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Body Composition Influenced by Progressive Elastic Band Resistance Exercise of Sarcopenic Obesity Elderly Women: A Pilot Randomized Controlled Trial

Short running title: Elastic band exercise for Sarcopenic Obesity

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Abstract

BACKGROUND: Sarcopenia involves age-related decreases in muscle strength and muscle mass, leading to frailty and disability in elderly people. When combined with obesity, it is defined as sarcopenic obesity (SO), which can result in more functional limitations and metabolic disorders than either disorder alone.

AIM: The aim of this study was to investigate body composition changes after elastic band resistance training in elderly women with sarcopenic obesity (SO).

DESIGN: Randomized single-blinded (assessor blinded) controlled pilot trial.

SETTING: Academic medical center.

POPULATION: 35 elderly (>60 years old) women with SO.

METHODS: This pilot randomized controlled trial focused on elderly women with SO. The study group underwent progressive elastic band resistance training for 12 weeks (3 times per week). The control group received only a 40-minute lesson about the exercise concept. Dual-energy X-ray absorptiometry was performed before and after intervention to evaluate body composition. Mann–Whitney U and Wilcoxon signed rank tests were used to analyze the differences within and between these groups.

RESULTS: In total, 35 elderly women with SO were enrolled and divided into study ($n = 18$) and control groups ($n = 17$). No difference was observed in age, biochemical parameters, or body mass index between both groups. After the intervention, the fat proportion of body composition in the right upper extremity ($P = 0.03$), left upper extremity ($P = 0.04$), total fat ($P = 0.035$), and fat percentage ($P = 0.012$) had decreased, and bone mineral density (BMD) ($P = 0.026$), T-score ($P = 0.028$), and Z-score ($P = 0.021$) had increased in the study group. Besides, statistical difference was observed in outcome measurements of right upper extremity ($P = 0.013$), total fat ($P = 0.023$), and fat percentage ($P = 0.012$) between the groups.

CONCLUSIONS: Our study demonstrated that progressive elastic band resistance exercise can reduce fat mass and increase BMD in elderly women with SO, and that this exercise program is feasible for this demographic. Additional studies with larger sample sizes and longer intervention periods should be conducted.

CLINICAL REHABILITAION IMPACT: 12 weeks of progressive elastic band resistance exercise program is safe and effective for SO elder women.

Key Words: Sarcopenia, obesity, women, dual-energy X-ray absorptiometry, elastic band resistance exercise

Introduction

Progressive decline in skeletal muscle mass and strength occurs with age.(1) The age-related loss of muscle mass and strength is termed sarcopenia, which has adverse effects on the performance of daily tasks and thus leads to reduced quality of life.(2) The prevalence of sarcopenia increases with age, and there was approximately 20 billion US dollars of annual healthcare costs for sarcopenia in the United States.(3, 4) Sarcopenia is related to frailty, increases the risk of falls, and leads to disability.(5) Frailty and sarcopenia often overlap among the elderly. Frailty is a geriatric syndrome caused by multiple physiological function declination with aging and lead elderly people had risk of falls, institutionalization and mortality.(6, 7) In addition to physiological aspect, which often influenced by sarcopenia, frailty also had the concept of psychological and social dimensions such as cognitive function factors.(6) In addition to muscle mass loss, body fat mass increases because of aging-associated body composition changes, which can result in obesity and increased risk of metabolic and cardiovascular disorders.(8) Muscle mass decline accompanied by increased adiposity is termed sarcopenic obesity (SO).(9) Sarcopenia and obesity have common inflammatory pathways, and the synergistic adverse influence of both disorders can accelerate functional decline.(8) SO lead to metabolic syndrome, physical disability, and mortality in elderly people.(10) To safeguard public health, the effective prevention and intervention of SO is crucial.

