Exercise prescription effects on bone and biochemical markers in osteoporotic elderly men

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Abstract: Objective: To investigate the effects of a 16-week brisk walking exercise prescription on bone mass, blood indices, respiratory function, and body composition in elderly male patients with osteoporosis. Methods: Seventy elderly male patients diagnosed with osteoporosis through screening were randomly divided into an exercise group and a control group. Patients in the exercise group underwent a 16-week brisk walking training program, while those in the control group maintained their original lifestyle. After 16 weeks, bone strength values, bone mineral density T-scores, blood indices, vital capacity, timed vital capacity, and body fat percentage were measured in both groups. Results: Compared with the control group, the exercise group showed significant differences in bone strength values and bone mineral density T-scores ($P<0.05$). Significant differences were also observed in blood high-density lipoprotein, whole blood viscosity, and erythrocyte deformation index ($P<0.05$). Vital capacity was significantly increased ($P<0.05$), and body fat percentage was significantly decreased ($P<0.05$). Conclusion: Long-term brisk walking exercise can significantly improve respiratory function, reduce body fat, improve blood lipid levels and hemorheology, and enhance calcaneal bone mineral density in elderly male patients with osteoporosis.

keywords: osteoporosis, body fat percentage, vital capacity, elderly

1. Introduction

With advancing age, the incidence of osteoporosis shows an increasing trend. Elderly patients with osteoporosis are prone to low back pain, decreased respiratory function, kyphosis, and fall-related fractures. Due to the influence of sex hormones, the occurrence of osteoporosis in elderly men is less severe than in elderly women. In developed regions of China, the incidence of osteoporosis in elderly patients is approximately 13%, and the fracture-related mortality caused by osteoporosis is significantly higher in men than in women [1]. Studies have shown that male patients have poorer compliance with pharmacological treatment compared to female patients [2]; however, men are more inclined to exercise than women, yet they are averse to complicated exercise regimens. Therefore, based on the interests and habits of male patients, a simple and feasible exercise prescription was designed to delay the progression of osteoporosis and improve bone mass in elderly male patients. This study aims to investigate the effects of simple exercise prescription intervention on bone mass, blood indices, respiratory function, and body composition in elderly male patients with osteoporosis.

2. Subjects and methods

2.1. Study subjects

The cases were recruited from 70 elderly male patients with primary osteoporosis diagnosed through osteoporosis screening during the retirement health examination of Jilin Normal University at a tertiary Grade A hospital in 2013. The diagnosis was in accordance with the WHO diagnostic criteria for osteoporosis. Based on the instruments used in this study, the diagnostic criteria were defined as follows: $T\geq-1.0$ indicated normal bone mass, $-2.5\leq T<-1.0$ indicated reduced bone mass, and $T<-2.5$ indicated osteoporosis. The patients had no knee joint swelling, weakness, or walking impairment. Prior to the study,

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informed consent was obtained from all participating patients after soliciting their opinions. According to the patients' willingness, they were randomly divided into an exercise group and a control group, with 35 cases in each group. The age of patients in the exercise group was (60.4±9.6) years, and that in the control group was (60.3±9.2) years. There were no significant differences in age, bone mineral density values, and other indices between the two groups before intervention (P>0.05). All subjects in both groups had no regular exercise history within the two years prior to the study.

2.2. Intervention methods

Patients in the exercise group underwent exercise risk level assessment prior to training and participated in a 16-week brisk walking exercise prescription under the guidance of professional exercise coaches. They exercised collectively under the leadership of professional coaches five times per week, with two days of rest. Each session lasted 60 minutes, including 10 minutes of warm-up, 5 minutes of cool-down, and 45 minutes of brisk walking training, with the walking speed controlled at 5.5-6 km/h. Individual health and exercise records were established for each participating patient to ensure at least four exercise sessions per week. Medical supervision was provided for each exercise session to prevent exercise-related accidents, and on-site follow-up visits were conducted monthly. Patients in the control group maintained their original lifestyle and received monthly telephone follow-ups.

2.3. Measurement of physiological biochemical indices and BMD

The Lunar Achilles Express ultrasound bone densitometer (USA) was used to measure the calcaneal bone strength value and the corresponding T-score intensity index (the patient's intensity index above or below the reference mean of young adults, expressed in standard deviation units). Blood lipids were determined, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDLC), and low-density lipoprotein cholesterol (LDLC). Hemorheological indices measured included whole blood viscosity and erythrocyte deformation index. Respiratory function was assessed using the AS-500 MINATO spirometer, with measured indices including vital capacity (VC) and forced vital capacity (FVC). Body composition was analyzed using the Biospace InBody 3.0 body composition analyzer (Korea). Measurements of left calcaneal bone mineral density, blood biochemical indices, respiratory function, and body composition were performed before and after the intervention, respectively.

