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Original Article

The effect of resistance training on the body composition and muscle functions of healthy elderly men

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Abstract: Objective: To investigate the effect of resistance training on the body composition and muscle functions of healthy elderly men. Methods: A total of 113 healthy elderly men were enrolled in the study and were assigned to two groups based on the intervention method. Group A maintained the previous lifestyle, while group B did resistance exercises. The changes in the body composition indices such as waistline, body fat percentage, body mass index (BMI), and basal metabolic rate, as well as skeletal muscle content, bone mineral density, upper and lower limb muscle strength, and muscle endurance, balancing ability, and walking ability were compared between the two groups. Results: After the intervention, group B showed smaller waistlines and lower BMI, lower body fat percentages and higher basal metabolic rates than group A ($P<0.05$). Compared with the pre-intervention levels, the skeletal muscle content was increased in group B ($P<0.05$), but the change was not significant in group A ($P>0.05$), and the BUA, T-values, and Z-values were all increased in group B ($P<0.05$), but the change was not significant in group A ($P>0.05$). After the intervention, the 30-ACT and 30-CST levels in group B were higher than they were in group A ($P<0.05$). After the intervention, group B showed longer standing times in the eye-closed single-leg stance test, farther reaching distances in the functional reach test, and shorter times in the 2.4-meter timed up and go tests than group A ($P<0.05$). Compared with the pre-intervention values, the walking distance in the 6-minute walk test (6MWT) was increased in group B after the intervention ($P<0.05$), but the change was not significant in group A ($P>0.05$). Conclusions: Resistance training is conducive to improving body composition and bone mineral density as well as the muscle strength and the muscle endurance of the upper and lower limbs and the balance fitness of healthy elderly men.

Keywords: Resistance training, health, elderly men, body composition, muscle function

Introduction

As humans start to succumb to aging, the muscles and strength will decline with age due to natural conditions. This kind of degenerative change easily causes a variety of diseases in the middle-aged and elderly population, commonly including cardiovascular diseases, paralysis, osteoporosis, etc. [1, 2]. Resistance training, *i.e.* strength training, is defined as the way to help the body increase strength and muscle growth by overcoming resistance [3, 4]. Resistance training has long been an effective way to exercise muscle function and enhance muscle strength [5, 6]. Numerous studies have shown that resistance training can effectively prevent and treat diseases that pose a serious threat to human health, such as diabetes, cancer, cardiovascular disease, and osteoporosis [7, 8]. As the aged population in China continues to grow, it is necessary to help the elderly prevent fall injuries, cardiovascular diseases, osteoporosis, joint pain and other diseases, and improve their daily living and exercise abilities and enhance their body balance ability, and guide them to do regular strength exercises with the appropriate intensity [9, 10]. Muscle activity is the most important factor affecting the energy metabolism in the human body. Any slight movement of the human body can increase the metabolic rate of the body [11]. During physical activity, the body will oxidize nutrients to effectively replenish the energy expenditure triggered by muscle activity, and the intensity of muscle activity is positively correlated with the increase in the body's oxygen consumption [12]. Most studies have confirmed that physical exercise is an important way for obese people to eliminate excess fat, and persistent exercise can not only improve the basal metabolic rate of the body, but it also plays a role in weight loss [13].

In order to improve the muscle function and physical quality of the elderly, healthy elderly men were selected as the study subjects for resistance exercise, and we compared them with those who maintained their previous lifestyle, so as to achieve the desired intervention effectiveness.

Materials and methods

Materials

A total of 113 healthy elderly men were included in the study. All the study subjects passed a health assessment and provided informed consent prior to the trial, in order to ensure that the trial was completed in a healthy physical state. Based on the intervention method, the subjects were assigned to one of two groups, with 56 subjects in group A, who maintained their previous lifestyle, and 57 subjects in group B, who did resistance exercises. (1) Inclusion criteria: Participants who signed the informed consent form, participants in a normal mental state, in good health, males aged ≥60 years and with no contraindications for the exercise test. This study was approved by the Medical Ethics Committee of Jilin Sport University. (2) Exclusion criteria: Those who dropped out of the study, those in the high-risk population unsuitable for exercise intervention upon diagnosis by specialists, those suffering from mental or cognitive impairments or movement impairments, those suffering from any disease affecting bone metabolism, those with severe cardio-cerebrovascular diseases or severe hypertension.

Methods

The patients in group A maintained their previous lifestyle and were taught the importance and necessity of exercise training but without any exercise intervention.

