

# EFFECTS OF TAEKWONDO TRAINING ON BONE MINERAL DENSITY OF HIGH SCHOOL GIRLS IN KOREA

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**ABSTRACT:** The incidence of bone fractures has increased in the current decade due to osteoporosis. Bone mineral density (BMD), or the amount of mineralized bone, is an important determinant of risk for bone fractures. Bone mineralization is strongly stimulated by weight-bearing exercise during growth and development. Taekwondo, a Korean martial art, is a well-known form of strenuous and weight-bearing physical activity. Therefore, the primary goal of this study was to determine the effects of taekwondo training on the bone health of female high school students in Korea. The secondary goal of this study was to clarify the relationships between body weight and BMD in this sample. Thirty taekwondo players (TKD) and 30 sedentary high school girls (CON) voluntarily participated in the present study and were split into three groups by weight: light weight (L) under 51 kg; middle weight (M) between 51 and under 57 kg; and heavy weight (H) over 57 kg. BMD was determined from dual-emission X-ray absorptiometry (DEXA), and percent body fat was measured by the skin-fold method. Lumbar spine and femoral BMD were not significantly different between light, middle and heavy body weight groups. However, the average BMD in the TKD group was significantly greater than in the CON group for all lumbar spine regions ( $P < 0.05$ ). The results of this study suggest that taekwondo training during growth significantly improved bone health in all weight groups.

**KEY WORDS:** taekwondo, body weight, bone mineral density

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## INTRODUCTION

The increasing incidence of bone fractures is a major modern medical problem [20,6]. Half of all women and one-third of all men will suffer bone fractures during their lifetimes [20]. Bone fractures lead to increased morbidity, mortality and medical costs at the societal level [14]. The increase in the incidence of bone fractures is attributed in part to the increased prevalence of osteoporosis in aging populations [1]. Attaining maximal peak bone mass during growth, and minimizing bone mineral loss due to aging, are important strategies for the prevention of osteoporosis and bone fractures. The greatest accumulation of bone mass occurs during the first and second decades of life, and bone mass peaks around 20 years of age [18]. Therefore, the first two decades of life may play an important role in realizing the full genetic potential for bone health, especially in women.

In previous studies, skeletal loads including dynamic loads, high magnitude loads, high frequency loads, fast loads and loads with unusually distributed strains have been shown to constitute the most pronounced osteogenic stimuli [17,19]. Taekwondo, a Korean martial art, is a strenuous physical activity. taekwondo may be recommended

as a form of weight-bearing exercise to stimulate the osteogenic process and improve bone health. However, few investigators have evaluated the effects of taekwondo activity on bone health.

A number of studies have reported an association between body size and bone mass in adulthood [4,7]. Cooper et al. [3] found significant correlations between weight at the ages of 1, 5, and 10 years and bone mineral content in the lumbar spine and the femur in adulthood. Blum et al. [2] detected associations between weight and bone mineral density (BMD) of the lumbar spine and femur in women. Although taekwondo competitors are segregated by body weight, the effects of body weight on bone health during taekwondo training have not been empirically determined.

Therefore, the primary goal of this study was to determine the effects of taekwondo training on bone health in Korean female high school students. The secondary goal of this study was to clarify the relationship between body weight and BMD in this sample. The information gained from this study will allow researchers and clinicians to better understand the effects of taekwondo training on female bone health.

**TABLE 1.** SUBJECT CHARACTERISTICS

		Age (yr)	Height (cm)	Body weight (kg)
L (~51kg)	CON (n=10)	17.0 ± 0.2	159.7 ± 1.3	48.5 ± 0.4
	TKD (n=10)	17.2 ± 0.2	158.8 ± 1.4	48.5 ± 0.9
M (51.1~56.9kg)	CON (n=10)	16.9 ± 0.3	160.2 ± 1.8	52.8 ± 0.9
	TKD (n=10)	16.7 ± 0.3	161.0 ± 1.3	54.8 ± 0.9
H (57~kg)	CON (n=10)	17.5 ± 0.2	162.9 ± 1.3	62.6 ± 0.4
	TKD (n=10)	17.0 ± 0.3	166.5 ± 1.6	64.0 ± 1.2

Note: Data are means ± SE. TKD, Taekwondo players; CON, sedentary high school girls. L, Light weight; M, middle weight; H, heavy weight.

## MATERIALS AND METHODS

**Subjects.** The study subjects were female high school students in Daegu, Korea. Thirty girls who had undergone at least five years of taekwondo training (TKD) participated in this study, and 30 sedentary girls served as control subjects (CON). None of the participants had medical problems associated with normal menstrual cycle. Written informed consent was obtained from all subjects. This study was approved by the Ethics Committee of Kyungpook National University. Table 1 presents participant characteristics.

