Long-term effect of two-type exercise capacity on muscle strength and endurance performance in elderly adults

Author: RAHIL ABUBAKER MOHAMMED
Institution: College of Physical Education, University of Sulaimani

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Abstract

Background: Elderly adults have the highest rates of disability because prolongation of life is accompanied by significant changes in body composition, such as a decline in muscle mass and metabolic quality of skeletal muscle. These changes are associated with poor physical activity. The main purpose of this study was to assess the effect of two-type exercise capacity endurance training (ET) and resistance training (RT) on muscle strength and endurance performance in elderly adults.

Objective: Considering muscle strength along with aerobic power decrease with age, we investigated what types of training are more effective in increasing physical performance in the elderly. In particular, we desired to find out whether endurance training is superior to increase muscle strength and whether resistance training can increase the aerobic power of healthy elderly adults.

Methods: For this study, 24 participants (15 women, 9 men), 51 to 61 years old, were randomized into three groups: 8 persons (4 women, 4 men), undertook a continuous 12-weeks ET program, 8 (4 women, 4 men), undertook a continuous 12-weeks RT program and 8 persons (7 women, 1 men) served as a control group. All participants were evaluated with step tests of American College of Sport Medicine (ACSM) to estimate maximal oxygen consumption (VO2max) before and after the training period 12-weeks. Maximum strength was determined from one repetition maximum (1-RM).

Results: The endurance training group improved by 4% in Aerobic power, under other conditions the resistance training group improved by 1.5%, both of which were significant. Maximum strength increased for leg press, bench press, and bench pull respectively by 11 %, 19% and 23% ($P < 0.001$) in the resistance training group, although the endurance training group showed no influence on maximum strength except for the 1-RM in bench pull. Body fat declined in the endurance training group by 3.3% which was significant at ($P = 0.05$), whereas just the resistance training group increased lean body mass by 1.0 ± 0.5 kg.

Conclusion: Our results suggest that a two-type exercise capacity can improve muscle strength and endurance performance and prevent a decline in functional fitness in older individuals, influence their lifestyle and positively affect their ability to stay independent. Resistance training leads to a substantial improvement in muscle strength in healthy elderly adults. Endurance training seems to be the most effective training mode for keeping and increasing maximum aerobic power in the elderly and should be viewed as a complement to resistance training.

استخدام منهج التدريبات التحمل و المقاومة واثرها على القوة العضلية و التحمل الاداء لدى كبار السن

م.م رەهێڵ أبوكر محمد جامعة السليمانية – كلية التربية البدنية وعلوم الرياضية

ملخص البحث

قدرة على العيش الحياة لمدة اطول هو هدف هام لمنظمات الصحة العامة، في نفس الوقت اطالة العمر ينبغي أن تشمل الحفاظ على القدرة على العيش بصورة مستقلة واعتماد على انفسهم. الشيخوخة يرتبط مع فقدان كل من كتلة العضلات ونوعية التمثيل الغذائي في العضلات والهيكل العظمي .ويرتبط جزء كبير من هذه التغييرات مع الانخفاض المرتبطة بالعمر في

مستوى النشاط البدني. ومن هنا جاءت اهمية البحث في اظهار دور التدريبات الرياضية من اجلال قدرة على العيش لمدة اطول و بصورة مستقلة و إمكانية اعتماد على انفسهم.

و من خلال هذا البحث، قام الباحث بالدراسة هذه المشكلة باستخدام منهج تدريبي منقسم الى مجموعتين، المجوعة الاولى يتم استخدام فيها منهجيت التدريب على التحمل Endurance Training (ET) و مجموعة الثانية يتم استخدام منهجيت المقاومة التدريب Resistance Training (RT) . بما أن كلا من قوة العضلات و الطاقة الهوائية يخفضان مع تقدم العمر، لذا اردنا معرفة أي شكل من منهجيت التدريب قد يكون من الأفضل لإدخال تحسينات في الأداء البدني لدى كبار السن.

و كذلك أراد الباحث أن يعرف ما إذا كان منهجيت التدريب على التحمل يمكن زيادة قوة العضلات أو ما إذا منهجيت المقاومة التدريب يمكن زيادة قوة الهوائية لدى كبار السن.