Group B did resistance exercises. In this study, the elastic-band-based resistance training program with high safety and easy operation was adopted in combination with the characteristics of the elderly. The training process lasted 12 weeks and strictly followed the principle of "step by step", *i.e.*, in the first 4 weeks - the number of exercise sets were reduced to allow optimal and adaptive exercises, in the middle 4 weeks - the intensity was determined based on the original training prescription, and in the last 4 weeks - the exercise intensity was appropriately increased on a safe basis according to each patient's actual situation. The elastic bands were classified by the colors red, yellow, blue, green, and gray, with different resistance levels and elasticity levels. The resistances were 5 lbs., 10 lbs., 15 lbs., 20 lbs., and 25 lbs. respectively. During the exercise regime, the subjects might make reasonable choices based on their initial muscle strength and the strength manipulation motion of the elastic bands. According to the physiological characteristics of the elderly, the following 8 sessions of exercises were selected for this study: (1) Session 1: Upright stretching exercise for the deltoid muscles. Exercise method: Stand with your feet apart about the width of your shoulders, step on the middle of the elastic band with one foot and allow your arms to hang loosely at your sides. The two ends of the elastic bands are wrapped around and held by both hands respectively, which are then pulled up to both sides slowly and forcefully until the two arms are lifted horizontally. The starting load of this session was set at 10 lbs. (2) Session 2: Upright arm bending exercise for the biceps brachii. Exercise method: Stand with your feet apart about the width of your shoulders, step on the middle of the elastic band with one foot and allow your arms to hang loosely at your sides. The two ends of the elastic band are wrapped around and held by both hands respectively. Bend your elbows while inhaling, and return to the original position after exhaling. Fully relax your shoulders, stay still, bend the elbows and clamp your upper arms close to the body with your palms facing backwards, tense your biceps brachii as much as you can, hold for a few seconds, and return to the original position. (3) Session 3: Standing backward leg raising exercise for gluteal muscle groups (*e.g.* gluteus maximus). Exercise method: Stand straight, keep your arms crossed to catch the shoulders, straighten one leg and raise the toe and knee to the rear as far as possible, inhale while raising and exhale while lowering, try to raise the leg as much as you can, hold it for a few seconds and then return your leg to the original position. (4) Session 4: Standing arm straightening and chest stretching exercise for the latissimus dorsi and other back muscles. Exercise method: Stand straight with your chest out, head up and feet apart about the width of your shoulders. Overlap the two ends of the elastic band, with one end wrapped around and held by one hand and the other end held by the other hand, with the palms outward, stretch your two arms backward horizontally with an angle above 180° while inhaling, keep the chest out, hold for a few seconds, exhale, and return to the original position. (5) Session 5: Standing back-of-head resistance exercise for the deltoid and triceps brachii. Exercise method: Stand straight with your chest out, head up, and feet apart about the width of your shoulders. Raise and place one hand with the elbow flexed behind the head, keep the upper arm upright and perpendicular to the ground, place the other hand on the lower back, and tense the elastic band so it's perpendicular to the ground. Overlap the two ends of the elastic band, with one end wrapped around and held by one hand and the other end held by the other hand, pull the elastic band toward the opposite direction while inhaling, hold for a few seconds and return to the original position. (6) Session 6: Abdominal muscle load increasing exercise for abdominal muscle groups. Exercise method: Lie supine on the cushion, keep your legs flexed and put them together, place the tips of middle fingers and thumbs of both hands into a rhombus shape onto the navel as the midpoint of the rhombus shape. Curl the abdomen and lift the shoulders while exhaling, feel the contraction of the upper abdominal muscle through the hands, and return to the original position while inhaling. Raise the legs flexed at an angle of 60° between the thighs and the shins, hold for a few seconds, and return to the original position. Lie supine on the cushion, do V-up exercises all the way at an angle of 90° between the thighs and shins which are parallel to the ground, place the tips of middle fingers and thumbs of both hands into a rhombus shape onto the navel as the midpoint of the rhombus shape, maintain even breathing, and bend the two legs alternatively. (7) Session 7: Supine side leg raising exercise for inner and outer thigh muscle groups. Exercise method: Put the elastic band around the ankle of one foot, push it with the other foot until it is under the foot arch, lie supine with both legs together, hold the two ends of the elastic band using the opposite hand, extend the elastic band outward as much as you can while inhaling to fasten the side leg, straighten the knee joint, hold for a few seconds, exhale and return to the original position gradually. In this process, you should avoid letting the leg touch the ground and avoid stretching the elastic band all the way. Switch to the other side and do the same exercise, with the toes of both feet up all the time. (8) Session 8: Lumbar muscle load increasing exercise for lower back muscle groups. Exercise method: Lie supine on the cushion, keep your legs flexed and put them together with all your fingertips placed around your ears, lift the upper body while inhaling, hold for a few seconds, and return to the original position. Lie supine on the cushion with your hands at your sides, straighten your legs and put them together, inhale, lift your legs upward, hold for a few seconds, and then return to the original position. Make sure to keep your upper body close to the ground while lifting your legs.

