wrestling 8, Judo 10, Running 12) volunteered to take part in the study. The measurements were taken during the competition period.

The content of the study were explained to the athletes in the beginning; the volunteer, desirous athletes without any health problem were accepted for the study.

Use of the apparatus and measurement

The height (cm) of the athletes that participated in the study was measured with 1 mm sensitivity by using anthropometric set, in a barefoot position with feet placed on the ground on one level, heels joined, the knees stretched and upright. The weights (kg) were measured through an electronic scale with clothes as thin as possible on the athletes with 100 gr sensitivity. BMD measurements were taken at Nuclear Medicine Department, Medical Faculty, Selcuk University, Konya. BMD measurements were taken by Dual Energy X-Ray Absorbtiometry (DEXA) technique with Hologic QDR 4500W apparatus, and BMD value was expressed as g/cm². Each athlete was taken to the chamber in which the measurements were taken one by one. The radiology technician scanned each athlete placing them on DEXA table in suitable position. The athletes were told to lie motionless for approximately 7 - 8 min until the scanning was completed. Once the scanning had been completed, the athletes got up carefully and dressed. The process was repeated for each athlete. The athletes did not have any metal things on them during the measurements. Lumbar spine zone L1, L2, L3, L4 and total L1 - L4 zones of the athletes were measured, and T-Z scores and BMD were used in statistical evaluation. The measurements were taken especially with DEXA apparatus because it releases the least radiation to the body, and it is most reliable technique for BMD evaluation (Cadarette et al., 2001; Kaya et al., 2009).

Statistical analysis

In comparing the data obtained, the Statistical Package for the Social Sciences (SPSS) 12 package program was used and they were determined by one-way Anova test. For the groups in which some differences were determined, Tukey test was used to determine which groups are different.

RESULTS

BMD values of L1, L2, L3, L4 and L1-L4 zones of the athletes competing in different branches and their T and Z scores were compared. The statistical data obtained as the result of comparing the measurements taken for each zone to T and Z scores are given in Tables 1, 2, 3, 4, 5, 6, 7 and 8.

When Table 1 was examined, no statistical differences were determined between the sport branches ($p > 0.05$). There were statistical differences between the taekwondo competitors and wrestlers with regard to weight, and between the teakwondoists and judoists with regard to age ($p < 0.05$).

When Table 3 was examined, some statistically significant differences were determined between wrestling, judo, teakwondo, and athletizm in comparing BMD, Z and T scores of lumbar spine zone with regard to different branches.

While the wrestlers' bone mass density of lumbar spine zone L1 was higher than judo and taekwondo competitors and athletism (Table 4); the bone mass density of L1 zone of judo competitors and runners were similar. L1 zones BMD of the runners were lower ($p < 0.05$). While there was no statistical significant difference between the wrestlers and judo competitors, between the taekwondo and judo competitors; wrestlers' BMD were lower than taekwondo and judo competitors, and the judo and taekwondo competitors' were lower than the runners ($p < 0.05$). When T and Z scores were compared, there was no statistical significant difference between wrestlers, judo, and taekwondo competitors; however, there were significant differences between the runners.

Although the wrestlers' BMD of L2 lumbar spine zone was higher than judo, taekwondo competitors and runners (Table 5), taekwondo competitors' bone mass densities of L2 zone were similar. Runners' BMD of L2 zones were found lower ($p > 0.05$). While there were no statistical differences between judo and teakwond competitors, the wrestlers' BMD were different from the judo, taekwondo competitors, and runners; and judo and taekwondo competitors' BMD were lower than the runners ($p < 0.05$). Though there was no statistical difference between judo and taekwondo competitors with regard to T and Z scores, there was a significant difference between the wrestlers and runners.

For the fact that the wrestlers' bone mass density of lumbar spine zone L3 was higher than the judo, taekwondo competitors, and runners, the bone mass densities of L3 zone of judo and taekwondo competitors were similar. L3 zones BMD of the runners were lower ($p < 0.05$). As there was no statistical significant difference between the judo and taekwondo competitors, the wrestlers' BMD were lower than judo, taekwondo competitors, and runners; and the judo and taekwondo competitors' BME were lower than the runners ($p < 0.05$). When T and Z scores were compared, there was no statistical significant difference between judo, and taekwondo competitors; however,

Table 1. Multiple comparisons of different branches with regard to height, weight and age.