وقد طُبِقَ البحث على عينة على اربعة وعشرون متطوعا اعمارهن ٥١-٦١ سنة من كلا الجنسين و يتم توزيعهم عشوائيا الى ثلاث مجموعات المجوعة منهجيت التدريب على التحمل، مجموعة منهجيت المقاومة التدريب مع المجوعة الضابطة و يتم تطبيق مهج التدريبي لمدة ١٢ اسابيع لكلا المجموعتين، وقد يتطلب البحث باجراء الاختبارات القبلية و البعدية لمجتمع البحث: اجراء اختبار step test لتقييم المستوى اللياقة البدنية (VO2max) ، و كذلك تم تحديد القوة القصوى من التكرار واحدة كحد أقصى (1-RM) .

وكان من نتائج البحث تطور في المستوى اللياقة البدنية لكلا المجموعتين و لصالح المجوعة منهجيت التدريب على التحمل، كما لاحظت تطور في القوة القصوى لدى مجموعة منهجيت المقاومة التدريب.

Introduction

The aging process is linked with a decline in both muscle mass and the metabolic quality of skeletal muscle, also accompanied by notable changes in body composition, identified by declines in lean body mass and raises in fat mass [1]. The loss of muscle mass, especially, is associated with the poor physical performance [1]. A larger part of these changes is linked with an age-related decrease in the level of physical activity that may be prevented by endurance training (ET), and resistance training (RT). It is well proved that ET leads to substantial improvements in maximum aerobic power (VO2max) in elderly adults since an enhanced VO2max is the first specific physiologic response to ET [2]. Aerobic exercise-training studies in the elderly show that healthy older adults adapt physiologically to ET likewise to younger adults [3]. Although ET induces oxidative improvements in skeletal muscle [4], it is less clear whether ET can slow down or reverse sarcopenic processes. Some studies have demonstrated that ET results in little or no improvement in age-related muscle mass or strength [4, 5, and 6]. However, a recent cross-sectional study suggests that long-term ET can delay the onset of sarcopenia up to the age of 70 [7].

The basic physiologic response to RT, even into old age, is an increase in the mass and strength of muscles. In addition to increasing muscle strength, RT improves submaximal muscle performance (muscle endurance) in older adults [8]. The effects of RT on aerobic power have proved controversial [9, 10, and 11]: some investigators consider that RT can significantly improve VO2max in elderly people [12–15], but whether this conclusion is supported by evidence depends on what magnitude of a change constitutes real improvement. For example, Frontera and co-workers reported an increase of 5% in VO2max after 12 weeks of RT in healthy elderly men [13]; nevertheless, although this change was statistically significant, it is substantially below the magnitude of changes reported with ET.

It is clear that the ability to carry out the activities of daily living may be improved with physical training [14, 16]. However, since both muscle strength and aerobic power decrease with age, the question is what form of training might be best for improvements in physical performance in the elderly. Hitherto, data on the effects of ET on muscle strength and the effects of RT on aerobic power among older individuals have been limited and unclear. Our new approach was to measure the long-term effects of ET and RT in elderly adults under precisely controlled *intervention conditions. The present work attempted to answer the following questions:*

- *Can systematic ET augment muscle strength in elderly adults?*
- *Can systematic RT augment aerobic power in elderly adults?*

The null hypothesis was to find improvements in aerobic power after 12-weeks of RT and/or improvements in muscle strength after 12-weeks of ET. However, we expected to find neither a significant increase in aerobic power after 12-weeks of RT, since strength stimulus is too short-lived to improve mitochondrial density, nor a significant increase in muscle strength after 12-weeks of ET since hypertrophy occurs in the normal aging muscle only following increased loading.

Methods

Study population

Twenty-four participants (15 women, 9 men) were recruited through flyers distributed in elderly care homes and clubs. Inclusion criteria were age > 70 years, a healthy cardiopulmonary system and no previous training. Exclusion criteria were participation in an ET or RT program, cardiac arrhythmia, recent myocardial infarction, stroke, cancer or untreated hypertension. The purpose, nature and potential risks of the study were explained to the participants before obtaining their written consent. Volunteers were allocated into three groups using a randomization plan [17] in the order of their consent to participate: 8 (4 women, 4 men) persons (age 56 ± 5 years) undertook a continuous 12-weeks ET program, 8 (4 women, 4 men) persons (age 54 ± 5 years) a continuous 12-weeks RT program and 8 (7 women, 1 men) persons (age 54 ± 5 years), who underwent all examinations but did not participate in the training exercises, served as the control group. We advised the control group not to change their lifestyle during the 12-weeks study period.