Observed indices

(1) Body composition index: The changes in the waistline, the body fat percentages, the BMI (body mass index), and the basal metabolic rates of the two groups were compared before and after the intervention. All the levels were measured by professional testers scientifically and consistently. (2) The skeletal muscle content was measured before and after the intervention using the Biospace InBody 3.0 body composition analyzer (NEO-MYTH, Korea) in strict accordance with the instructions. (3) Bone mineral density: Before and after the intervention, the subjects took off their right shoes and socks and sat on the stool with the bare foot on the foot pedal of the ultrasound device to measure their bone mineral density in the calcaneus bone. The coupling agent was evenly smeared to the right ankle. The foot pedal of the appropriate size was selected, the corresponding measurement parameters were set up, and the BUA (bone strength), Z-value, and T-value were measured using dual energy X-ray absorptiometry (DEXA) [14]. (4) Muscular fitness: Before and after the intervention, the

Table 1. Comparison of the general data of the two groups [n (%)]/($\bar{x} \pm s$)

Data	group A (n=56)	group B (n=57)	t/X^2	P
Age (years)	71.26 ± 1.16	71.32 ± 1.09	0.283	0.777
Weight (kg)	68.56 ± 1.25	68.12 ± 1.19	1.917	0.058
Degree of education (Person-time)				
Elementary school or below	12 (21.43)	14 (24.56)	1.258	0.996
Junior high school	23 (41.07)	21 (36.84)		
Senior high school and secondary technical school	13 (23.21)	15 (26.32)		
College or above	8 (14.29)	7 (12.28)		

muscle strength and the muscle endurance of the upper limbs were assessed using 30-ACT (a 30-second arm curl test), and the muscle strength and muscle endurance of the lower limbs were assessed using 30-CST (a 30-second chair stand test) in both groups of subjects [15]. (5) Balance ability: Before and after the intervention, both groups of subjects were tested for their balancing ability using an eye-closed single-leg stance test, a functional reach test, and a 2.4-meter timed up and go test [16]. (6) Walking ability: Before and after the intervention, both groups of subjects were tested using a 6-minute walking test (6MWT) to observe their walking ability. The subjects wore telemetric electrocardiosignal monitors on which the heart rate and electrocardiogram were displayed, and we asked the subjects to walk back and forth along the corridor as fast as they could for 6 minutes, and the total distance reached by each participant was recorded [17].

Statistical analysis

The data were analyzed using SPSS 22.0. The measurement data were expressed as the mean ± standard deviation (mean ± SD). The data following a normal distribution were subject to *t* tests, otherwise they were subject to Mann-Whitney U tests. The count data were expressed as [n (%)]. X^2 tests were used to compare the count data between groups. $P<0.05$ was considered statistically significant.

Results

Comparison of the general clinical data between the two groups

The subjects ranged in age from 62 to 82 years old (average: 71.26 ± 1.16 years) in group A and 61 to 85 years old (average: 71.32 ± 1.09 years) in group B. The subjects' weights ranged from 61 to 81 kg (average: 68.56 ± 1.25 kg), and 60 to 80 kg (average: 68.12 ± 1.19 kg) in group B. In group A, 12, 23, 13 and 8 subjects had a primary school education or below, junior high school education, senior high school education or secondary technical school education, and a college education or above respectively, accounting for 21.43%, 41.07%, 23.21%, and 14.29% respectively. In group B, 14, 21, 15, and 7 subjects had a primary school education or below, junior high school education, senior high school education or secondary technical school education, and a college education or above respectively, accounting for 24.56%, 36.84%, 26.32%, and 12.28% respectively. There was no statistically significant difference between the two groups in terms of the general data ($P>0.05$) (**Table 1**).

Comparison of the body composition indices between the two groups

Before the intervention, the waistlines, body fat percentages, BMI, and basal metabolic rates of the subjects in group A were (82.56 ± 2.58) cm, (29.86 ± 5.12)%, (26.05 ± 0.58) kg/m^2 and (1498.58 ± 15.68) kcal respectively, which had no significant difference ($P>0.05$) compared with the (82.59 ± 2.52) cm, (29.92 ± 5.08)%, (26.08 ± 0.52) kg/m^2, and (1498.66 ± 15.62) kcal in group B. After the intervention, the average waistline was (78.12 ± 1.25) cm in group B, less than the (82.58 ± 2.18) cm in group A. The body fat percentage was (26.12 ± 2.15)% in group B, lower than the (29.55 ± 4.12)% in group A. The BMI was (24.15 ± 0.15) kg/m^2 in group B, which was less than the (27.15 ± 0.62) kg/m^2 in group A, and the basal metabolic rate was (1556.12 ± 20.58) kcal in group B, which was higher than the (1492.15 ± 12.36) kcal in group A ($P<0.05$) (**Figure 1**).