### Bone mass measurements

We conducted health examinations in spring 2005. Lumbar and femoral BMD were measured using dual-energy X-ray absorptiometry (Hologic, Bedford, MA, USA). Measurement precision, expressed as the coefficient of variation (CV), for BMD measurements was 0.89% for the lumbar spine and 1.97% for the femur.

### Statistical analysis

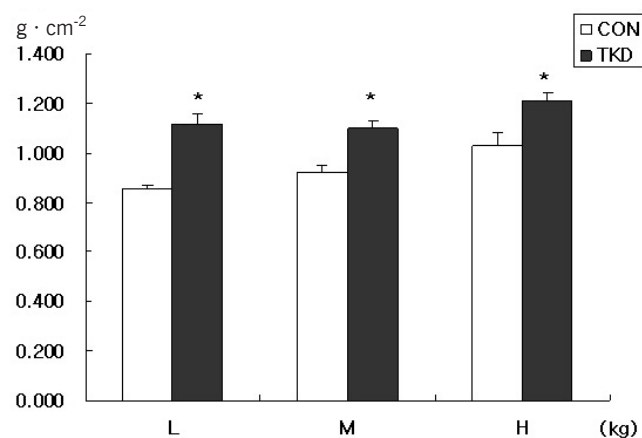
Data are expressed as mean ± SE. Two-way ANOVA was performed, and P values less than 0.05 were considered statistically significant.

## RESULTS

**BMD in the lumbar spine.** Lumbar spine BMD did not significantly differ between light, middle and heavy body weight groups (data not shown). However, the average BMDs in the TKD group were significantly greater than in the CON group for all lumbar spine regions (P<0.05) (Table 2, Figure 1).

### BMD in the femur

Femoral BMD did not significantly differ between light, middle and heavy body weight groups (data not shown). However, the average BMDs in the TKD group were significantly greater than in the CON group for all femoral regions (P<0.05) (Table 3, Figure 2).



**FIG. 1.** BMD IN LUMBAR SPINE. TKD, TAEKWONDO PLAYERS; CON, SEDENTARY HIGH SCHOOL GIRLS. L, LIGHT WEIGHT; M, MIDDLE WEIGHT; H, HEAVY WEIGHT. DATA ARE MEANS ± SE. \*P<0.05 VS CON.

**TABLE 2.** BONE MINERAL DENSITY IN LUMBAR SPINE

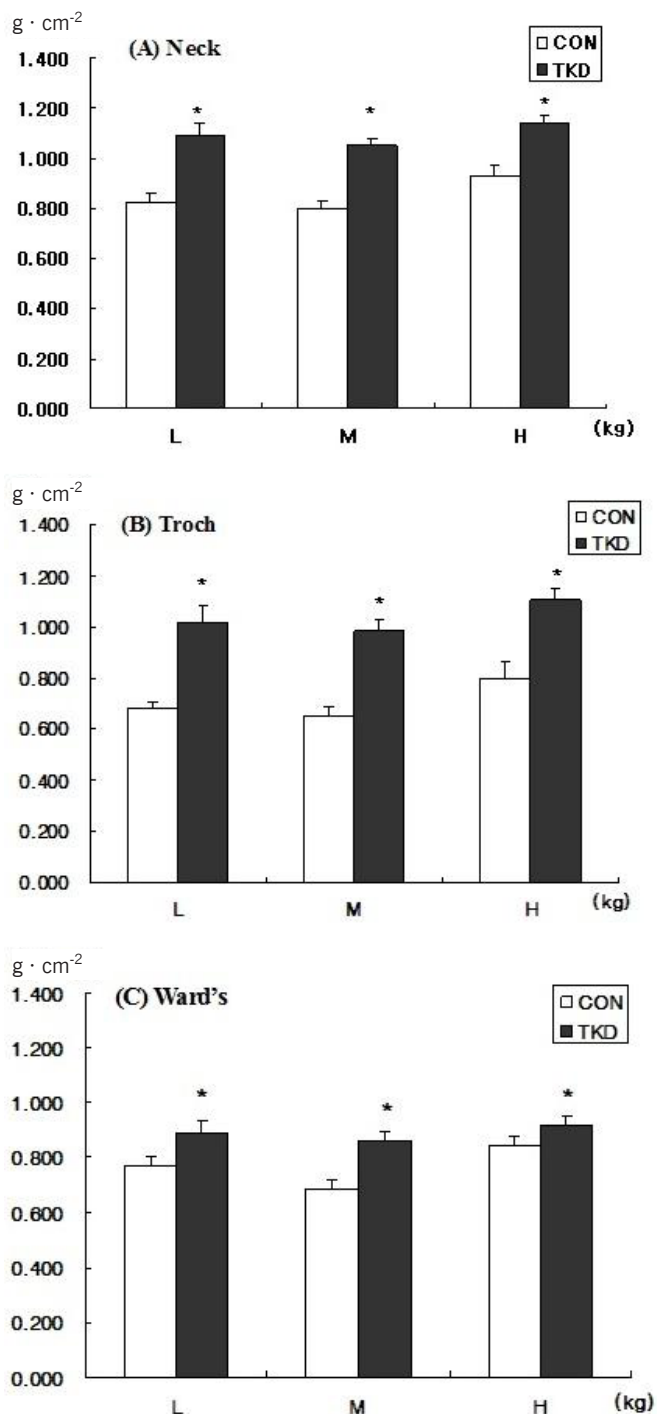
		WL (~51kg)	WM (51.1~56.9kg)	WH (57~kg)
L1	CON	0.788 ± 0.021	0.841 ± 0.029	0.947 ± 0.060
	TKD	1.036 ± 0.030*	1.042 ± 0.030*	1.144 ± 0.034*
L2	CON	0.863 ± 0.021	0.923 ± 0.031	1.017 ± 0.049
	TKD	1.121 ± 0.045*	1.113 ± 0.027*	1.226 ± 0.023*
L3	CON	0.891 ± 0.014	0.945 ± 0.030	1.054 ± 0.055
	TKD	1.159 ± 0.051*	1.131 ± 0.029*	1.251 ± 0.027*
L4	CON	0.877 ± 0.017	0.962 ± 0.025	1.079 ± 0.052
	TKD	1.141 ± 0.049*	1.117 ± 0.027*	1.220 ± 0.038*