Testing

The medical history was taken and clinical examination performed in all three groups immediately before and at the end of the training period.

Maximum oxygen consumption: *To measure maximum oxygen consumption by the step test, stairs with the height of 40 cm were used for participants so that the person who was being tested went up and down for 5 minutes and every minute 22.5 times, and then the frequency of going up and down was obtained. After the test, by using the subject's age and heart rate measured immediately after the test (beats per minute) (4) maximum oxygen consumption was calculated by the following equation [13]:*

$$VO2max = AG\,(131.5 \times VO2)/(HR + GF - 72)$$

Where:

VO2-Max: maximum oxygen consumption (l/min)

HR: heart rate (beats per minute)

GF: sex factor (for men 10 and for women zero)

AG: age correction factor obtained by the following equation: AG = 1.12 - 0.0073 age. In this formula age is person's age.

VO2 (oxygen consumption) in the above formula is calculated by the following equation (5):

$$VO2 = (0.35 \times f) + (2.395 \times f \times h)$$

In this formula:

F: frequency of going up and down the steps (step per minute)

H: step height (m)

Vo2: oxygen consumption at a steady-state (ml/kg/min)

Maximum strength: *Maximum muscle strength was determined from 1 repetition maximum (1-RM in k) using the Concept 2 Dyno (Concept 2 Ltd, Wilford, Notts, UK). 1-RM is defined as the maximum strength that a muscle group can generate with a single contraction. Resistance is created in direct response to the participant's effort. After each completed lift, a monitor shows how much weight has been lifted. Concept 2 Dyno has three basic positions for the determination of muscle strength using the 1-RM. A maximum of three tests is allowed, to avoid muscle fatigue. The three representative exercises include bench press (m. pectoralis major/minor), bench pull (m. latissimus dorsi) and leg press (m. quadriceps femoris, m. glutei, ischiocrural muscles), all performed in a seated position.*

Anthropometric measurements:

1. Body mass index: All participants had body weight (Seca, Hamburg, Germany) to the nearest 0.1 kg and height to the nearest 0.1 cm recorded while wearing light indoor clothes but no shoes. BMI was calculated as weight divided by height squared (kg/mÇ).

2. Fat mass: The same person measured all skinfolds with calipers (Model Caliper GMP; Siber Hegner Maschinen AG, Zürich, Switzerland) and recorded them to the nearest 0.1 mm. To minimize inter observer variation; the same experienced instructor assessed each patient's skinfold. A mean of three measurements was considered to be representative. Measurements were taken at 10 body locations (bucca, chin, chest, mid-axillary-suprailiac, thigh, abdomen, triceps, sub scapula, calf, and knee). Percentage body fat was estimated using the following sex-appropriate equation [18]: BF (%) = BW x √ {[(sum of mean values of the 10 skinfold measurements – 40) / 20 x BS x .739 / BW] –.003} x 100 where body weight (BW) is measured in kg and body surface

(BS) is equal to .007184 x BW.425 x height.725.

3. Lean body mass: This was calculated as total weight minus fat mass.

Training program

***Endurance training**: Systematic ET was performed on a cycle ergometer on three non-consecutive days of the week. During the first four weeks, ET participants trained for 15 minutes per session, three times per week. Exercise sessions were increased by 5 minutes every four weeks. The total exercise time per week, during the last four weeks, excluding warm up and cool down, was 120 minutes. HR was monitored continuously throughout the training period (POLAR Electro, Kempele, Finland). Based on the linear correlation between VO2max and HR, training was controlled by an HR according to 60% of VO2max. This was derived from algometry using the following formula [19]: HR = HR rest + (HRmax – HRrest) x 0.6 ± 5 beats/min, where HRrest was HR after a break of 10 min, in supine position. Thus, the stress in relation to the maximum power was constant over the training period according to 60% of VO2max.*