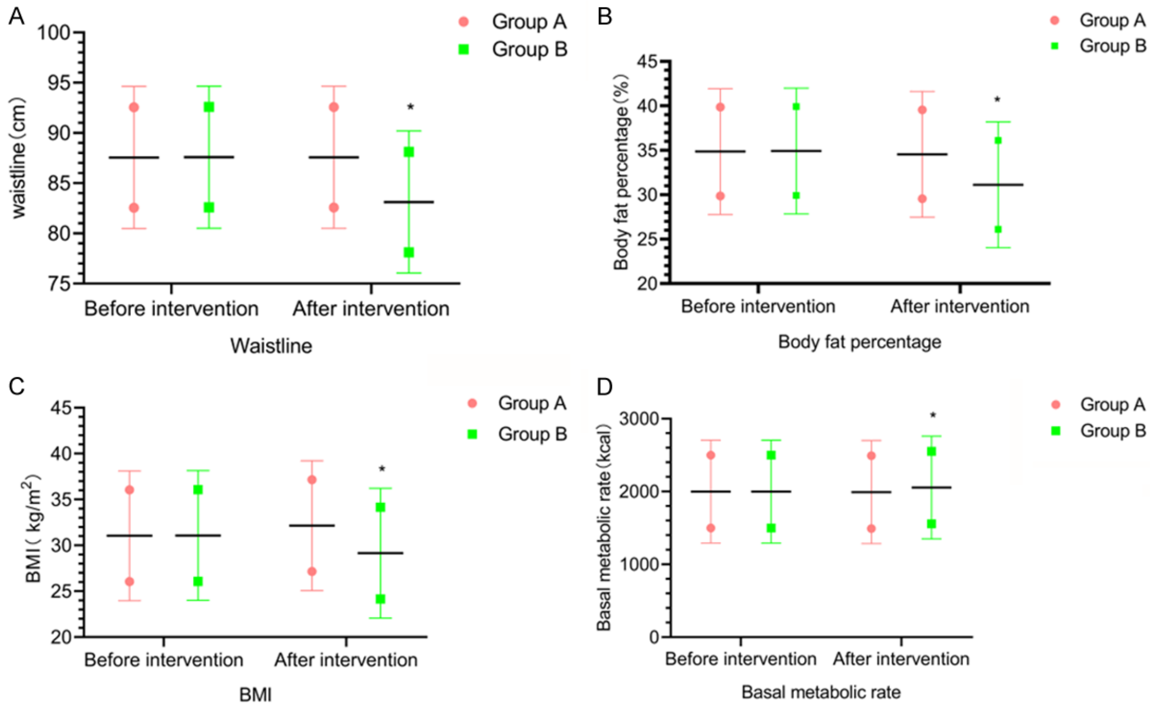


Figure 1. Comparison of the body composition indices between the two groups. Before the intervention, there were no significant differences in waistlines, body fat percentages, BMI, or the basal metabolic rates between the two groups (*P*>0.05). After the intervention, the average waistline as (78.12 ± 1.25) cm in group B, less than the (82.58 ± 2.18) cm in group A; the body fat percentage was (26.12 ± 2.15)% in group B, lower than the (29.55 ± 4.12)% in group A; the BMI was (24.15 ± 0.15) kg/m^2 in group B, less than the (27.15 ± 0.62) kg/m^2 in group A, and the basal metabolic rate was (1556.12 ± 20.58) kcal in group B, higher than the (1492.15 ± 12.36) kcal in group A (*P*<0.05). * refers to the *P* value which was <0.05 compared with group A.

Table 2. Comparison of the skeletal muscle content in the two groups ($\bar{x}$ ± s, kg)

group	Before intervention	After intervention
group A (n=56)	20.45 ± 1.25	20.48 ± 1.21
group B (n=57)	20.49 ± 1.22	22.58 ± 1.26$^{\#,*}$
t	0.172	9.034
P	0.864	0.000

Note: $^{\#}$refers to the *P* value which was <0.05 compared with the pre-intervention; *refers to the *P* value which was <0.05 compared with group A.

Comparison of the skeletal muscle content in the two groups

There was no significant difference in skeletal muscle content between the two groups before the intervention (*P*>0.05). Compared with the pre-intervention levels, the skeletal muscle content in group B was increased after the intervention (*P*<0.05), but the change was not significant in group A (*P*>0.05). After the intervention, the skeletal muscle content in group B was higher than it was in group A (*P*<0.05) (**Table 2**).

Comparison of the bone mineral density between the two groups

There were no significant differences in terms of the BUA, T-values, and Z-values between the two groups before the intervention (*P*>0.05). Compared with the pre-intervention levels, the BUA, T-values, and Z-values of the subjects in group B were all increased after the intervention (*P*<0.05), but the changes were not significant in group A (*P*>0.05). After the intervention, the BUA, T-values, and Z-values in group B were higher than they were in group A (*P*<0.05) (**Table 3**).

Comparison of the muscular fitness between the two groups

Before the intervention, the 30-ACT and 30-CST times were (20.25 ± 4.22) and (17.56 ± 2.12) respectively in group A, which had no signifi-

Table 3. Comparison of the bone mineral density between the two groups ($\bar{x} \pm s$)

group	BUA		T-value		Z-value	
	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention
group A (n=56)	56.48 ± 3.12	56.45 ± 3.08	-1.58 ± 0.12	-1.59 ± 0.11	-0.48 ± 0.15	0.51 ± 0.13
group B (n=57)	56.51 ± 3.09	59.98 ± 2.12$^{\#,*}$	-1.61 ± 0.09	-1.22 ± 0.11$^{\#,*}$	-0.45 ± 0.12	-0.22 ± 0.08$^{\#,*}$
t	0.051	7.107	1.505	17.877	1.175	36.019
P	0.959	0.000	0.135	0.000	0.243	0.000

Note: #refers to the *P* value which was <0.05 compared with the pre-intervention; *refers to the *P* value which was <0.05 compared with group A.