Dependent variable	(I) Branch	(J) Branch	Mean difference (I-J)	Std. Error	Sig.
Height	Wrestler	Judo	5.775	3.867	0.451
		Taekwondo	7.542	3.721	0.196
		Runner	1.208	3.721	0.988
	Judo	Wrestler	-5.775	3.867	0.451
		Taekwondo	1.767	3.491	0.957
		Runner	-4.567	3.491	0.563
	Taekwondo	Wrestler	-7.542	3.721	0.196
		Judo	-1.767	3.491	0.957
		Runner	-6.333	3.328	0.244
	Runner	Wrestler	-1.208	3.721	0.988
		Judo	4.567	3.491	0.563
		Taekwondo	6.333	3.328	0.244
Weight	Wrestler	Judo	4.625	5.600	0.842
		Taekwondo	16.375	5.388	0.021*
		Runner	13.458	5.388	0.076
	Judo	Wrestler	-4.625	5.600	0.842
		Taekwondo	11.750	5.055	0.110
		Runner	8.833	5.055	0.314
	Taekwondo	Wrestler	-16.375	5.388	0.021*
		Judo	-11.750	5.055	0.110
		Runner	-2.917	4.819	0.930
	Runner	Wrestler	-13.458	5.388	0.076
		Judo	-8.833	5.055	0.314
		Taekwondo	2.917	4.819	0.930
Age	Wrestler	Judo	-0.625	0.649	0.771
		Taekwondo	0.958	0.625	0.428
		Runner	0.792	0.625	0.589
	Judo	Wrestler	0.625	0.649	0.771
		Taekwondo	1.583	0.586	0.048*
		Runner	1.417	0.586	0.091
	Taekwondo	Wrestler	-0.958	0.625	0.428
		Judo	-1.583	0.586	0.048*
		Runner	-0.167	0.559	0.991
	Runner	Wrestler	-0.792	0.625	0.589
		Judo	-1.417	0.586	0.091
		Taekwodo	0.167	0.559	0.991

*Mean difference significant at $p < 0.05$.

there were significant differences between them and wrestler and runners (Table 6).

As the wrestlers' bone mass density of lumbar spine zone L4 was higher than the judo, taekwondo competitors, and runners, the bone mass densities of L4 zone of judo and taekwondo competitors were similar. L4 zones BMD of the runners were lower ($p < 0.05$). While there was no statistically significant difference between the judo and taekwondo competitors and the wrestlers, the wrestlers' BMD were lower than the taekwondo competitors and runners. The judo and taekwondo competitors' BMD were lower than the runners ($p < 0.05$). When T and Z scores were compared, there were no statistically significant difference between taekwondo competitors and wrestlers ($p > 0.05$); however, the wrestlers were lower than taekwondo competitors and runners. Judo and taekwondo competitors were different from the runners ($p < 0.05$) (Table 7).

Despite the fact that the wrestlers' bone mass density of lumbar spine zone L1-L4 was higher than the judo, taekwondo competitors, and runners; the bone mass density of L1-L4 zone of judo and taekwondo competitors were similar. L1-L4 zones BMD of the runners were lower ($p < 0.05$). As there was no statistically significant