Resistance training: *Systematic RT was performed on three non-consecutive days of the week. A brief warm-up period that involved 10 min low-intensity cycling was performed before each training session. Instructions on correct exercise techniques and supervision of the patients throughout the entire training period were given by a professional instructor and an experienced physician. During the first two weeks, the exercise weights were kept to a minimal level so that the patients could learn the techniques and allow their muscles to adapt to the training, as well as to prevent muscle soreness. From the third week the objective of the training was hypertrophy. Participants started with three sets per muscle group per week. One set consisted of 10–15 repetitions without interruption, until severe fatigue occurred and completion of further* *repetitions was impossible. The training load was systematically increased to keep the maximum possible repetitions per set between 10 and 15. A repetition maximum from 10 to 15 repetitions corresponds to 60–70% 1-RM. When more than 15 repetitions were successfully performed at a given weight, the weight was increased by an amount that permitted approximately 10 repetitions to be performed. The number of sets for each muscle group was systematically increased from three per week at the beginning of the program to finally six sets per week at the end. The RT program consisted of exercises for all major muscle groups. Exercises to strengthen the upper body included bench press (pectoralis), chest cross (horizontal flexion of the shoulder joint), shoulder press (trapezius), pull downs (latissimus dorsi), bicep curls, tricep extensions and exercises for abdominal muscles (sit-ups). Lower body exercises included leg press (quadriceps femoris).*

Statistical analysis

The statistics software SPSS version 11.0 (Statistical Package for Social Sciences, SPSS incorporated, Chicago IL) was used for statistical analyses. The arithmetic mean and the standard deviation were calculated for all data. Analysis of variance was used to compare pre- and post-training data within the groups. One-factorial ANOVA with post-hoc tests by Sheffé was used to compare differences between the groups. P values < 0.05 were considered statistically significant.

Results

At study entry, all three groups of volunteers had similar profiles for all parameters examined except for the 1-RM in leg press. Participants who undertook RT had higher baseline levels than the ET group and the control group.

Changes in muscle strength

After the 12 weeks training period, there were highly significant changes in the maximum strength of all measured muscle groups for the RT group and between the training groups for bench press and bench pull. Maximum strength increased by an average of 11% for leg press (from 76.90 ± 23.95 kp before to 82.10 ± 23.73 kp after the RT period, P = 0.008), 19% for bench press (from 36.30 ± 14.27 kp to 43.00 ± 18.29 kp, P = 0.001) and 23% for bench pull (from 39.60 ± 15.95 kp to 51.80 ± 16.30 kp, P = 0.000). ET showed no effect on maximum strength except for the 1-RM in bench pull, with a significant improvement of 15% (from 27.33 ± 8.40 kp before to 33.42 ± 10.34 kp after the ET period, P = 0.003). Data on muscle strength are shown in Table 1. Changes in strength of all measured muscle groups for each training group are shown in Fig. 1.

Changes in aerobic power

Maximum oxygen uptake improved by 4% for the ET group and 1.5% for the RT group, neither of which was significant. Significant differences were also observed in maximum HR (P = 0.033) for the ET group after the training period. Cardiorespiratory data are shown in Table 1. Changes in VO2max for each training group are shown in Fig. 2.

***Table 1.** physical characteristics, muscle strength and cardiorespiratory endurance before and after endurance training (ET), resistance training (RT) and control (CO)*