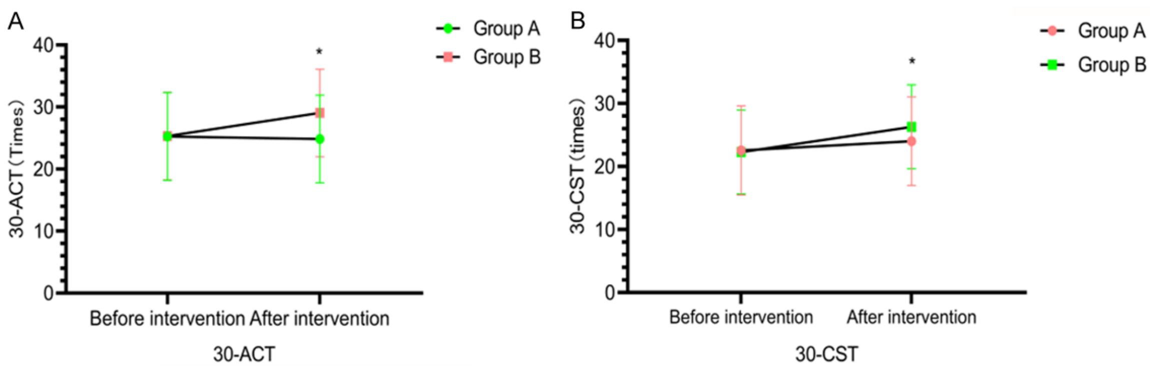


Figure 2. Comparison of the muscular fitness between the two groups. Before the intervention, there was no significant difference in the 30-ACT and 30-CST times between the two groups (*P*>0.05). After the intervention, the 30-ACT and 30-CST times were (24.02 ± 5.68) and (21.59 ± 2.63), respectively in group B, higher than the (19.85 ± 3.26) and (19.05 ± 0.23) in group A (*P*<0.05). * refers to the *P* value which was <0.05 compared with group A.

cant difference (*P*>0.05) compared with (20.32 ± 4.19) and (17.59 ± 2.09) in group B. After the intervention, the 30-ACT and 30-CST times were (24.02 ± 5.68) and (21.59 ± 2.63) respectively in group B, higher than (19.85 ± 3.26) and (19.05 ± 0.23) in group A (*P*<0.05) (**Figure 2**).

Comparison of the balance abilities in the two groups

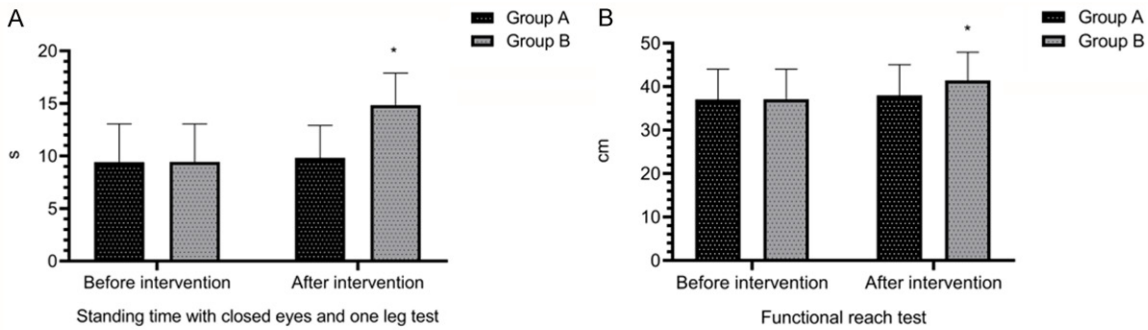
Before the intervention, the standing times of the eye-closed single-leg stance test, the reaching distances of the functional reach test, and the times of the 2.4-meter timed up and go test were (6.85 ± 1.18) s, (32.15 ± 5.18) cm, and (5.71 ± 0.58) s respectively in group A, which had no significant difference (*P*>0.05) compared with the (6.88 ± 1.15) s, (32.18 ± 5.16) cm, and (5.75 ± 0.52) s in group B. After the intervention, the standing times of the eye-closed single-leg stance test were (12.68 ± 2.28) s in group B, longer than the (7.65 ± 1.28) s in group A; the reaching distance of the functional reach test was (36.85 ± 4.28) cm in group B, longer than the (33.05 ± 5.22) cm in group A, and the times of the 2.4-meter timed up and go test were (5.02 ± 0.05) s in group B, shorter than the (5.69 ± 0.58) s in group A (*P*<0.05) (**Figure 3**).

