

# A Review of Research on Resistance Training and Physical Fitness of the Elderly

Xiaolei Yang\*

School of Physical Education, Liaoning Normal University, Dalian, China

\*Corresponding author

**Abstract:** *The physical health of the elderly is an important measure to realize the "Healthy China" strategy, and sports activities are an important means to achieve healthy aging. Healthy physical fitness is an important aspect in the aging era, and resistance training is an effective and feasible means to improve the level of healthy physical fitness of the elderly. This paper uses qualitative research methods to review the effects of resistance training on the elderly body composition, muscle strength and muscle endurance, cardiopulmonary endurance, balance and coordination function, and discusses the safety aspects, with a view to improving the understanding level of clinical resistance training and promoting its rational application.*

**Keywords:** *resistance training, elderly, physical fitness*

## 1. Introduction

China's population aging process has accelerated. By the end of 2019, the number of elderly people over 65 years old in China has reached 176.03 million, accounting for 12.6% of the total population. By 2050, the number of elderly people over 65 years old in China will account for 1/5 of the total population in China, reaching more than 320 million, accounting for 1/4 of the world's elderly population, and China will enter the ranks of ultra-high aging countries. Aging will lead to a significant decline in the level of physical fitness of the elderly and pose a serious threat to the quality of life of the elderly[1]. Biological changes in the process of aging may lead to a decline in the quality, strength and function of skeletal muscle, a decline in the tolerance and stress capacity of the body, resulting in falls, limited activities, an increase in social dependence, and a significant reduction in the number of years without disability. Aging has brought many adverse consequences, so it is imperative to formulate timely and effective response measures. Among many factors related to aging, problems related to muscle are reversible and preventable. Resistance training is an effective and feasible means to treat muscle weakness and physical weakness. It can not only supplement the positive effects of aerobic training on health and physical fitness, but also effectively reduce the adverse effects of age on neuromuscular function.

## 2. Effect of resistance training on health fitness

### 2.1 Effect of resistance training on body composition

Body composition refers to the relative percentage of muscle, fat, bone and other body components. Body fat is one of the main indicators to evaluate body composition. An ideal body fitness should have an appropriate percentage of body fat. With the growth of age, the incidence of chronic inflammation increases, the ability of protein synthesis decreases, muscle strength and muscle protein quality decrease, and the incidence of aging obesity increases. A large number of studies have shown that resistance training can not only improve bone density and insulin sensitivity, but also reduce abdominal and visceral fat, reduce muscle fat infiltration and muscle mass, and improve muscle ductility. Peterson et al. found that when the elderly [age (65.5 ± 6.5) years old] received whole-body resistance training (average 20.5 weeks), their lean weight increased by 1.1 kg, and the greater the amount of training, the greater the lean weight increased.

## ***2.2 Effect of resistance training on muscle strength and endurance***

The muscle strength of healthy elderly people decreases at the level of 0.8% to 3.6% per year, and this speed is more obvious in the ultra-elderly. Aging can cause a large number of motor neurons to decrease. The number of motor units in 60-81 years old people can decrease by up to 47%, resulting in a decrease in muscle strength. Resistance training can effectively alleviate the changes of skeletal muscle in muscle strength, muscle morphology and structure and neuromuscular control caused by aging, and have a positive impact on muscle contraction function. Resistance training has a significant effect on slowing down the decline of muscle strength caused by aging. If the elderly are trained with medium-intensity resistance for a long time, the strength of hip extensor and hip flexor can increase by 30% to 97% [2]. Fiatarone et al. conducted resistance training for 100 frail elderly people for 10 weeks, and the results showed that the leg muscle strength of the strength training group increased by 220% compared with that before the training. For the super elderly over 85 years old, resistance training is also effective in improving muscle strength. Serra et al. performed incremental resistance training of 30%~70% RM three times a week for 20 ultra-elderly people aged 90~97 years [3]. After 8 weeks, the lower limb flexor strength of the subjects increased by 10.6 kg on average. Resistance training can also improve the contraction speed of single muscle fiber. Research shows that the muscle cross-sectional area of the elderly can increase by 4% to 33% after resistance training. A large number of research results show that resistance exercise can effectively increase the length of muscle fibers and feather angle, thus having a beneficial effect on muscle structure. After 30 weeks of resistance training, Pyka et al. it was found that the cross sectional area (CSA) of type I and type II muscle fibers increased by 58% and 67% respectively compared with that before training. Resistance training can also slow down the speed and degree of aging of the neuromuscular system.