Table 2. Comparing the data with regard to the branches and their sum up as 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)	21.88	0.641	22.50	1.900	20.92	1.240	21.08	1.311
Height (cm)	177.38	7.999	171.60	7.648	169.83	8.737	176.17	8.043
Weight (kg)	76.62	12.872	72.00	13.832	60.25	12.469	63.17	7.998
L1 BMD (g/cm^2)	1.197	0.146	1.043	0.124	0.986	0.080	0.875	0.066
L1 T value	1.719	1.322	0.597	1.015	0.441	0.686	-0.983	0.693
L1 Z value	1.719	1.322	0.548	1.027	0.307	0.665	-1.025	0.657
L2 BMD (g/cm^2)	1.310	0.106	1.132	0.108	1.088	0.081	0.950	0.072
L2 T value	1.962	0.962	0.597	0.886	0.509	0.699	-1.050	0.687
L2 Z value	1.962	0.962	0.544	0.893	0.364	0.677	-1.092	0.660
L3 BMD (g/cm^2)	1.312	0.111	1.162	0.115	1.111	0.010	0.951	0.067
L3 T value	1.905	1.009	0.670	0.930	0.371	0.879	-1.250	0.630
L3 Z value	1.905	1.009	0.606	0.988	0.213	0.879	-1.292	0.607
L4 BMD (g/cm^2)	1.303	0.110	1.182	0.143	1.105	0.114	0.670	0.053
L4 T value	1.440	0.997	0.495	1.126	0.005	1.016	-1.442	0.476
L4 Z value	1.440	0.997	0.431	1.203	0.158	0.747	-1.500	0.467
L1-L4 BMD (g/cm^2)	1.284	0.112	1.134	0.116	1.076	0.087	0.938	0.060
L1-L4 T value	1.755	1.018	0.583	0.901	0.305	0.769	-1.200	0.548
L1-L4 Z value	1.755	1.018	0.529	0.938	0.158	0.747	-1.241	0.523

Table 3. Comparing height, weight, age, and BMD of lumbar spine zones and Z and T scores with regard to sport branches.

Parameter	Sum of squares	Df	Mean square	F	Sig.
Height	402.892	3	134.297	2.021	0.127
Weight	1714.208	3	571.403	4.100	0.013
Age	17.268	3	5.756	3.072	0.039
L1 BMD	0.514	3	0.171	15.968	0.000
L1 Z value	37.693	3	12.564	15.230	0.000
L1 T value	36.977	3	12.326	14.653	0.000
L2 BMD	0.632	3	0.211	25.551	0.000
L2 Z value	45.996	3	15.332	24.816	0.000
L2 T value	45.230	3	15.077	23.761	0.000
L3 BMD	0. 654	3	0.218	22.754	0.000
L3 Z value	51.607	3	17.202	22.965	0.000
L3 T value	50.833	3	16. 944	23.172	0.000
L4 BMD	0.582	3	0. 194	16.682	0. 000
L4 Z value	45.371	3	15. 124	17.053	0.000
L4 T value	43.966	3	14.655	17.289	0.000
L1-L4 BMD	0.598	3	0.199	22.740	0.000
L1-L4 Z value	45.286	3	15.095	23.569	0.000
L1-L4 T value	44.451	3	14.817	23.102	0.000

difference between the judo and taekwondo competitors, the wrestlers' BMD were lower than taekwondo competitors and runners. The judo and taekwondo competitors' were lower than the runners' ($p < 0.05$). When T and Z scores were compared, there were no statistically significant difference between judo, and taekwondo competitors; however, there were significant differences between the wrestlers and runners (Table 7).

Table 4. Multiple comparison of BMD and related Z and T scores of lumbar spine zone L1 with regard to different branches.

