EFFECTS OF WHOLE BODY RESISTANCE TRAINING ON BONE STATUS AND BODY COMPOSITION IN YOUNG FEMALES

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ABSTRACT

The purpose of this study was to determine the effects of whole body resistance training on bone status and body composition in young female. Twenty five moderately active females volunteered to participate in this study and were randomly assigned to whole body resistance trained (WRT) (n=13; 23.1±2.0 years) and control (C) groups (n=12; 22.5±1.7 years). Height, body weight and body composition measurements were held. Total body fat (%BF), fat mass (FM), fat-free mass (FFM), and bone mineral density (BMD) measurements were performed with dual-energy X-ray absorptiometry. After completing the pre-test measurements, the WRT subjects were participated in 12 week whole body resistance training. At the end of the 12-week training period, paired t-test results showed that there was a significant ($p<.05$) decrease in the WRT group subjects' %BF (-1.07%), FM (-1.05kg) and significant ($p<.05$) increase in FFM (.84kg), and BMD (.005g/cm^2) but there were no significant change in the body weight (-.21kg) or BMI (.09). In the control group, significant increase were observed %BF (.9%), FM (.75kg), and BMI (.32) but there were no significant change in the body weight (.85kg), FFM (.12kg), and BMD (-.002 g/cm^2) after 12 week period. These results showed that 12 week whole body resistance training had a optimize effect on body composition and bone status, but had no effect on body weight and body mass index in young female subjects.
Key words: DXA, resistance exercise, bone mineral density, body fat, fat free mass.

GENÇ BAYANLARDA TÜM VÜCUT DİRENÇ EGZERSİZLERİNİN KEMİK MİNERAL YOĞUNLUĞU VE VÜCUT KOMPOZİSYONUNA OLAN ETKİLERİNİN İNCELENMESİ

ÖZET

Bu çalışmanın amacı, genç bayanlarda tüm vücut direnç antrenmanlarının kemik mineral yoğunluğu ve vücut kompozisyonuna olan etkilerinin incelenmesidir. Çalışmaya orta derecede aktif yirmibeş bayan gönüllü denek olarak katılmıştır. Denekler rasgele tüm vücut direnç egzersizi grubu (n=13; 23.1±2.0 yaş) ve kontrol grubu (n=12; 22.5±1.7 yaş) olarak belirlenmiştir. Boy, vücut ağırlığı ve vücut kompozisyonu ölçümleri yapılmıştır. Vücut yağ yüzdesi, yağ kitlesi, yağsız doku kitlesi ve kemik mineral yoğunluğu ölçümleri dual-energy X-ray absorptiometry cihazı ile yapılmıştır. Antrenman öncesi ölçümleri tamamlandıktan sonra, direnç antrenmanı denekleri 12 hafta süreli tüm vücut direnç antrenmanı programına katılmıştır. 12 haftalık antrenman periyodu sonunda deneklere ait ölçüm değerlerinin ilişkili örneklemler t-testi sonuçlarına göre; antrenman grubunun vücut yağ yüzdesinde (-1.07%), yağ kitlesinde (-1.05kg)'lık anlamlı azalmalar, yağsız vücut kitlesinde (.84kg) ve kemik mineral yoğunluğunda (.005g/cm^2)'lik anlamlı artışlar görülürken, vücut ağırlığında (-.21kg) yada vücut kitle indeksinde (.09) anlamlı ($p>.05$) bir değişim görülmemiştir. Kontrol grubunda ise; vücut yağ yüzdesinde (.9%), yağ kitlesinde (.75kg) ve vücut kitle indeksinde (.32)'lik anlamlı artışlar görülürken; vücut ağırlığında (.85kg), yağsız vücut kitlesinde (.12kg) ve kemik mineral yoğunluğunda (-.002 g/cm^2) anlamlı bir değişim görülmemiştir. Bu sonuçlar genç bayanlarda tüm vücut direnç egzersizlerinin vücut kompozisyonu ve kemik mineral yoğunluğunu olumlu etkilediğini, vücut ağırlığı ve beden kitle indeksi değerlerini ise etkilemediğini göstermiştir.
Anahtar kelimeler: DXA , direnç egzersizi, kemik mineral yoğunluğu, vücut yağ yüzdesi, yağsız vücut kitlesi.