	ET group		RT group		CO group				
	X±SD	P	X±SD	P	X±SD	P	P (E-C)	P (R-C)	P (E-R)
Age	**56±5**		**54±5**		**54±5**				
BMI Pre	**26.04±4.66**		**28.35±3.64**		**26.05±3.53**				
BMI Post	**26.24±4.73**	**0.378**	**28.33±3.36**	**0.962**	**25.99±3.57**	**0.774**	**0.842**	**0.996**	**0.860**
BW Pre (Kg)	**65.17±12.01**		**77.20±11.51**		**67.00±10.91**				
BW Post (Kg)	**65.67±12.29**	**0.389**	**77.10±11.46**	**0.925**	**66.29±10.89**	**0.356**	**0.594**	**0.881**	**0.853**
% BF Pre (%)	**40.23±5.89**		**38.83±4.88**		**36.09±9.46**				
% BF Post (%)	**38.09±4.40**	**0.032***	**37.24±4.59**	**0.207**	**34.52±8.54**	**0.988**	**0.424**	**0.636**	**0.918**
HR_{max} Pre (1/min)	**131.5±20.5**		**141.0±26.8**		**139.0±20.1**				
HR_{max} Post (1/min)	**136.7±17.1**	**0.033***	**135.7±22.7**	**0.331**	**136.5±19.1**	**0.755**	**0.544**	**0.921**	**0.250**
VO_{2max}/Kg pre (ml/kg per min)	**18.59±5.30**		**19.15±5.87**		**17.61±3.74**				
VO_{2max}/Kg post (ml/kg per min)	**19.40±5.08**	**0.068**	**19.64±5.22**	**0.648**	**19.90±3.14**	**0.342**	**0.358**	**0.769**	**0.737**
Leg press pre (KP)	**51.83±23.49**		**76.90±23.95**		**63.86±16.12**				
Leg press post (KP)	**57.42±21.71**	**0.136**	**88.10±23.73**	**0.008***	**69.43±22.30**	**0.159**	**1.000**	**0.581**	**0.491**
Bench press pre (KP)	**24.50±7.44**		**36.30±14.27**		**28.57±8.56**				
Bench press post (KP)	**26.17±8.54**	**0.186**	**45.00±18.29**	**0.001***	**29.43±10.00**	**0.510**	**0.931**	**0.006***	**0.004***
Bench pull pre (KP)	**27.33±8.40**		**39.60±15.95**		**31.86±7.24**				
Bench pull post (KP)	**33.42±10.34**	**0.003***	**51.80±16.30**	**0.000***	**32.71±8.20**	**0.604**	**0.993**	**0.001***	**0.055**

The arithmetic mean (X) with standard deviation (SD), probability of error between pre and post within the groups by analysis of variance (P), probability of error between ET and CO,

P(E-C), RT and CO, P(R-C), ET and RT, P(E-R) by one-factorial ANOVA with post-hoc tests by Sheffe for the mean changes after the study period in body mass index (BMI), body weight (BW) body fat content in percent (%BF), maximum heart rate (HRmax), maximum oxygen uptake in ml/kg/min (VO2max), and maximum strength in kp for leg press, bench press and bench pull before (pre) and after (post) the training period. Significant result*.

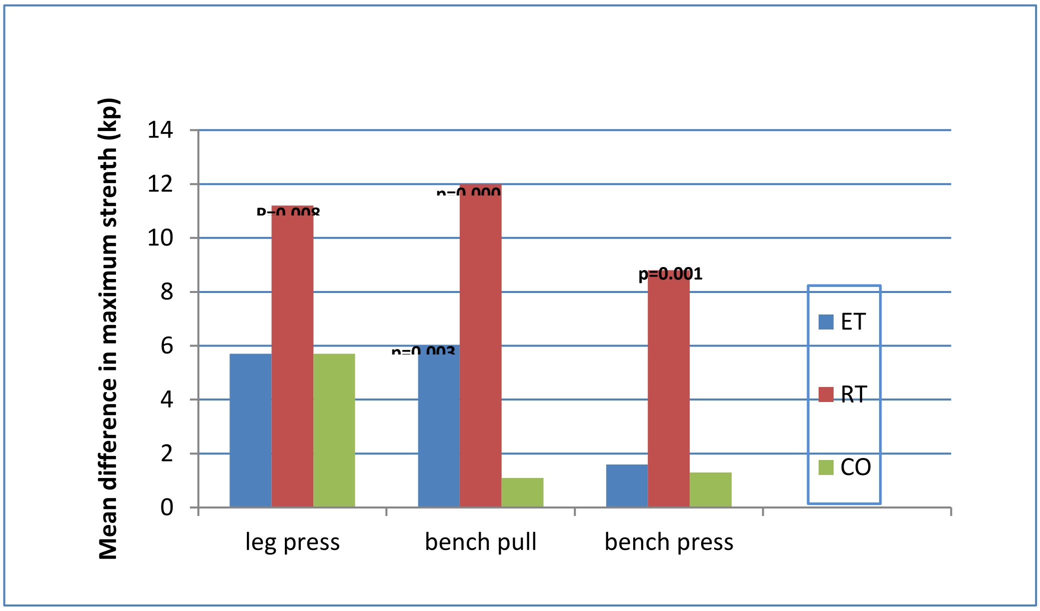

Fig. 1. Mean difference in maximum strength (kp) before and after endurance training (ET), resistance training (RT) and control (CO) for three exercises (leg press, bench pull, bench press). P-values represent the probability of error between pre and post data within the groups

Changes in body composition

After the training period, no significant differences in body weight were observed within or between the groups (Table 1). However, a significant difference was observed in percentage body fat in the ET group before and after completion of the ET program (from 40.23 ± 5.89 %BF to 38.09 ± 4.40 %BF, P = 0.032).