Comparison of the walking abilities in the two groups

There was no significant difference between the two groups in the 6MWT walking distances before the intervention (*P*>0.05). Compared with the pre-intervention values, the 6MWT walking distance in group B was increased after the intervention (*P*<0.05), but the change was not significant in group A (*P*>0.05). After the intervention, the 6MWT walking distance in group B was greater than it was in group A (*P*<0.05) (**Table 4**).

Discussion

Health is the most fundamental and universal need of human beings, and the people's health



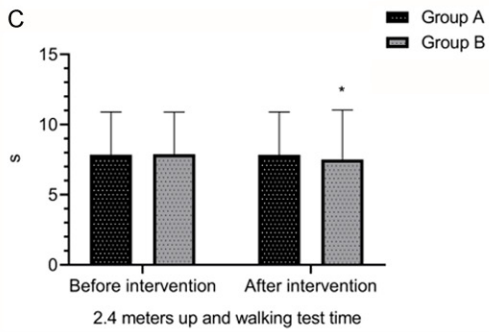


Figure 3. Comparison of the balance abilities between the two groups. Before the intervention, there was no significant difference in the standing times in the eye-closed single-leg stance test, the reaching distance of functional reach test, or the times of 2.4-meter timed up and go test group between the two groups ($P>0.05$). After the intervention, the standing times of the eye-closed single-leg stance test was (12.68 ± 2.28) s in group B, longer than the (7.65 ± 1.28) s in group A; the reaching distance of the functional reach test was (36.85 ± 4.28) cm in group B, longer than the (33.05 ± 5.22) cm in group A; and the time of the 2.4-meter timed up and go test was (5.02 ± 0.05) s in group B, shorter than the (5.69 ± 0.58) s in group A ($P<0.05$). * refers to the *P* value which was <0.05 compared with group A.

Table 4. Comparison of the 6MWT walking distances between the two groups ($\overline{x} \pm s$)

group	Before intervention	After intervention
group A (n=56)	526.32 ± 18.52	530.12 ± 18.99
group B (n=57)	526.98 ± 18.02	562.28 ± 20.28$^{\#,*}$
t	0.192	8.698
P	0.848	0.000

Note: $^{\#}$refers to the *P* value which was <0.05 compared with the pre-intervention; *refers to the *P* value which was <0.05 compared with group A.

is an important symbol of a prosperous country and nation [18]. As a result of old age, a variety of body functions are significantly decreased, showing degenerative changes, including decreased balance, declined cognition, gait disorders, and muscle strength decay, which have a significant impact on the elderly's physical and mental health, reduce their quality of life, and deprive them of a sense of well-being [19, 20]. With the improvement of the social and economic development levels, people's health needs have also significantly increased, and people pay more and more attention to disease prevention, individual good health, the improvement of individual function and life extension, etc. How to scientifically improve the physical and mental health of the elderly and actively prevent and treat various diseases is a problem worth pondering [21, 22].

Some studies have shown that scientific and proper exercise can not only improve the physical fitness of the elderly, but it also effectively prevents accidents such as falls [23]. Resistance training aims to help the body gain strength and muscle growth by overcoming resistance [24]. Traditional resistance training methods, such as barbells and dumbbells, have some limitations such as high risk and difficulty in carrying training equipment [25].

Resistance training methods highly recommended by professional athletic coaches include free weights and machine training, which generally require professional equipment. In addition, it may be difficult for the elderly to complete the training for physical reasons, so these training methods are less acceptable for the elderly. Elastic resistance training tools were first developed more than 100 years ago and have been mainly used for children's growth training, female body building training, and male strength training in the health field [26]. In the late 1970s, two physiotherapists developed and designed a color code system for elastic progressive resistance training, in which different colors of elastic bands have different elongations, rational coefficients, and resistance. The trainers can choose the proper elastic band according to their own needs and abilities [27]. Compared with traditional resistance training equipment, the elastic bands are easy to carry and low in price and allow free rotation during training with low risk. Most muscles in the body can be exercised using elastic bands to achieve the ideal effect. In addition, resistance training with elastic bands has no fixed trajectory and has better function and pertinence [28].