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INTRODUCTION

Peak bone mineral density is determined during early adulthood and later in life may be an important determinant of bone fracture (Javaid and Cooper, 2002). Physical activity in childhood and early adulthood is very important to maximize bone density and to reduce the fall risk and bone fractures in older age (Cooper et al., 2005; Lange et al. 2005; Ryan et al., 2004). Peak bone mineral density achieved in his twenties, given that the period of early adulthood is the last opportunity to increase bone density (ACSM, 2004). Bone mineral density changes during the life of the adult (Kelly et al.1993; Lohman, 1995). Bone mineral density is due to many effects including, genetic, mechanical forces, hormonal changes and feeding mechanisms (Bennell, 2000; Borer, 2005). The mechanical stresses on the bone is created by muscular strength (Eickhoff J.A et al., 1993). Strength training is beneficial to increase bone strength. Muscle strength is positively associated with bone mineral density and bone strength (Ahles et al., 2013; Calatayud et al., 2013; Karlsson et al., 2008; Katch et al., 2011). Physical activities that includes high intensity loading, such as plyometrics, gymnastics, and high-intensity resistance training improve bone mineral status in children and adolescents (ACSM, 2004; Mosti et al., 2013). In addition, there is some evidence showing that physical activity habits in childhood due to the effect of exercise-induced gains in bone tissue, leading to bone health over the long-term benefits of adulthood (ACSM, 2004; Campos et al., 2014).

Body composition has a meaningful influence on physical performance. To solidify, as to consider two individuals having the same fat-free mass, one of whose body fat percentage is higher or fat mass is bound to take on with a higher total body mass and thereto show a decreased performance in physical activities such as jumping and running (Kramer et al., 2012). Body composition is a significant factor, which leads to an increased maximal performance, showing a series of effects in physiological parameters and training-based adaptations (Venkata et al., 2004). Regular physical activity effectively prevents weight gain and adverse changes in body composition (Katch et al., 2011). The basic reason to putting on weight, which does a harm on body composition, could be defined as a positive energy-balance. That is, the energy-intake makes more than the energy output or expenditure in energy (Heyward, 1991; Jakicic and Otto, 2006). Resistance training provides enhanced lean body mass and bone mineral density (Lohman, 1995; Wilmore and Costill, 1994). Besides, resistance trainings could be suggested to have positive changes in body composition in line with the related literature (Broeder et al. 1992; Kwon et al. 2010; Marra, 2005; Ucan, 2013).

Whole body resistance training could make significant changes in body composition through an increased fat-free mass and muscular strength, and bone-mineral density. In this context, the aim of this study is to investigate the effects of whole body resistance training (WRT) on body composition and bone status in young female.

MATERIALS & METHODS

Study Group

Twenty five moderately active female students volunteered to participate in this study and were randomly assigned to whole body resistance trained (n=13; 23.1±2.0 years) and control groups (n=12; 22.5±1.7 years). Physical characteristics of the subjects are presented in table 1.Subjects in the study and control groups are composed of sports management 3rd and 4th grade students. They do not participate any professional sports except lessons in school. All subjects were non-smokers and the last 3 months have not participated any resistance training and diet regimen. Baseline physical characteristics of the subjects are presented in table 1.

Table 1. Baseline physical characteristics of the subjects (Mean ± SD)

Variables	WRT n = 13	C n = 12	P
Age (year)	23.07 ± 2.06	22.50 ± 1.67	.453
Body Weight (kg)	58.84 ± 7.83	54.03 ± 4.98	.084
Body Mass Index (kg/m^2)	21.10 ± 2.45	19.90 ± 1.66	.170
Height (cm)	166.9 ± 7.33	164.7 ± 3.95	.372
%BF	35.10 ± 6.42	34.64 ± 4.87	.841
FM (kg)	20.02 ± 5.44	17.93 ± 3.34	.264
FFM (kg)	38.80 ± 3.97	36.10 ± 3.69	.092
BMD (g/cm^2)	1.157 ± .057	1.117 ± .058	.101