Dependent variable	(I) branches	(J) branches	Mean difference (I-J)	Std. error	Sig.
L1BMD	Wrestler	Judo	0. 154	0. 065	0. 181
		Taekwondo	0. 211	0. 056	0. 024*
		Runner	0. 321	0. 055	0. 002*
	Judo	Wrestler	-0. 154	0. 064	0. 181
		Taekwondo	0. 057	0. 045	0. 795
		Runner	0. 167	0. 043	0. 012*
	Taekwondo	Wrestler	-0. 211	0. 056	0. 024*
		Judo	-0. 057	0. 045	0. 795
		Runner	0. 110	0. 030	0. 008*
	Runner	Wrestler	-0. 321	0. 055	0. 002*
		Judo	-0. 167	0. 043	0. 012*
		Taekwondo	-0. 110	0. 030	0. 008*
L1 Z value	Wrestler	Judo	1. 170	0. 569	0. 311
		Taekwondo	1. 411	0. 505	0. 115
		Runner	2. 743	0. 504	0. 002*
	Judo	Wrestler	-1. 170	0. 569	0. 311
		Taekwondo	0. 240	0. 377	0. 990
		Runner	1. 573	0. 376	0. 005*
	Taekwondo	Wrestler	-1. 411	0. 505	0. 115
		Judo	-0. 240	0. 377	0. 990
		Runner	1. 332	0. 269	0. 000*
	Runner	Wrestler	-2. 743	0. 504	0. 002*
		Judo	-1. 573	0. 376	0. 005*
		Taekwondo	-1. 332	0. 269	0. 000*
L1 T value	Wrestler	Judo	1. 121	0. 566	0. 351
		Taekwondo	1. 277	0. 507	0. 175
		Runner	2. 702	0. 508	0. 002*
	Judo	Wrestler	-1. 121	0. 566	0. 351
		Taekwondo	0. 156	0. 377	0. 999
		Runner	1. 580	0. 3781	0. 005*
	Taekwondo	Wrestler	-1. 277	0. 507	0. 175
		Judo	-0. 156	0. 377	0. 999
		Runner	1. 424	0. 281	0. 000*
	Runner	Wrestler	-2. 702	0. 508	0. 002*
		Judo	-1. 580	0. 378	0. 005*
		Teakwondo	-1. 424	0. 281	0. 000*

*Mean difference significant at $p < 0.05$.

DISCUSSION

Physical activities are directly proportional to BMD increase (Teegarden et al., 1995; Janz et al., 2007). Both the weight and thickness of the bone increases more by physical activities. The studies show that persons who do exercises from childhood to maturity have, in their 20 - 30, more BMD than the ones who do not do sports. This shows that exercise increases BMD in the long term (Etherington et al., 1996; Kudlac et al., 2004; Torstveit and Sudgot-Borgen, 2005). Unsystematic nutrition affects BMD negatively (Cobb et al., 2003; Nakahara et al., 2006). In addition to exercise, people's genetic structure affects BMD up to 50- 80%. Regular consumption of nourishment containing calcium and protein is effective on BMD both in childhood and in adolescence. In addition, the height and weight index affects BMD positively as well (Bush, 2008).

In Table 1, the height, weight and age mean values of the branches were compared and no significant difference

Table 5. Multiple comparison of BMD and related Z and T scores of lumbar spine zone with regard to different sport branches.

Dependent variable	Branch (I)	Branch (J)	Mean difference (I-J)	Std. error	Sig.
L2 BMD	Wrestler	Judo	0.178	0.043	0.001*
		Takewondo	0.222	0.041	0.000*
		Runner	0.359	0.041	0.000*
	Judo	Wrestler	-0.178	0.043	0.001*
		Taekwondo	0.044	0.039	0.671
		Runner	0.182	0.039	0.000*
	Taekwondo	Wrestler	-0.222	0.041	0.000*
		Judo	-0.044	0.039	0.671
		Runner	0.137	0.037	0.004*
	Runner	Wrestler	-0.359	0.041	0.000*
		Judo	-0.182	0.039	0.000*
		teakwondo	-0.137	0.037	0.004*
L2 Z value	Wrestler	Judo	1.418	0.373	0.003*
		Taekwondo	1.598	0.359	0.000*
		Runner	3.054	0.359	0.000*
	Judo	Wrestler	-1.418	0.373	0.003*
		Taekwondo	0.180	0.336	0.950
		Runner	1.636	0.336	0.000*
	Taekwondo	Wrestler	-1.598	0.359	0.000*
		Judo	-0.180	0.336	0.950
		Runner	1.456	0.321	0.000*
	Runner	Wrestler	-3.054	0.359	0.000*
		Judo	-1.635	0.336	0.000*
		Taekwondo	-1.456	0.321	0.000*
L2 T value	Wrestler	Judo	1.365	0.378	0.005*
		Taekwondo	1.453	0.363	0.002*
		Runner	3.012	0.363	0.000*
	Judo	Wrestler	-1.365	0.378	0.005*
		Taekwondo	0.088	0.341	0.994
		Runner	1.647	0.341	0.000*
	Teakwondo	Güreş	-1.453	0.363	0.002*
		Judo	-0.088	0.341	0.994
		Atletizm	1.559	0.325	0.000*
	Runner	Wrestler	-3.012	0.363	0.000*
		Judo	-1.647	0.341	0.000*
		Taekwondo	-1.559	0.325	0.000*