## ***2.3 Effect of resistance training on cardiopulmonary endurance***

The decrease of physical fitness level is closely related to the occurrence and development of cardio-cerebrovascular disease and motor system disease. However, due to the different advantages of resistance exercise and aerobic exercise, it is recommended to combine the two types of exercise to improve neuromuscular function and cardiovascular function, thereby improving the fitness of the elderly [4]. Shaw et al. divided the subjects into untrained group and resistance training group. After 8 weeks of resistance training, the maximum oxygen uptake of the resistance training group was significantly higher than that of the untrained group. DosSantos et al. found that the combined training program of aerobic exercise and resistance exercise can effectively optimize the health-related factors such as high-density lipoprotein, diastolic blood pressure, maximum muscle contractility, etc. In the same way, Johannsen et al. found that the combined aerobic and resistance training program has a significant effect on improving insulin sensitivity and blood glucose control compared with single training, and can effectively reduce the risk of death related to cardiovascular disease. However, there is also evidence that for patients with low heart rate and high myocardial (diastolic) perfusion pressure, resistance exercise may be more beneficial to the balance of myocardial oxygen supply and demand than aerobic exercise, so it is necessary to develop individualized exercise prescriptions for different elderly patients, so as to improve the physical fitness level of the elderly more efficiently [5].

## ***2.4 Effect of resistance training on functional ability***

The decline of age-related functional ability is mainly manifested in the loss of muscle mass and muscle strength, the decline of dynamic balance ability, the decline of motor coordination ability, and the decline of rapid muscle contraction ability (RFD/RTD). RFD/RTD is closely related to functional ability and fall risk, and the decline of RFD/RTD with age is faster than the decline of maximum muscle strength [6]. Resistance training can effectively improve RFD/RTD, thus improving the functional ability of the elderly and preventing functional disability. Caserotti et al. found that the explosive heavy resistance training was basically safe and well tolerated for the elderly in the survey of elderly community women aged 60 to 89 years; At the same time, it can optimize the indicators related to the functional ability of the elderly (such as RFD/RTD, maximum muscle strength, vertical jump height, etc.). Orr et al. made a systematic review of the relationship between resistance exercise and balance function of the elderly. Among the 68 balance tests, 14 reported that the balance function of the resistance training intervention group was significantly better than that of the control group, and concluded that resistance training could significantly improve the balance function of the elderly. Topp et al. tested the effect of 12-week dynamic resistance strength training program on the gait speed and balance function of the elderly aged 65 and above. The test results show that the balance ability and

backward walking ability have been improved, and the walking speed has not changed significantly. Resistance training has a significant effect on increasing muscle strength for the elderly with weak muscle strength, but for the elderly with good muscle strength foundation, additional strength increase will not improve the functional performance of daily life. The application of combined training with multi-component training plan can further improve the training effect, such as dynamic resistance training combined with dynamic balance function training (variable speed climbing, resistance station transfer training, etc.).

### **3. Effects of different resistance training prescriptions on muscle strength and muscle endurance**

The explosive force is different from the maximum muscle strength, which reflects the ability of the muscle to develop rapidly, and can indirectly reflect the level of the ability of daily life activities. Compared with muscle strength, the explosive force of the elderly decreases faster[7]. High speed and low resistance training emphasizes that the maximum speed can make the muscle give out the maximum strength in a short time interval. It plays a significant role in improving the maximum muscle strength, explosive force, muscle volume and functional ability of the elderly. Some studies have shown that compared with the traditional resistance training for the elderly (resistance training at normal or slow speed), high-speed and low-resistance training is more helpful to promote the improvement of function. In high-speed and low-resistance training, low and medium-intensity resistance has the best effect on maximum muscle strength, explosive force, muscle volume and functional performance. The effect of resistance training is greatly affected by training intensity and training time. When formulating resistance training prescription for the elderly, it is necessary to fully consider the training intensity, training time and repetition times. In terms of training intensity, a large number of studies have shown that high-intensity resistance training plays a greater role in improving muscle strength than medium-low intensity resistance training; compared with low intensity resistance training, medium intensity resistance training plays a more important role. However, some studies have shown that when the total level of training is basically the same, the impact of training intensity on muscle strength will be weakened[8]. Periodic resistance training has no advantage over non-periodic training in strengthening muscle strength of the elderly; however, compared with constant resistance, variable resistance may be more helpful to improve the physical function of the elderly. Cadore et al. and DaSilva recommended a larger weight bearing and a smaller number of single group repetitions to cause a greater increase in muscle strength. The research results of Borde et al. showed that each action was repeated in 2-3 groups, with 7-9 actions in each group having the greatest impact on muscle strength and quality. Straight and other studies showed that the total number of single action repetitions was 24 (group number  $\times$  Single group repetition=24) has the most significant effect on maximum muscle strength. Some studies have shown that the application of high repetitions and low resistance training has a significant effect on muscle fiber hypertrophy in the elderly. For short-term resistance training and early resistance training, the number of repetitions of each group has no obvious effect on muscle strength; for long-term resistance training, it is more helpful to repeat 3 groups of each action for the increase of muscle strength.