In this study, a targeted elastic band resistance training program was developed according to the physiological characteristics of the elderly. The results showed that the body composition indices of the subjects in group B were all superior to those in group A, suggesting that elastic band resistance training is beneficial for improving body composition. This might be because elastic band resistance training can improve the muscle control and nerve control abilities through appropriate strength load stimulation, thus improving the body's control over skeletal muscle movements. Second, during the elastic band resistance training, the body overcame the resistance, thus stimulating the expansion of the muscle physiological cross-sectional area and increasing the skeletal muscle cell volume, promoting protein synthesis in the recovery period after exercise, and activating the satellite cells next to the muscle cells which recombines skeletal muscle cell-like cells to form new muscle cells. The total number of skeletal muscle cells and the fat utilization rate were increased, thus reducing the waistline and BMI, decreasing the body fat percentage and increasing the basal metabolic rate. Third, the study results show that the bone mineral density in group B was superior to group A ($P<0.05$), suggesting that elastic band resistance training can also improve bone mineral density. The reason is that the physiological and mechanical principles show that the mechanical load and stress stimulations within an appropriate threshold can promote the positive growth of the body's skeleton [29]. Muscle contraction during elastic band resistance training is an important factors in maintaining bone quality. The bone mineral content in human bones is closely related to the frequency and intensity of muscle contractions. Skeletal muscle can effectively stimulate the growth of osteogenic cells through resistance training, so as to promote dynamic bone reconstruction and improve bone mineral density. Lai [30] found that after 5 weeks of resistance training, male subjects showed significantly increased strength and improved hormone levels, which were highly similar to the results of this study, further demonstrating the effectiveness of resistance training. Most studies have shown that 30-ACT and 30-CST can effectively reflect the muscle strength and muscle endurance of the upper and lower limbs, so they are widely used in medical evaluation. In this study, both the 30-ACT and 30-CST in group B were increased after the intervention, suggesting that elastic band resistance training can improve the muscle strength and muscle endurance of the upper and lower limbs. This might be because elastic band resistance training involves the gluteal muscle groups such as the deltoids, biceps brachii, gluteus maximus, latissimus dorsi, and other various back muscles, abdominal muscle groups, inner and outer thigh muscle groups, and lower back muscle groups. The muscles in the upper and lower limbs were effectively exercised, thus significantly improving the muscular fitness. After the intervention, the balance and walking abilities of the subjects in group B were significantly improved. This might be because each movement continuously and systematically stimulated the proprioceptive, visual and vestibular sensory organs during elastic band resistance training, and long-term training can improve the comprehensive ability of the nervous system to respond to sensory stimulation and proprioceptive sensitivity, thus improving the balance ability of trainers [31].

To sum up, resistance training is beneficial to improving the body's composition and bone mineral density, as well as the muscle strength and muscle endurance of the upper and lower limbs, and balance fitness in healthy elderly men.

Although this study has achieved some results, it is limited by a small sample size. More comprehensive research and analysis with a larger sample size and a longer duration are necessary in the future.

Disclosure of conflict of interest

None.

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References

[1] Nery C, Moraes SRA, Novaes KA, Bezerra MA, Silveira PVC and Lemos A. Effectiveness of resistance exercise compared to aerobic exercise without insulin therapy in patients with type 2 diabetes mellitus: a meta-analysis. Braz J Phys Ther 2017; 21: 400-415.

[2] Hashida R, Kawaguchi T, Bekki M, Omoto M, Matsuse H, Nago T, Takano Y, Ueno T, Koga H, George J, Shiba N and Torimura T. Aerobic vs. resistance exercise in non-alcoholic fatty liver disease: a systematic review. J Hepatol 2017; 66: 142-152.

[3] de Oliveira NC, Portes LA, Pettersson H, Alexanderson H and Boström C. Aerobic and resistance exercise in systemic sclerosis: state of the art. Musculoskeletal Care 2017; 15: 316-323.

[4] Prazeres T, Correia MA, Cucato GG, Gomes CC and Ritti-Dias RM. Cardiovascular responses during resistance exercise after an aerobic session. Braz J Phys Ther 2017; 21: 329-335.

[5] Wewege MA, Booth J and Parmenter BJ. Aerobic vs. resistance exercise for chronic non-specific low back pain: a systematic review and meta-analysis. J Back Musculoskelet Rehabil 2018; 31: 889-899.

[6] Iversen VM, Vasseljen O, Mork PJ, Gismervik S, Bertheussen GF, Salvesen Ø and Fimland MS. Resistance band training or general exercise in multidisciplinary rehabilitation of low back pain? A randomized trial. Scand J Med Sci Sports 2018; 28: 2074-2083.

[7] Iversen VM, Vasseljen O, Mork PJ and Fimland MS. Resistance training vs. general physical exercise in multidisciplinary rehabilitation of chronic neck pain: a randomized controlled trial. J Rehabil Med 2018; 50: 743-750.

[8] Northey JM, Cherbuin N, Pumpa KL, Smee DJ and Rattray B. Exercise interventions for cognitive function in adults older than 50: a systematic review with meta-analysis. Br J Sports Med 2018; 52: 154-160.

[9] Olver TD and Laughlin MH. Endurance, interval sprint, and resistance exercise training: impact on microvascular dysfunction in type 2 diabetes. Am J Physiol Heart Circ Physiol 2016; 310: H337-350.

[10] Halabchi F, Alizadeh Z, Sahraian MA and Abolhasani M. Exercise prescription for patients with multiple sclerosis; potential benefits and practical recommendations. BMC Neurol 2017; 17: 185.

[11] Schwartz AL, de Heer HD and Bea JW. Initiating exercise interventions to promote wellness in cancer patients and survivors. Oncology (Williston Park) 2017; 31: 711-717.

[12] LaStayo P, Marcus R, Dibble L, Wong B and Pepper G. Eccentric versus traditional resistance exercise for older adult fallers in the community: a randomized trial within a multicomponent fall reduction program. BMC Geriatr 2017; 17: 149.