A previous study demonstrated that dietary and exercise interventions could prevent and treat sarcopenia in adults.(11) Regarding exercise intervention, resistance training is an effective method for improving the physical function of elderly people. Furthermore, resistance training can increase muscle strength and size.(12) Moreover, recent studies have found that circuit training, which is a strength-training method involving the repetition of exercises with a short rest period and resistance training, can increase muscle mass and reduce body fat.(13, 14) For the effective prevention of adverse effects caused by SO, resistance training can be a valuable intervention route to increasing muscle mass and reducing body fat in elderly people.(15)

Elastic band resistance exercise has been used for the functional training of elderly people with disabilities, and can improve the physical performance of this population. Resistance strength is based on variations in the stretching tension when performing elastic band resistance training. It has the characteristics of a dynamic exercise form with different stretching ranges and speeds. Different to traditional resistance exercise, elastic band resistance exercise can provide smooth progression of resistance strength.(16) It was mentioned as a safe and effective method to improve the muscular performance among elderly people.(17) Fahlman et al also mentioned that elastic band exercise had advantages of high acceptance among the elderly adults with characters of simplicity, portability, less space requirements and relatively low costs.(18) Although elastic band resistance training is easy to perform at home or institution and safe for elderly individuals, few studies have investigated the effect of elastic band resistance training in elderly patients with SO. However, the influence of body composition changes after elastic band resistance training among sarcopenic obesity elderly women was still not well investigated. Therefore, we conducted this randomized controlled trial to investigate body composition changes after elastic band resistance training in elderly women with SO.

Methods

Subjects

Participants were recruited from the local community around a university hospital in Taipei by placing posters and flyers at the hospital. The inclusion criteria included postmenopausal women aged more than 60 and less than 90 years, those who could independently perform daily activities in the community, and those who met the definition of both obesity and sarcopenia. In this study, sarcopenia was defined by the method provided by Janssen et al.(19) We measured total skeletal muscle mass (TSM) by an eight-polar bioelectrical impedance analysis device with using multifrequency current (Inbody™ 220, Biospace, Seoul, Republic of Korea), which was identified to be a valid TSM estimator.(20) TSM was estimated using an equation by Janssen: TSM = $[(Ht^2/\text{ BIA-R}) \times .401 + (\text{sex} \times 3.825) + (\text{age} \times -.071) + 5.102]$, where Ht is height, evaluated in centimetres; BIA-R is BIA resistance, evaluated in ohms; sex is equal to 1 for men and 0 for women; and age is in (years).(21) The TSM was converted as to skeletal muscle mass index (SMI) by dividing it as derived from the total body mass. When SMI was less than 27.6%, we defined the elderly women participant as sarcopenia.(19) With regarding to percentage of body fat (BF%), we also measured it by using bioelectrical impedance analysis and participants with a BF% more than 30% were defined as obesity of this study.(22) The exclusion criteria included neurological impairments such as hemiplegia, weakness or cognitive deficits caused by stroke or traumatic brain injury; severe musculoskeletal disorders or a history of receiving arthroplasty or artificial implants; diabetes mellitus, which could lead muscle mass loss; and unstable chronic diseases such as congestive heart failure, because of which patients cannot undergo resistance training intervention. The study protocol was explained to the participants, all of whom subsequently provided written informed consent. The protocol was approved by the Institutional Review Board of Taipei Medical University. And this clinical trial was registered and the number was ChiCTR-IPR-15006069

Study Design

This pilot study was designed as a prospective randomized controlled trial to determine the effect of elastic band resistance training on body composition. An independent administrative assistant who did not participate in the intervention was permitted to disclose envelopes according to the number sequence, and the patients were grouped according to the enclosed allocation plan. For assessment aspect, the assessors (a radiologist and a nurse) was blinded to which group was participated when measurement of body composition and performed blood withdrawal procedure.