*Mean difference significant at $p < 0.05$.

was seen with regard to height. Some statistical differences were determined between the taekwondo competitors and wrestlers with regard to weight, and the difference was seen between taekwondo and judo com-petitors with regard to age ($p < 0.05$). Some statistically significant differences between the branches were seen in the evaluation with regard to BMD (g/cm²) of lumbar spine zone and T, Z scores.

In the study, while the wrestlers' BMD of lumbar spine zone between L2, L3,L1-L4 were higher than judo and taekwondo competitors and runners, the bone mass density of L2,L3,L1-L4 zones of judo and taekwondo competitors were similar. The runners' BMD of L2, L3, L1-L4 zones were lower ($P > 0.05$). While no statistically significant difference was seen between judo and taekwondo competitors, the wrestlers' BMD were different from the judo and taekwondo competitors and the runners ($p < 0.05$). When T and Z scores were compared, there were no statistically significant difference between judo, and taekwondo competitors, however, there were significant differences between the wrestlers and runners ($p < 0.05$). While the wrestlers' BMD of lumbar spine

Table 6. Multiple comparison of BMD and related Z and T scores of lumbar spine zone L3 with regard to different branches.

Dependent variable	Branch (I)	Branch (J)	Mean difference (I-J)	Std. error	Sig.
L3 BMD	Wrestler	Judo	0.150	0.046	0.013*
		Taekwondo	0.201	0.045	0.000*
		Runner	0.361	0.045	0.000*
	Judo	Wrestler	-0.150	0.046	0.013*
		Taekwondo	0.050	0.042	0.629
		Runner	0.210	0.042	0.000*
	Taekwondo	Wrestler	-0.201	0.045	0.000*
		Judo	-0.050	0.042	0.629
		Runner	0.160	0.040	0.002*
	Runner	Wrestler	-0.361	0.045	0.000*
		Judo	-0.210	0.042	0.000*
		Taekwondo	-0.160	0.040	0.002*
L3 Z value	Wrestler	Judo	1.299	0.410	0.016*
		Taekwondo	1.692	0.395	0.001*
		Runner	3.197	0.395	0.000*
	Judo	Wrestler	-1.299	0.410	0.016*
		Taekwondo	0.393	0.370	0.716
		Runner	1.898	0.370	0.000*
	Taekwondo	Wrestler	-1.691	0.395	0.001*
		Judo	-0.393	0.370	0.716
		Runner	1.505	0.353	0.001*
	Runner	Wrestler	-3.197	0.395	0.000*
		Judo	-1.898	0.370	0.000*
		Taekwondo	-1.505	0.353	0.001*
L3 T value	Wrestler	Judo	1.235	0.406	0.021*
		Taekwondo	1.534	0.390	0.002*
		Runner	3.155	0.390	0.000*
	Judo	Wrestler	-1.235	0.406	0.021*
		Taekwondo	0.299	0.366	0.846
		Runner	1.920	0.366	0.000*
	Taekwondo	Wrestler	-1.534	0.390	0.002*
		Judo	-0.299	0.366	0.846
		Runner	1.621	0.349	0.000*
	Runner	Wrestler	-3.155	0.390	0.000*
		Judo	-1.920	0.366	0.000*
		Taekwondo	-1.621	0.349	0.000*

*Mean difference significant at $p < 0.05$.