### **4. Impact of resistance training on the health of the elderly**

#### ***4.1 Effect on muscle endurance and strength of the elderly***

With the natural growth of age, the muscle strength of knee extensor and flexor of male and female decreased by about 14% and 16% every decade. The weakening of muscle strength may be related to the occurrence of chronic diseases[9]. The 4-year follow-up prospective study showed that low muscle strength may increase the risk of cardiovascular disease, cancer, pneumonia, falls and fractures. Meta analysis found that the decrease of muscle strength with age may be related to the increase of mortality. In addition, muscle strength may be more important than muscle mass in predicting the mortality risk and body function of the elderly. Resistance training is a safe and effective exercise form of choice to prevent the decline of muscle strength in the elderly, which can prevent the decline of muscle strength in the elderly. Meta analysis showed that the muscle strength of the elderly increased significantly after resistance training. Therefore, it is of great significance to determine the best resistance training method to improve muscle strength. Scholars compared the training response of low intensity and high intensity resistance training (HIRT) in the elderly population and found that compared with low intensity (<60% 1RM), the participants' muscle strength increased more significantly during high intensity (about 80% 1RM) resistance training. In addition, there is a dose-response relationship

between muscle strength and resistance training intensity of the elderly. Peterson et al. said that with the increase of resistance training intensity, the average muscle strength increased by 29% (leg lift+31.6kg), 33% (knee extension+12.1kg), 24% (chest push+9.83kg) and 25% (lateral pull+10.6kg) after 18 weeks of training. In addition, the average change of muscle strength from one magnitude to another is about 5% (low intensity:<60% 1RM, low/medium intensity: 60% ~ 69% 1RM, medium/high intensity: 70% ~ 79% 1RM, high intensity:  $\geq$  80% 1RM). HIRT has also been proved to improve muscle strength of 90-year-old people. Fiatarone et al. used HIRT three times a week for 8 weeks (80% 1RM) for 10 frail elderly people. The results showed that the average muscle strength and muscle mass increased by 174% and 9% respectively, and the walking speed increased by 48%. A meta-analysis conducted by Liu et al. found that progressive resistance training with exercise intensity of more than 70% - 80% 1RM and lasting for more than 12 years can significantly improve the strength of lower limb muscles of the elderly, improve exercise function, and delay the aging decay of skeletal muscles. In addition, Hu et al. performed clinical treatment on osteoporosis patients over 60 years old. According to the analysis of the results of the treatment, compared with the control group (drug treatment) and the aerobic training group (drug treatment+exercise), aerobic exercise combined with progressive resistance exercise has a significant effect on the treatment of osteoporosis in the elderly, with high safety. Pan and others said that low-intensity resistance training can improve the muscle ability and exercise ability of the elderly in the community to a certain extent, but the control group is a group without resistance training, only indicating that low-intensity resistance training is more effective than no training. It can be seen that the effectiveness of resistance training for the elderly and the importance of intensity selection on the training effect have preliminarily proved that high intensity resistance training is better.