The participants in the study group completed a 12-week elastic band resistance training program. Those in the control group attended only a 40-minute lesson about SO and the home exercise concept. (Figure 1)

Intervention

As part of the 12-week progressive elastic band resistance training program, the study group participants performed individual resistance exercises by using elastic bands

(Thera-Band®, The Hygenic Corporation, Akron, OH, USA). The different resistance levels of these elastic bands are represented by different colors (yellow, red, green, blue, black, or silver), with 20% increase in resistance intensity. The elastic band resistance training program was designed to train all major muscle groups, and the amount and intensity were progressively increased. Resistance training was performed in small groups comprising fewer than 6 participants in a group physical therapy classroom and according to the guidelines of the American College of Sports Medicine for older adults.(23) To ensure the compliance and safety of this resistance training program, the small groups were supervised and guided by a trained physical therapist. The program was performed at a frequency of 3 times per week over 12 weeks for a total of 36 sessions. Each session lasted 55 minutes and consisted of 10 minutes of general warm-up followed by 40 minutes of elastic band resistance exercise and finally 5 minutes of cooling down. For the elastic-band resistance exercise, we designed 1 or 2 types of exercises for training each muscle group, namely the shoulders, arms, lower limbs, chest, and abdomen. For each type of exercise, 3 sets of 10 repetitions of gentle concentric and eccentric contractions through the full range of motion were performed slowly by using a yellow elastic band. The timing of resistance progression depended on the Borg scale of participants. The Borg scale is used for rating perceived exertion (RPE) during exercise and can describe the subjective physical exercise intensity. In this study, this scale was used to estimate the exercise intensity and individualize the intervention protocol for participants.(24) When the perceived effort of participants was rated as 13 points (somewhat hard) on the RPE scale, the resistance exercise intensity was progressively increased using the next elastic band color. However, if participants could not tolerate the progressive intensity of the next stage, the previous resistance intensity of the elastic band was maintained for an additional session until the participants could achieve a 20% increase in the resistance intensity of the next elastic band color.

Control Group

The participants in the control group received only a health education booklet about SO and home exercise. They visited the laboratory for data collection at the respective time points and maintained records of their daily routine regarding nutrition and physical activity.

Measurement

The ages of the participants were recorded. At baseline and follow-up after the 12-week intervention, height was measured to the nearest 0.1 cm by using a Leicester stadiometer (Invicta, Leicester, UK) and weight was measured to the nearest 0.1 kg by using electronic scales (Heine, Dover, USA). BMI (kg/m^2) was calculated. To determine the soft tissue composition, all participants received a whole-body scan by using dual-energy X-ray absorptiometry (Hologic Delphi densitometer, Hologic, Waltham, USA). Total body fat, total body fat percentage, trunk fat, and appendicular lean mass were calculated. A spine phantom was used before testing to maintain the same densitometer throughout the study and for quality control. Regarding the accuracy of this method for determining body composition, a previous study reported that the coefficients of variation for total body lean mass and fat mass measured using the Hologic Delphi densitometer were 0.5% and 1.5%, respectively.(25) Another study reported that the longitudinal coefficient of variation for bone mineral density measured using a spine phantom was 0.39%.(26) We also evaluated laboratory data including the lipid profile, liver enzyme activity, renal function, creatine phosphokinase (CPK), and high-sensitivity C-reactive protein (hs-CRP) for both the study and control groups.

Statistical Analyses

For analyzing the effect of intervention in the group, the Mann–Whitney U test was used to compare continuous variables at baseline and separately after the study and control group interventions. We used the Wilcoxon signed rank test to analyze the difference between the 2 groups. All data analyses were performed using the SPSS 20.0 IBM statistical software, and $P < 0.05$ was considered statistically significant.

Results

In total, 35 participants met the inclusion and exclusion criteria and were enrolled in this pilot study (18 were randomized to study group and 17 were enrolled to control group). Comparison of baseline data including demographic characteristics, lipid profile, liver enzyme activity, renal function, CPK, and hs-CRP between the elastic band resistance training and control groups revealed no statistical difference. Regarding the body fat percentage by inbody evaluation, the training group had decreased the body fat percentage after intervention ($P = 0.02$) and it was also statistical significant ($P = 0.011$) with comparing the control group (Table 1). The body composition of fat in the right upper extremity ($P = 0.03$), left upper extremity ($P = 0.04$), total fat ($P = 0.035$), and fat percentage ($P = 0.008$) had decreased after the 12-week elastic band resistance training program. In addition, the BMD ($P = 0.026$), T-score ($P = 0.028$), and Z-score ($P = 0.021$) in the group had significantly increased. Regarding outcome measurements, the training program group, compared to the control group, exhibited statistical differences in right upper extremity fat ($P = 0.013$), total fat ($P = 0.023$), and fat percentage ($P = 0.012$) (Table 2).