WRT = Whole body resistance group, C = Control group, %BF = percent body fat, FM = fat mass, FFM = fat free mass, BMD = bone mineral density

Anthropometric Measurements

Body Weight and height

All measurements took place under laboratory conditions. Participants were asked not to eat or drink within 2 hours before the appointment and to empty their bladder before the measurements were started. Body weight and height were measured by using a mechanical scale with height rod (Seca 700; Seca GmbH & Co. KG., Hamburg, Germany). Weight graduation was 50 g and measure rod graduation was 1 mm. Subjects were weighed in the morning at 09:00-10:00, with shorts, t-shirt and on bare feet. Body mass index was calculated the ratio of body weight to squared body height as kg/m^2.

Body composition and bone minerale

Measurements were held on the university's physical therapy center. Body composition was assessed by dual-energy X-ray absorptiometry (DXA) by using the GE Lunar DPX Pro (GE Medical Systems Lunar, Europe, Belgium). Before measurment device is calibrated. The total body scan provided values for bone mineral content, non-bone lean tissue, and fat-mass (FM) in the whole body and in the arms, legs, trunk, android, gynoid separately. Fat-free mass (FFM) was defined as the sum of non-bone lean tissue and bone mineral content.

Training program

After the pre-test measurements, training group participated for 12 weeks, and three days per week whole body resistance exercise. All subjects were instructed not to change regular daily activities and dietary habits. A total of 13 subjects were in the WRT group. The whole body resistance training program was formed of all body (upper and lower extremity) muscles. Every training session began with a 5 to 10-min warm-up. During the resistance training sessions, subjects performed three sets for each exercise and 12-14 repetitions per set, with an intensity equivalent to 50-60% of their one repetition maximum. A resistance training session lasted approximately one hour. Control group (n=12) did not do any aerobic or resistance exercise during the 12 week study period. The training protocol and exercises were presented in table 2.

Table 2. Training protocol and exercises for the WRT group

Practice sequence of exercises				
Upper extremity			Lower extremity	
1.barbell curl 2.preacher curl 3.pushdown 4.triceps extension 5.back press 6.lateral raise 7.chest press 8.pec deck fly 9.lat pull down 10.seated row			11.leg press 12.leg extension 13.lying leg curl 14.machine hip extension, 15.machine crunch	
Weeks	Repetitions	Rest between sets	Rest between exercises	Workload (1RM %)
1-3	10-12	45 sec.	90 sec.	50
4-6	10-12	45 sec.	90 sec.	50
7-9	12-14	30-45 sec.	60-90 sec.	60
10-12	12-14	30-45 sec.	60-90 sec.	60

STATISTICS

The mean and standard deviations (mean ± SD) were calculated as descriptive statistics. Data were analysed by using Statistical Packages for the Social Sciences software (SPSS for Windows version 19.0). Differences between pre- and post-test (within group) were analysed using paired t-tests. The difference between the groups was analysed by Independent sample t-test. The homogeneity of variances was assessed by Levene tests. Shapiro-Wilk test was used to assess normality. The level of significance was set at. 05.

RESULT

As can be seen in table 1, there were no significant differences among WRT and C groups in any baseline measurements (age, body weight, height, BMD, %BF, BMI, FM, FFM). At baseline, participants had similar values and study groups were homogeneous. After 12 weeks interventions, the pre- and post-test measurement results of the WRT group are presented in table 3. WRT group showed a significant decrease in %BF (t=-7.682; p<.05), FM (t=-5.111; p<.05) and significant increase in FFM (t=3.560; p<.05), BMD (t=2.574; p<.05) but there were no significant change in the body weight (t=-0.647; p>.05) and BMI (t=-0.759; p>.05).

Table 3. Paired t-test results for whole body resistance training (WRT).