#### ***4.2 Regulation of blood and hormones***

Research shows that HIRT is effective in improving insulin sensitivity and blood glucose control in the elderly. During a 16 week progressive resistance training and explosive strength training (2 times/week, 3-5 groups, 5-6 repetitions), it was found that the abdominal fat of elderly men with type II diabetes was significantly reduced by about 11%, and insulin sensitivity was increased by about 46%[10]. Similarly, high-intensity resistance training (80% 1RM) twice a week for six months can improve blood lipids and fasting insulin levels of healthy elderly people. Moro et al. also found that HIRT is not only safe and effective, but also can reduce the levels of basic insulin, total cholesterol, low density lipoprotein and triglyceride in the elderly, and help the elderly control their weight. In addition, Meta analysis found that HIRT significantly increased the glycosylated hemoglobin level in elderly patients with type II diabetes compared with low intensity. However, Zhang discussed the effect of different intensity of resistance training on blood glucose tolerance, and found that after 36 weeks of intervention, BMI, body fat percentage, waist to hip ratio (WHR), OGTT, HOMA-IR, resistin values were significantly lower than those of the previous test. It is also found that resistance training can significantly improve insulin sensitivity and glucose metabolism in people with impaired glucose tolerance. The mechanism may be caused by non-single factors, which may be related to the increase of serum GH, IGF-1 and the decrease of resistin induced by resistance exercise, but not related to the intensity of resistance training. Li et al. showed that 16W resistance training can effectively increase the muscle content of limbs and reduce the level of serum inflammatory factors. The mechanism of long-term resistance training to reduce inflammation may be related to the increase of skeletal muscle content induced by training. The research of Dai shows that the combination of resistance training and protein supplement in the elderly can help maintain the muscle function of the elderly, but the above two studies do not explain the intensity of resistance training. Chen et al. compared the effects of long-term resistance training of different intensities on the carotid compliance of healthy middle-aged and elderly men and women, and found that the carotid compliance of men was significantly lower than that of women in the first four months of moderate intensity resistance training (55% ~ 65% RM), and there was no significant change after four months. The carotid compliance of long-term low intensity resistance training did not have an age-related decline. It can be seen that the effects of resistance training on blood and hormones are significantly improved with the increase of resistance training intensity.

#### ***4.3 Safety and feasibility analysis of high-intensity resistance training***

It is worth noting that there is no significant difference between the intensity of resistance training for the elderly and the exercise persistence and safety accidents. It is even found that high HIRT is safe for the elderly under 96 years old[11]. In addition, the strategy of HIRT may be more interesting to the

elderly, because its intervention time is shorter and its efficiency is higher than that of low-intensity exercise, and high-intensity resistance is still effective within 12 weeks[12]. Although experts and scholars of HIRT program for the elderly are skeptical and cautious at present, limited research suggests that the resistance training program for the elderly should start from the transition period of 5 to 6 weeks, and the training volume should be less than 60% 1RM once or twice a week. After that, when the muscle strength reaches a certain level, gradually increase the training volume (3-4 times per week) and intensity (60%~80% 1RM). Other types of resistance training can also be considered. The latest research found that high-speed resistance training is more effective than traditional low-speed resistance training in increasing muscle strength and improving body function. Similarly, Zhang and others conducted a systematic review of the relevant research on explosive power to improve the physical function of the elderly, and said that the high-speed resistance training program significantly improved the physical function performance of the elderly than the traditional strength training. In addition, Mayer et al. said that progressive high-intensity strength training 3 to 4 times a week can reduce muscle loss and maintain body movement function.

To sum up, due to the significant decline in muscle strength of the elderly, high-intensity resistance training has become a new method of clinical treatment. This program can be considered when carrying out exercise prescription plan for the elderly to prevent muscle strength reduction and promote healthy aging. The implementation of high-intensity resistance training in the elderly needs to consider the basis of individual strength training, and gradually increase the intensity of resistance training in the specific process to obtain the best benefits. However, at present, the safety and feasibility of HIRT need to be reserved. Few studies have confirmed that HIRT is safe and feasible. In the future, the safety and feasibility of HIRT can be further explored. In conclusion, the implementation of HIRT research in the elderly population is limited and the evidence is lacking. It is still necessary to explore the aspects of reducing the risk of death and improving chronic diseases.

## 5. Conclusion

Resistance training has a positive impact on body composition, muscle strength, muscle endurance, cardiopulmonary endurance and balance function of the elderly; Different resistance training prescriptions have different effects on improving muscle performance; Individualized and progressive training prescriptions are mostly tolerated by the elderly. Formulate scientific and effective guidelines and suggestions to help the elderly integrate resistance training into their lives safely and appropriately, which is of great significance to improve the quality of life of the elderly and reduce the social burden. Even though resistance exercise has a prominent effect on improving physical fitness, the elderly with chronic pain, fatigue and less social support still have less resistance training, and the participation rate is low. How to improve the compliance of the elderly with resistance training will be a long-term issue.

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