Discussion

In our study, although lean muscle mass did not significantly increase, the fat amount in the right upper extremity, left upper extremity, total fat and fat percentage had decreased after the 12-week elastic band resistance training program in elderly women with SO. Moreover, BMC, T-score, and Z-score had increased after intervention in the study group. The decrease in body fat proportion, trunk fat, BMD, T-score, and Z-score of the study group compared with the control group at follow-up after 12 weeks was nearly significant at the 0.05 level. However, not all of the outcome measurement parameters (except total fat and fat percentage) achieved statistical significance and could be considered as having improved. Although the study group exhibited only the total fat and fat percentage had statistical improvement in body composition compared with the control group, we found a tendency for fat to have decreased and BMD to have increased after the intervention.

Patients with SO exhibit 2 risk factors for body composition characteristics: loss of muscle mass and increased fat; the combination of these risk factors can result in more functional limitations and metabolic disorders than either factor alone.(27) The pathogenesis of SO should be discussed to clarify the effect of elastic band resistance training intervention in postmenopausal elderly women with SO. A previous study revealed that multiple interactions exist between muscle and fat tissue, indicating that their interrelationship can explain SO development.(8) Muscle mass and strength decrease with age.(1) Decreased muscle mass can lead to substitution by fat infiltration. Moreover, decreased muscle mass and physical activity can increase abdominal fat, insulin resistance and inflammation. When adipose tissue increases, the secretion of leptin, cytokine, and other adipokines can lead to the inflammatory process responsible for sarcopenia and SO development.(28) We propose that resistance exercise intervention for fat mass reduction and muscle mass increase can reverse the process of SO development.

Previous studies have suggested that slow-velocity resistance exercise is feasible, safe, and effective for increasing muscle strength and muscle mass in elderly people.(29) Regarding the mechanism of muscle mass increase, previous studies have reported that resistance exercise can increase muscle protein synthesis and satellite cell activation, reduce catabolic cytokines, and increase anabolic hormone production in elderly people.(30, 31) Moreover, resistance exercise can increase the type I and type II muscle fiber cross-sectional area and lean muscle mass, thereby increasing muscle strength.(32, 33) However, our study revealed no increase in lean muscle mass after elastic band resistance exercise in elderly women with SO. This could be attributed in part to the inadequate resistance exercise period and absence of additional nutritional supplement or diet control. Candow et al investigated the effect of whole-body resistance training for 22 weeks at a frequency of 3 times per week on the health of elderly men and found that the amount of resistance exercise intervention can overcome age-related deficits in whole-body lean muscle mass, regional muscle size, and strength.(34) In our study, elastic band resistance exercise was conducted for only 12 weeks, and we focused on elderly women with SO. If exercise is conducted for a longer period, the muscle mass increase may achieve adequate statistical significance. Moreover, dietary factors were not considered in this study. Adequate protein intake is required to maintain muscle mass, and essential amino acids have a crucial role in promoting positive muscle protein balance in elderly individuals.(35) The influence of nutritional supplements on elderly women with SO could be a confounding factor for lean muscle mass increase in this pilot study with an extremely small sample size.