		Mean ± SD	t	df	p
$Weight_{kg}$	Measurement 1.	58.63 ± 7.85	-0.647	12	.530
	Measurement 2.	58.84 ± 7.83			
BMI_{kg/m^2}	Measurement 1.	21.10 ± 2.45	-0.759	12	.463
	Measurement 2.	21.01 ± 2.30			
%BF	Measurement 1.	35.10 ± 6.42	-7.682	12	.000**
	Measurement 2.	33.40 ± 6.25			
FM_{kg}	Measurement 1.	20.02 ± 5.44	-5.111	12	.000**
	Measurement 2.	18.96 ± 5.18			
FFM_{kg}	Measurement 1.	38.80 ± 3.97	3.560	12	.004**
	Measurement 2.	39.65 ± 4.18			
BMD_{gr/cm^2}	Measurement 1.	1.157 ± .0577	2.574	12	.024*
	Measurement 2.	1.162 ± .0536			

* Significant at p<.05, ** Significant at p<.01

The pre- and post-test measurement results of the Control group are presented in table 4. Control group showed a significant increase in BMI (t=2.297; p<.05), %BF (t=2.920; p<.05), FM (t=3.106; p<.05), but there were no significant change in the body weight (t=2.149; p>.05), FFM (t=0.588; p>.05), and BMD (t=-0.928; p>.05).

Table 4. Paired t-Test results for C group.

		Mean ± SD	t	df	p
$Weight_{kg}$	Measurement 1.	54.03 ± 4.98	2.149	11	.055
	Measurement 2.	54.89 ± 4.37			
BMI_{kg/m^2}	Measurement 1.	19.90 ± 1.66	2.297	11	.042*
	Measurement 2.	20.23 ± 1.41			
%BF	Measurement 1.	34.64 ± 4.87	2.920	11	.014*
	Measurement 2.	35.54 ± 4.46			
FM_{kg}	Measurement 1.	17.93 ± 3.34	3.106	11	.010**
	Measurement 2.	18.69 ± 2.98			
FFM_{kg}	Measurement 1.	36.10 ± 3.69	0.588	11	.568
	Measurement 2.	36.22 ± 3.45			
BMD_{gr/cm^2}	Measurement 1.	1.117 ± .058	-0.928	11	.373
	Measurement 2.	1.114 ± .062			

* Significant at p<.05, ** Significant at p<.01

The result of Independent sample t-test after the 12 weeks period between WRT and Control group is presented in table 5. There are significant difference between WRT and Control groups in body weight (t=-2.11; p<.05), BMI (t=-2.19; p<.05), %BF (t=-6.93; p<.05), FM (t=-5.68; p<.05), FFM (t=2.26; p<.05), and BMD (t=2.19; p<.05).

Table 5. Independent sample t-Test results between groups.

Variables	Groups	N	Mean ± SD	t	P
$Weight_{kg}$	WRT	13	-.22 ± 1.21	-2.11	.046*
	C	12	.86 ± 1.36		
BMI_{kg/m^2}	WRT	13	-.10 ± .45	-2.19	.038*
	C	12	.31 ± .50		
%BF	WRT	13	-1.70 ± .79	-6.93	.000**
	C	12	.90 ± 1.06		
FM_{kg}	WRT	13	-1.07 ± .79	-5.68	.000**
	C	12	.74 ± .86		
FFM_{kg}	WRT	13	.85 ± .84	2.26	.033*
	C	12	.13 ± .73		
BMD_{gr/cm^2}	WRT	13	.013 ± .006	2.19	.039*
	C	12	-.002 ± .042		