Data are means ± SE. See Table 1 for abbreviations and details. L1, Lumbar 1; L2, Lumbar 2; L3, Lumbar 3; L4, Lumbar 4. \*P<0.05 vs CON

**TABLE 3.** BONE MINERAL DENSITY IN TOTAL FEMUR

		L	M	H
		(~51kg)	(51.1~56.9kg)	(57~kg)
FT	CON	0.870 ± 0.030	0.829 ± 0.034	0.957 ± 0.033
	TKD	1.001 ± 0.049*	0.969 ± 0.032	1.058 ± 0.035*

Note: Data are means ± SE. See Table 1 for abbreviations and details.  
FT, total femur. \* P<0.05 vs CON.



**FIG. 2.** BMD IN THE FEMUR. SEE FIGURE 1 FOR ABBREVIATIONS AND DETAILS DATA ARE MEANS ± SE. \*P<0.05 VS CON.

## DISCUSSION

Weight-bearing exercise has been shown to improve bone health in women. Several studies have demonstrated an association between vigorous exercise and BMD at various body sites [12,15,16]. It has been suggested that vigorous physical activity affects the skeleton, bone mineral content (BMC) and BMD in an anabolic manner [8]. However, girls in modern society are subjected to few daily biomechanical strains on their skeletal systems, and this may influence bone formation. In the current study, we determined the effects of taekwondo training on BMD in the lumbar spine and femoral neck region in Korean high-school girls through comparisons with a sedentary control sample.

According to the results of this study, the BMD was around 15% higher in the lumbar spine and 17% higher in the femoral neck of taekwondo participants when compared to sedentary controls. These results agree with the results of previous studies. BMC is 25–35% higher in the dominant arm compared to the non-dominant arm in professional tennis players [11]. Furthermore, life-long tennis players who were 70–84 years of age exhibited 4–7% higher BMC in the dominant forearm compared to the non-dominant forearm [10]. Both male and female gymnasts, soccer players, weight-lifters and ballet dancers are reported to have 10–25% higher BMCs than non-exercising controls [12,13].

Previous exercise studies identified types of exercise that confer maximal anabolic effects on the skeleton. The mechanical load required to stimulate osteogenesis decreases as strain magnitude and frequency increase [5,9]. The osteogenic response to high magnitude loading saturates after a few loading cycles, after which additional loading has limited benefits [12]. Thus, high intensity sports such as squash, tennis, soccer, ice hockey, badminton, volleyball and weight-lifting are most effective when performed periodically, at different times during the week, if the aim is to improve skeletal strength [12]. Based on the results of these studies and the present study, we strongly recommend intermittent taekwondo activity to increase BMD in high-school-age girls.

## CONCLUSIONS

In summary, taekwondo training significantly enhances bone health during the growth period in adolescent females. The effectiveness of taekwondo training did not significantly differ between light, middle and heavy weight groups in our sample. Therefore, taekwondo activity is strongly recommended to improve bone health and prevent osteoporosis in women. Further well-designed investigations of the relationship between taekwondo activity and bone health across age groups are warranted.

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