[13] Cassilhas RC, Tufik S and de Mello MT. Physical exercise, neuroplasticity, spatial learning and memory. Cell Mol Life Sci 2016; 73: 975-983.

[14] Minshull C and Gleeson N. Considerations of the principles of resistance training in exercise studies for the management of knee osteoarthritis: a systematic review. Arch Phys Med Rehabil 2017; 98: 1842-1851.

[15] Shire AR, Stæhr TAB, Overby JB, Bastholm Dahl M, Sandell Jacobsen J and Høyrup Christiansen D. Specific or general exercise strategy for subacromial impingement syndrome-does it matter? A systematic literature review and meta analysis. BMC Musculoskelet Disord 2017; 18: 158.

[16] Rahbek MA, Mikkelsen EE, Overgaard K, Vinge L, Andersen H and Dalgas U. Exercise in myasthenia gravis: a feasibility study of aerobic and resistance training. Muscle Nerve 2017; 56: 700-709.

[17] Sklempe Kokic I, Ivanisevic M, Kokic T, Simunic B and Pisot R. Acute responses to structured aerobic and resistance exercise in women with gestational diabetes mellitus. Scand J Med Sci Sports 2018; 28: 1793-1800.

[18] Tomas-Carus P, Ortega-Alonso A, Pietilainen KH, Santos V, Goncalves H, Ramos J and Raimundo A. A randomized controlled trial on the effects of combined aerobic-resistance exercise on muscle strength and fatigue, glycemic control and health-related quality of life of type 2 diabetes patients. J Sports Med Phys Fitness 2016; 56: 572-578.

[19] Sabag A, Way KL, Keating SE, Sultana RN, O'Connor HT, Baker MK, Chuter VH, George J and Johnson NA. Exercise and ectopic fat in type 2 diabetes: a systematic review and meta-analysis. Diabetes Metab 2017; 43: 195-210.

[20] Berton R, Lixandrão ME, Pinto E Silva CM and Tricoli V. Effects of weightlifting exercise, traditional resistance and plyometric training on countermovement jump performance: a meta-analysis. J Sports Sci 2018; 36: 2038-2044.

[21] Westerberg E, Molin CJ, Spörndly Nees S, Widenfalk J and Punga AR. The impact of physical exercise on neuromuscular function in Myasthenia gravis patients: a single-subject design study. Medicine (Baltimore) 2018; 97: e11510.

[22] Low DC, Walsh GS and Arkesteijn M. Effectiveness of exercise interventions to improve postural control in older adults: a systematic re-

view and meta-analyses of centre of pressure measurements. Sports Med 2017; 47: 101-112.
[23] Menezes MA, Pereira TAB, Tavares LM, Leite BTQ, Neto AGR, Chaves LMS, Lima LV, Da Silva-Grigolleto ME and DeSantana JM. Immediate effects of transcutaneous electrical nerve stimulation (TENS) administered during resistance exercise on pain intensity and physical performance of healthy subjects: a randomized clinical trial. Eur J Appl Physiol 2018; 118: 1941-1958.
[24] Sañudo B, de Hoyo M, Del Pozo-Cruz J, Carrasco L, Del Pozo-Cruz B, Tejero S and Firth E. A systematic review of the exercise effect on bone health: the importance of assessing mechanical loading in perimenopausal and postmenopausal women. Menopause 2017; 24: 1208-1216.
[25] Park JS, Lee G and Jung YJ. Effects of game-based chin tuck against resistance exercise vs. head-lift exercise in patients with dysphagia after stroke: an assessor-blind, randomized controlled trial. J Rehabil Med 2019; 51: 749-754.
[26] Lund C, Dalgas U, Grønborg TK, Andersen H, Severinsen K, Riemenschneider M and Overgaard K. Balance and walking performance are improved after resistance and aerobic training in persons with chronic stroke. Disabil Rehabil 2018; 40: 2408-2415.
[27] Kumbhare D, Gupta P and Frontera W. Second-order peer reviews of clinically relevant articles for the physiatrist: what is more effective, aerobic or resistance exercise for obese older adults? Am J Phys Med Rehabil 2019; 98: e28-e31.
[28] Morishita S, Wakasugi T, Tanaka T, Harada T, Kaida K, Ikegame K, Ogawa H and Domen K. Changes in Borg scale for resistance training and test of exercise tolerance in patients undergoing allogeneic hematopoietic stem cell transplantation. Support Care Cancer 2018; 26: 3217-3223.
[29] Fuller JT, Hartland MC, Maloney LT and Davison K. Therapeutic effects of aerobic and resistance exercises for cancer survivors: a systematic review of meta-analyses of clinical trials. Br J Sports Med 2018; 52: 1311.
[30] Lai X. Effect of 5-week intermittent hypoxic resistance training on male hormone levels and strength. Beijing: Beijing Sport University; 2015.
[31] Pasanen T, Tolvanen S, Heinonen A and Kujala UM. Exercise therapy for functional capacity in chronic diseases: an overview of meta-analyses of randomised controlled trials. Br J Sports Med 2017; 51: 1459-1465.