zone L1-L4 was higher than the judo and taekwondo competitors and runners, the bone mass density of L1-L4 zone of judo and taekwondo competitors were similar. Bone mass density BMD of L1-L4 zone of the runners were lower ($P< 0.05$). While no statistically significant difference was found between the wrestlers and judo competitors and between taekwondo and judo competitors, the wrestlers' BMD was lower than the taekwondo competitors and runners, and BMD of taekwondo and judo competitors were different from the runners ($p < 0.05$). When T and Z scores of L1 lumbar spine zone were compared, no statistically significant difference was seen between judo and taekwondo competitors, but a statistically significant difference was seen between them and the runners. When T and Z scores of L4 lumbar spine zone were compared, no statistically significant difference was seen between judo competitors and the wrestlers and taekwondo competitors ($p > 0.05$). It was found that the wrestlers were different from taekwondo competitors; the runners, judo and taekwondo competitors were different from the runners ($p < 0.05$). It was reported that bone density values are considered normal

Table 7. Multiple comparison of BMD and related Z and T scores of lumbar spine zone L4 with regard to different branches.

Dependent variable	Branch (I)	Branch (J)	Mean difference (I-J)	Std. Error	Sig.
L4 BMD	Wrestler	Judo	0.121	0.051	0.101
		Taekwondo	0.199	0.049	0.001*
		Runner	0.334	0.049	0.000*
	Judo	Wrestler	-0.121	0.051	0.101
		Taekwondo	0.078	0.046	0.346
		Runner	0.213	0.046	0.000*
	Taekwondo	Wrestler	-0.199	0.049	0.001*
		Judo	-0.078	0.046	0.346
		Runner	0.135	0.044	0.020*
	Runner	Wrestler	-0.334	0.049	0.000*
		Judo	-0.213	0.046	0.000*
		Taekwondo	-0.135	0.044	0.020*
L4 Z value	Wrestler	Judo	1.009	0.447	0.126
		Taekwondo	1.610	0.430	0.003*
		Runner	2.940	0.430	0.000*
	Judo	Wrestler	-1.009	0.447	0.126
		Taekwondo	0.601	0.403	0.453
		Runner	1.931	0.403	0.000*
	Taekwondo	Wrestler	-1.610	0.430	0.003*
		Judo	-0.601	0.403	0.453
		Runner	1.330	0.384	0.007*
	Runner	Wrestler	-2.940	0.430	0.000*
		Judo	-1.931	0.403	0.000*
		Taekwondo	-1.330	0.384	0.007*
L4 T value	Wrestler	Judo	0.945	0.437	0.152
		Taekwondo	1.435	0.420	0.008*
		Runner	2.882	0.420	0.000*
	Judo	Wrestler	-0.945	0.437	0.152
		Taekwondo	0.490	0.394	0.604
		Runner	1.937	0.394	0.000*
	Taekwondo	Wrestler	-1.435	0.420	0.008*
		Judo	-0.490	0.394	0.604
		Runner	1.446	0.376	0.002*
	Runner	Wrestler	-2.882	0.420	0.000*
		Judo	-1.937	0.394	0.000*
		Taekwondo	-1.447	0.376	0.002*

*Mean difference significant at $p < 0.05$.

when it is between -1 SD and +1 SD. It reflects patogeny such as osteopeny (low bone density) when it is between -1 SD and -2.5 (Koçar et al., 2002).

It is known that there are some studies showing that exercise increases bone density (Jonsson et al., 1992; Menkes et al., 1993). Madsen et al. (1998) found that BMD of femur neck, total body, waist spine of the athletes competing in burden loading sport branches were higher than the sedanters in the same age group. In another study, it was determined that BMD of spine zone of male and female athletes competing in the branches requiring more strength and power were higher than the athletes competing in endurance requiring branches. It has been reported that weightlifters have the highest BMD, and marksmen, runners, footballers, and swimmers can be listed in this order (Sivrikaya, 2000).

In a study carried out to show the effect of physical activities on BMD, BMD of lumbar spinal, femural, arm and front arm of 67 middle and long distance runners between 40 and 65 years old, 16 tennis players, and 585 sedanter female constituting the control group were compared. It was found that tennis players' BMD was

Table 8. Multiple comparison of BMD and related Z and T scores of lumbar spine zone L1-L4 with regard to different branches.