2.4. Statistical analysis

Data were analyzed using SPSS version 17.0 statistical software. Measurement data were expressed as mean standard deviation ($\bar{x} \pm s$). Comparisons of detected indices between the exercise group and the control group were performed using t-tests. P<0.05 was considered statistically significant.

3. Results

3.1. Calcaneal bone strength comparison between groups

As shown in Table 1, there was no significant difference in calcaneal bone strength values or bone mineral density T-scores between the two groups before intervention (P>0.05). After 16 weeks of brisk walking exercise intervention, the calcaneal bone strength value in the exercise group increased by 10.33%, while that in the control group increased by 2%; the difference between the two groups was statistically significant (P<0.05). The bone mineral density T-score in the exercise group also showed a significant difference compared with the control group (P<0.05).

Table 1 Bone Strength Values and BMD T-Scores in Each Group(n=35,$\bar{x} \pm s$)

Group	Time	Bone strength value (%)	T of bone mineral density index
Exercise group	Before intervention	87.21±8.22	-1.02±0.12

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control	After intervention	96.22±7.84#	-0.62±0.14#
	Before intervention	86.43±10.27	-1.25±0.11
	After intervention	88.17±9.07	-1.30±0.13

3.2. Comparison of blood indices between exercise and control groups

As shown in Table 2, there were no significant differences in serum TC, TG, HDLC, LDLC, whole blood viscosity, or erythrocyte deformation index between the two groups before intervention (P>0.05). After intervention, the exercise group showed significant differences in blood HDLC, whole blood viscosity, and erythrocyte deformation index compared with the control group (P<0.05), while no significant differences were observed in other indices (P>0.05).

Table 2 Blood Lipid and Hemorheological Indices in Each Group(n=35,$\bar{x} \pm s$)

Group	Time	TC (mmol/L)	TG (mmol/L)	HDL-C (mmol/L)	LDL-C (mmol/L)	Whole blood viscosity	Erythrocyte deformation index
Exercise Group control	Before intervention	5.01±1.23	2.22±0.40	1.33±0.45	2.44±0.74	4.38±3.21	1.29±0.21
	After intervention	3.89±1.75	1.74±0.43	1.61±0.43$^{\#}$	2.31±0.63	4.01±3.99$^{\#}$	1.51±0.31$^{\#}$
	Before intervention	5.22±1.49	2.08±0.44	1.34±0.27	2.48±0.45	4.48±3.01	1.30±0.21
	After intervention	5.37±1.69	2.48±0.21	1.36±0.37	2.82±0.54	4.39±3.11	1.27±0.46

3.3. Respiratory function comparison between groups

As shown in Table 3, there were no statistically significant differences in vital capacity (VC) and forced vital capacity (FVC) between the two groups before intervention (P>0.05). After 16 weeks of brisk walking exercise intervention, the exercise group showed a significant difference in vital capacity compared with the control group (P<0.05), whereas no significant difference was observed in forced vital capacity (P>0.05).

3.4. Body composition comparison between groups

As shown in Table 4, there was no significant difference in body fat percentage between the two groups before intervention (P>0.05). After 16 weeks of brisk walking exercise intervention, the exercise group showed a significant difference in body fat percentage compared with the control group (P<0.05).

Table 3 Vital Capacity and Forced Vital Capacity in Each Group(n=35,$\bar{x} \pm s$)

Group	Time	Vital capacity(L)	Time vital capacity(L)
Exercise group control	Before intervention	2.41±0.22	1.94±0.12
	After intervention	2.97±0.44#	2.02±0.14

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	Before intervention	2.38±0.27	1.92±0.11
	After intervention	2.41±0.27	1.98±0.13

Table 4 Comparison of Body Fat Percentage in Each Group(n=35,$\bar{x} \pm s$)

Group	Time	Bodyfat percentage (%)
Exercise group control	Before intervention	28.86±3.88
	After intervention	24.02±2.44#
	Before intervention	27.99±4.27
	After intervention	28.12±2.27