* Significant at p<.05, ** Significant at p<.01

DISCUSSION

Physical activity is beneficial to skeleton. Therefore, exercise has been promoted as a means of preserving skeletal health and preventing age-related fractures. Physical activity is associated with improved muscle strength, coordinating, and balances (Maddalozzo and Snow, 2000). There is evidence that resistance training both increases bone mass and lean body mass (Chilibeck et al. 2002; Hawkins et al., 2002; Ilona et al., 2010). The results of the present study show that 12 weeks whole body resistance training improved bone mineral density and body composition parameters in young females. In the WRT group, significant differences were seen on %BF, FM, FFM and BMD at the end of the 12-week training period. WRT group showed a significant decrease in %BF (-1.07%), FM (-1.05kg) and significant increase in FFM (.84kg), and BMD (.005g/cm2) but there were no significant change in the body weight (-.21kg) or BMI (.09). In the control group, significant increase were observed %BF (.9%), FM (.75kg), and BMI (.32) but there were no significant (p>.05) change in the body weight (.85kg), FFM (.12kg), and BMD (-.002 g/cm2) after 12 week period. These results agree with the results of previous studies. Almstedt et al. (2011) conducted a study on recreationally active men (n = 12) and women (n = 12), ages of 18–23 to reveal the effects of a 24 weeks resistance training on bone mineral density. At the end of 24 weeks training period results indicate that resistance training is effective in increasing BMD in young healthy men. Similar benefits were not derived by women who followed the same protocol. In another study conducted by Ryan et al. (2004) younger men (n=12) and women (n=7) aged 20-29 years and older men (n=10) and women (n=10) aged 65-74 years were exposed to a 6 months of progressive whole-body RT program. The result of the study proved that 6 month RT program increases muscle mass and improves BMD of the femoral region in young and healthy older men and women.

Hawkins et al. (2002) examined the relationships between high-intensity resistance exercise and bone mass in postmenopausal women and serum reproductive hormone levels and bone-mass changes in response to resistance exercise. Thirty women 45-65 years old were assigned to an exercise or a control group. They trained 3 times weekly for 18 weeks at 90, 70, and 80% of their 1-RM. Results suggest that high-intensity resistance exercise can increase BMD of the hip and that serum estrogen concentrations might influence bone and muscle adaptations to resistance exercise in postmenopausal women. Karakiriou et al. (2012) investigated the effects of a specific vibration program with those of combined aerobic and resistance exercise training on bone mineral density (BMD), body composition, and muscular strength in post-menopausal women, over a period of 6 months. Thirty-two healthy, inactive post-menopausal women aged 46-62 years were divided into exercise (n=10), vibration (n=13), and control (n=9) groups. Findings indicate that conventional training contributed to the increase in BMD of L1-L4, while the vibration program helped to maintain BMD in post-menopausal women. Both training program were efficient in improving muscle strength. Campos et al. (2014) examined to evaluate the role of 2 types of exercise training (aerobic and aerobic plus resistance exercise) on adipokines parameters and bone metabolism in adolescents who are obese. Results suggest that both training types promoted reductions in body mass index, subcutaneous fat, insulin concentration, and homeostasis model assessment insulin resistance (HOMA-IR) index, but only aerobic plus resistance training showed statistical improvements in the bone mineral content, adiponectin concentration, and lean tissue. In the literature some other studies had adverse effects. In one of them Chilibeck et al. (2002) was to examine the effect of strength training combined with editronate therapy on bone mineral, lean tissue, and fat mass in postmenopausal women. Forty-eight postmenopausal women participated the study and performed strength training 3 d/week for 12 months. After training period they concluded that editronate significantly increases lumbar spine BMD and whole-body BMC and strength training had no additional effect. In another study Bennell et al. (2000) conducted on young and mature rats to reveal the effects of 10 weeks resistance training on bone parameters. At the end of training period results indicate that no significant differences were observed for any of the bone parameters when comparing exercise and control groups at either age. Vainionpaa et al. (2009) was to examine the effect of impact exercise on bone metabolism. Participants performed 12 month supervised high impact exercises three times per week. Results revealed that, regular impact exercise does not cause persistent alterations in bone turnover markers. The reason for the different findings of these studies may be the different training applications and characteristics of subject.

CONCLUSION

The findings of the present study showed that 12 week WRT program increased FFM and BMD, decreased %BF and FM, no significant changes on body weight and body mass index were found on the WRT group over 12 week in young female subjects. Control group's BMI, % BF, FM values are increased 12 week period. Consequently, moderate intensity whole body resistance training improves body composition and bone minerals. For this, especially young women encouraged to participating regular resistance training for to provide health-related benefits.

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