Dependent variable	Branch (I)	Branch (J)	Mean difference (I-J)	Std. error	Sig.
L1-L4 BMD	Wrestler	Judo	0.150	0.044	0.009*
		Taekwondo	0.208	0.043	0.000*
		Runner	0.345	0.043	0.000*
	Judo	Wrestler	-0.150	0.044	0.009*
		Taekwondo	0.057	0.040	0.486
		Runner	0.195	0.040	0.000*
	Taekwondo	Wrestler	-0.208	0.043	0.000*
		Judo	-0.057	0.040	0.486
		Runner	0.138	0.038	0.005*
	Runner	Wrestler	-0.345	0.043	0.000*
		Judo	-0.195	0.040	0.000*
		Taekwondo	-0.138	0.038	0.005*
L1-L4 Z value	Wrestler	Judo	1.226	0.380	0.013*
		Taekwondo	1.597	0.365	0.001*
		Runner	2.997	0.365	0.000*
	Judo	Wrestler	-1.226	0.380	0.013*
		Taekwondo	0.371	0.343	0.703
		Runner	1.771	0.343	0.000*
	Taekwondo	Wrestler	-1.597	0.365	0.001*
		Judo	-0.371	0.343	0.703
		Runner	1.400	0.327	0.001*
	Runner	Wrestler	-2.997	0.365	0.000*
		Judo	-1.771	0.343	0.000*
		Taekwondo	-1.400	0.327	0.001*
L1-L4 T value	Wrestler	Judo	1.1720	0.380	0.019*
		Taekwondo	1.450	0.365	0.002*
		Runner	2.955	0.365	0.000*
	Judo	Wrestler	-1.172	0.380	0.019*
		Taekwondo	0.278	0.343	0.849
		Runner	1.783	0.343	0.000*
	Taekwondo	Wrestler	-1.450	0.365	0.002*
		Judo	-0.278	0.343	0.849
		Runner	1.505	0.327	0.000*
	Runner	Wrestler	-2.955	0.365	0.000*
		Judo	-1.783	0.343	0.000*
		Taekwondo	-1.505	0.327	0.000*

*Mean difference significant at $p < 0.05$.

statistically higher than the runners, and the runners' BMD was higher than the control group (Yabancı, 1999). Heinonen et al. (1993) reported in another study that BMD values of male and female athletes of the same age competing in the branches requiring weight lifting activities were higher than the athletes competing in the branches not requiring them.

Nordström et al. (1995) reported that there is an important connection between the bone weight and endurance of developed muscles; they also remarked that the increase in the muscle weight affects the increase in the bone weight positively. Grimston et al. (1993) found that BMD of the children who engages in sports like running, gymnastics, and dancing were higher than those who do not. Lima et al. (2001) found that BMD of 12 - 18 year old children who engage in sports like basketball and gymnastics were higher than the same age children who do not engage in sports.

Nordström et al. (1998) carried out a study comprising 3 groups in order to investigate the effects of different sport branches on BMD. One group comprised of 17 year old 28 ice-hockey competitors who had 8 or 10 h training sessions a week. Second group comprised of 17 year old 12 badminton competitors who had 5 or 6 h training sessions a week and the third group comprised of control group containing 17 year old 24 badminton competitors who had 1 or 2 h training sessions a week but did not participate in the matches. The study shows that BMD of other sports were higher than the athletes who engaged in badminton. This shows that the physical training sessions requiring jumping are more affective on BMD.

It is concluded in the study that exercises that put more mechanical burden on the bone leading to increase of BMD. As it is seen in the other studies, the measurements are parallel to the results reported in literature and support the thesis in this study.

Conclusion

The study shows that physical exercises affect BMD positively when they are done regularly and properly. Yet the age, biologic conditions, and suitability of the exercises should be taken into consideration when they are being done. Besides, it shows that putting more mechanical burden on the bone before and during the adolescence affects BMD more. Exercises putting more burdens on the athletes' bone from the outside, as a special requirement for the branches they engage in, affect their local and total body BMD.

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