4. Effects of brisk walking on bone strength and bone mineral density

Bone strength values and bone mineral density T-scores are sensitive indicators reflecting changes in bone function, including alterations in mechanical structure, mechanical properties, and bone metabolism [3-6]. The results of this study showed that after 16 weeks of brisk walking exercise under professional coaching, elderly male patients with osteoporosis demonstrated significant increases in bone strength values and BMD T-scores compared with the control group, which is consistent with findings from previous studies [7-10]. In elderly individuals, bone strength is negatively correlated with age; decreased mineral content in bone leads to increased bone fragility, thereby predisposing to osteoporotic fractures upon falling. Moreover, with advancing age, the functional decline of the auditory and visual systems, along with reduced neuromuscular coordination, increases the likelihood of fall-related injuries during daily activities. Brisk walking exercise primarily involves lower limb movement driving coordinated whole-body swinging. Throughout the exercise, the continuous shift of body center of gravity, combined with the self-loading effect generated by body weight, creates effective mechanical stimulation that continuously acts on the calcaneus, thereby stimulating bone formation effects. Furthermore, long-term brisk walking training helps improve neuromuscular control, enhances lower limb muscle strength that declines with age, and increases joint stability, all of which are beneficial for preventing fall-related fractures.

5. Effects of brisk walking on blood lipid metabolism

With advancing age, the body undergoes a series of degenerative changes. The improvement of living standards, dietary factors, sedentary lifestyle, and the characteristic that elderly men are less likely than elderly women to participate in group exercise activities are the main causes of abnormal lipid metabolism in elderly men. An increasing number of studies have shown that there may be a certain relationship between osteoporosis and lipid disorders, but different types of lipid disorders have varying effects on osteoporosis. Research has found that HDL-C can prevent osteoblast apoptosis induced by oxidized lipids, thereby increasing bone mineral density and reducing fracture risk [11]. The results of this study indicate that after 16 weeks of brisk walking exercise, elderly male patients with osteoporosis showed a significant increase in blood high-density lipoprotein concentration. The increased HDL-C concentration resulting from long-term regular exercise can enhance the body's antioxidant, anti-inflammatory, antithrombotic, and profibrinolytic capacities, and can alleviate endothelial dysfunction. Moreover, after training, the hemorheological characteristics of the elderly in the exercise group were improved, thereby reducing the incidence of coronary heart disease and the risk of cardiovascular diseases.

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6. Effects of brisk walking on respiratory function

Studies have shown that vital capacity gradually declines after age 35, decreasing by approximately 50%25 by age 80 [12]. Moderate aerobic exercise can improve respiratory function. In this study, after 16 weeks of regular exercise, the elderly in the exercise group showed a significant increase in vital capacity compared with the control group, indicating that exercise effectively improved the subjects' respiratory function, which is consistent with findings from other studies [13]. Long-term regular exercise of certain intensity can help improve the body's metabolic capacity, enhance oxygen exchange and oxygen transport, increase respiratory muscle endurance and strength, and delay the aging of the respiratory system in the elderly [14, 15]. However, no significant difference in forced vital capacity was observed in this study. The main reason may be that the exercise intensity of brisk walking is relatively moderate to low, resulting in insufficient stimulation of respiratory function and limited impact on respiratory muscle endurance, which is also related to the overall age-related decline in muscle function among the elderly.

7. Effects of brisk walking on body fat percentage

Studies have shown that body fat percentage is associated with bone mineral density in adults, with both gender and site-specific differences [16]. Long-term regular brisk walking can significantly reduce body fat percentage. Regular exercise with certain intensity can not only prevent muscle degeneration and delay the aging of motor function, but also inhibit the accumulation of body fat. Moreover, prolonged exercise of moderate to low intensity can enhance the body's capacity for fat oxidation and energy supply, promote fat decomposition, and thereby reduce body fat. Concurrently, the reduction in body fat decreases the load on lower limb joints, lowering the risk of falls. The simple brisk walking exercise protocol designed in this study, with an effective exercise duration of 45 minutes and a total duration of 60 minutes including warm-up and cool-down activities, can effectively mobilize fat to participate in energy supply during exercise. Furthermore, the walking modality is more suitable for the elderly, reducing exercise-related risks while being easy to implement.

8. Conclusion

In conclusion, a 16-week simple brisk walking exercise prescription has positive effects on the prevention and treatment of osteoporosis and the improvement of quality of life in elderly male patients with osteoporosis. This exercise modality is simple, easily promoted, readily mastered by patients, and requires minimal facilities. It can be considered as an exercise recommendation in the comprehensive management of osteoporosis patients, as it is convenient, feasible, and has high compliance rates, thereby improving patients' quality of life and enhancing disease prevention and treatment.

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