Our study found that elastic band resistance training reduced fat mass among participants with SO. Previous study has indicated that obesity is associated with increased intramyocellular lipid accumulation in skeletal muscle.(36) Resistance exercise can increase mitochondrial enzyme activity and intramyocellular lipid oxidation.(37) This finding could be the possible mechanism for reducing fat mass in participants with SO. Our study also revealed that BMD increased after elastic band resistance intervention. The potential mechanism for bone remodeling after resistance exercise could be mechanotransduction, mechanical loading-induced nitric oxide production, and prostaglandin release.(38-40)

This study is the first to investigate the effect of elastic band resistance exercise on the body composition of elderly women with SO. Nevertheless, our study has some limitations, which should be addressed. First, the sample size was extremely small, and the intervention period (12 weeks) was insufficient. Our study found changes in fat mass and BMD in the study group but no statistical improvement compared with the control group. Moreover, muscle mass had not increased after the intervention, which is contradictory to the finding of the aforementioned studies that muscle mass had increased after resistance exercise. More participants and a prolonged intervention period could lead to more reliable results. Second, diet was not considered in this study. Although the participants did not change their nutritional supplement habits during the intervention period, these habits could have influenced the body composition outcomes during the 12-week study period. Finally, daily exercise habits were not recorded. The effect of the intensity and frequency of daily exercise should also be considered. To minimize the confounding effect caused by different exercise habits during the intervention period, we requested all participants to maintain their pre-enrollment exercise habits until completion of the 12-week exercise program.

Conclusion

In conclusion, this pilot study demonstrated that a 12-week elastic band resistance exercise can reduce fat mass and increase BMD in elderly women with SO. The progressive elastic band resistance exercise program is safe, feasible, and convenient for elderly people. Our study identified the benefits of elastic band exercise for SO, and additional studies with larger sample sizes and longer intervention periods should be conducted.

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Conflicts of Interest: None

Financial disclosure:

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Author Contributions: Conceived and designed the experiments: HSW LTH LLF. Performed the experiments: HSW LLF LCD CLC. Analyzed the data: HSW KJW. Contributed reagents/materials/analysis tools: HSW LTH LLF LCD. Wrote the paper: HSW.

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Table 1. Baseline demographic and laboratory data of elderly women with sarcopenic obesity who received elastic band resistance exercise or control before and after intervention

Variables	ERT group (n = 18) T1	ERT group (n = 18) T2	P value[a]	Control group (n = 17) T1	Control group (n = 17) T2	P value[a]	P value[b] T1	P value[b] T2
Age (y)	68.89(4.91)			69.53 (5.09)			0.707	
BW (kg)	62.13(8.11)	61.88(9.18)	0.555	66.45(8.30)	66.35(7.97)	0.587	0.128	0.135
BH (cm)	150.92 (4.94)	150.86 (4.96)	0.331	151.56 (4.56)	151.58 (4.33)	0.926	0.692	0.649
BMI(kg/m^2)	27.31(3.74)	27.26(4.09)	0.786	28.96(3.49)	28.86(3.15)	0.660	0.197	0.205
SMI (%)	22.37(2.14)	22.47(2.45)	0.692	22.03(2.25)	21.76(2.40)	0.268	0.649	0.393
BF (%)	41.66(7.65)	37.68(5.36)	0.020	42.39(6.07)	42.38(5.00)	0.859	0.756	0.011
Laboratory data								
TG	118.2(51.9)	115.3(52.2)	0.756	111.7(108.1)	109.3(74.3)	0.815	0.824	0.782
HDL	56.8(13.9)	58.1(12.4)	0.478	60.1(8.1)	59.5(9.1)	0.648	0.338	0.848
LDL	129.1(23.1)	127.0(20.6)	0.682	111.1(31.3)	118.1(26.1)	0.399	0.060	0.270
TC	208.9(29.7)	205.3(24.2)	0.588	190.4(30.8)	200.2(28.5)	0.270	0.080	0.576
GOT	25.7(10.7)	26.2(12.1)	0.137	24.8(9.6)	23.4(4.4)	0.480	0.260	0.259
GPT	26.5(13.4)	24.6(12.3)	0.174	25.6(16.7)	22.2(7.3)	0.314	0.851	0.495
BUN	13.6(3.2)	13.4(3.3)	0.583	13.6(5.1)	14.4(5.3)	0.398	0.731	0.507
Cr	0.77(0.12)	0.74(0.08)	0.104	0.79(0.13)	0.76(0.21)	0.208	0.378	0.387
CPK	99.0(35.9)	103.9(39.2)	0.452	99.8(39.9)	103.2(52.2)	0.814	0.953	0.964
CRP	2.77(3.49)	2.65(1.51)	0.389	2.21(3.33)	2.71(1.60)	0.264	0.633	0.658
Ca	9.41(0.27)	9.27(0.26)	0.135	9.29(0.27)	9.32(0.31)	0.714	0.225	0.559

ERT, elastic band resistance training

Values are expressed as mean (SD).

T1: before intervention, T2: after intervention

[a] P values were calculated by Mann–Whitney U test for comparing the variables at T1 and T2 within each groups respectively

[b] P values were calculated by Wilcoxon signed rank for comparing variables between ERT and control groups at T1 and T2 separately

Table 2. Body composition data before and after intervention of elderly female participants with sarcopenic obesity in elastic band resistance exercise and control groups

	ERT group (n = 18)			Control group (n = 17)			P value[b]	
Variables	T1	T2	P value[a]	T1	T2	P value[a]	T1	T2
LA fat	1.63 (0.37)	1.54 (0.40)	0.040	1.59 (0.51)	1.60 (0.46)	0.633	0.675	0.742
LA muscle	1.54 (0.23)	1.53 (0.22)	0.745	1.67 (0.25)	1.62 (0.24)	0.638	0.112	0.235
RA fat	1.64 (0.39)	1.50 (0.39)	0.030	1.63 (0.56)	1.69 (0.46)	0.572	0.848	0.013
RA muscle	1.67 (0.24)	1.64 (0.26)	0.101	1.76 (0.47)	1.72 (0.27)	0.647	0.263	0.387
Trunk fat	13.75(3.62)	13.56(3.58)	0.375	14.66(3.23)	15.70(3.65)	0.060	0.433	0.067
Trunk muscle	17.83(2.44)	18.26(2.60)	0.046	18.58(2.72)	18.60(1.99)	0.948	0.667	0.579
LL fat	3.67 (0.64)	3.67 (0.64)	0.946	3.66 (0.83)	3.62 (0.93)	0.369	0.418	0.923
LL muscle	5.26 (0.66)	5.30 (0.78)	0.611	5.62 (0.73)	5.45 (0.76)	0.315	0.141	0.570
RL fat	3.74 (0.72)	3.62 (0.70)	0.057	3.79 (0.78)	3.76 (0.94)	0.376	0.423	0.849
RL muscle	5.20 (0.61)	5.23 (0.79)	0.718	5.52 (0.76)	5.40 (0.74)	0.152	0.183	0.515
Total fat	25.52(5.01)	24.94(5.24)	0.035	28.42(4.78)	29.12(5.07)	0.080	0.096	0.023
Total muscle	34.29(4.02)	32.81(8.45)	0.442	36.06(4.02)	35.45(4.02)	0.060	0.216	0.243
Fat percentage	41.21(3.98)	40.34(3.74)	0.008	42.79(3.75)	43.65(3.61)	0.060	0.237	0.012
Total BMD	1.01 (0.10)	1.07 (0.15)	0.026	1.01 (0.10)	1.04 (0.11)	0.078	0.796	0.677
T-score	−1.29(1.33)	−0.56(1.29)	0.028	−1.21(1.29)	−0.81(1.45)	0.088	0.843	0.670
Z-score	−0.11(0.84)	0.48 (1.27)	0.021	−0.09(0.97)	0.23 (1.06)	0.072	0.523	0.526

ERT, elastic band resistance training

Values are expressed as mean (SD).

T1: before intervention, T2: after intervention

[a] P values were calculated by Mann–Whitney U test for comparing the variables at T1 and T2 within each groups respectively

[b] P values were calculated by Wilcoxon signed rank for comparing variables between ERT and control groups at T1 and T2 separately

Figure 1. Flow Diagram of this study