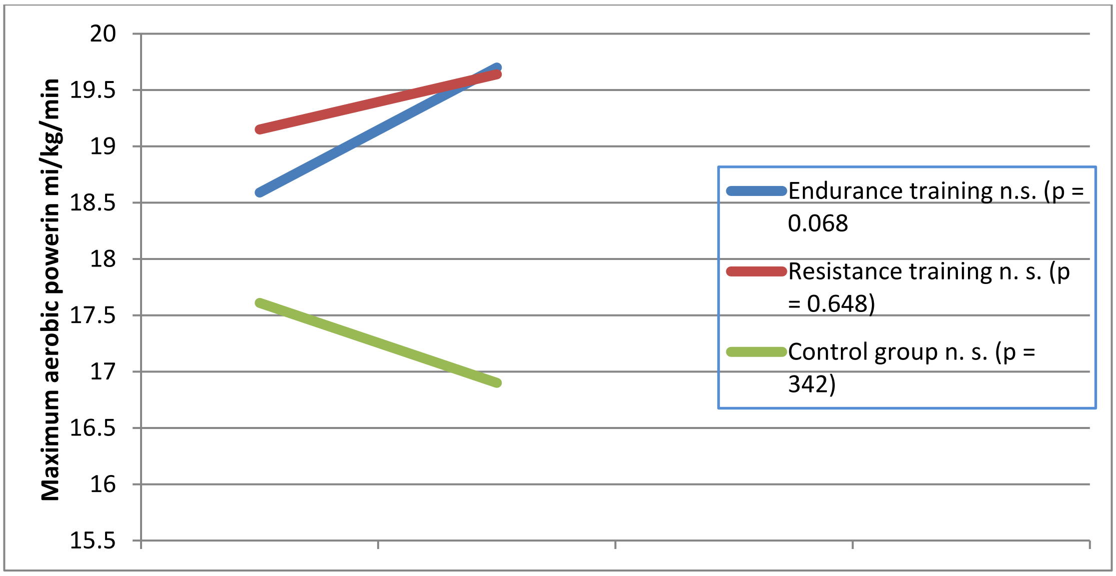

Fig. 2. Maximum aerobic power (VO2max) of the groups before and after the training period

Discussion

The key finding of our study on the efficacy of systematic ET or RT in elderly adults was an improvement in maximum strength (1-RM) by an average of 11% for leg press, 19% for bench press and 23% for bench pull after 12 weeks of RT, whereas ET showed no effect on maximum strength except for the 1-RM in bench pull. Aerobic power improved by 4% for the ET group and 1.5% for the RT group, neither of which was significant. ET resulted in a significant 4% reduction of body fat but only RT increased lean body mass by 1.0 ± 0.5 kg. 1-RM of all muscle groups increased after 12 weeks of RT (15–30% above initial levels) in contrast to no improvements after 12 weeks of ET, with the exception of an unexpected increase in bench pull. This could perhaps be explained by the systematic pulling on the handlebar during cycling. These results clearly highlight the physiologic specificity of exercise training and confirm results of other studies [4–6] demonstrating that ET has little or no effect on mass or strength of muscles in older adults. Thus, only RT has the ability to attenuate the dramatic losses of muscle mass associated with advancing age: approximately 0.5–1% per year from the 4th decade onwards [20]. The effectiveness of ET was shown by a 4% increase in VO2max. The difference in increase between the two may be due to better coordination of movement and thus better mechanical efficiency. It appears that the difference may also be influenced by an increase in anaerobic muscle metabolism after 12 weeks of ET. Based on the results of our study, training at moderate intensity levels, defined as 60% of HR reserve, is sufficient to achieve improvements in aerobic power. The physiologic adaptations attributed to ET may allow the trained older adult to better tolerate submaximal workloads such as those encountered during day-to-day functional activities. For example, a typical sedentary older woman with a VO2max of 17 ml/kg per min may have difficulty walking faster than 3 km/h for a sustained period of time and usually cannot climb more than 20 steps/min, since these tasks represent an increasing percentage of the individual's maximum aerobic power.

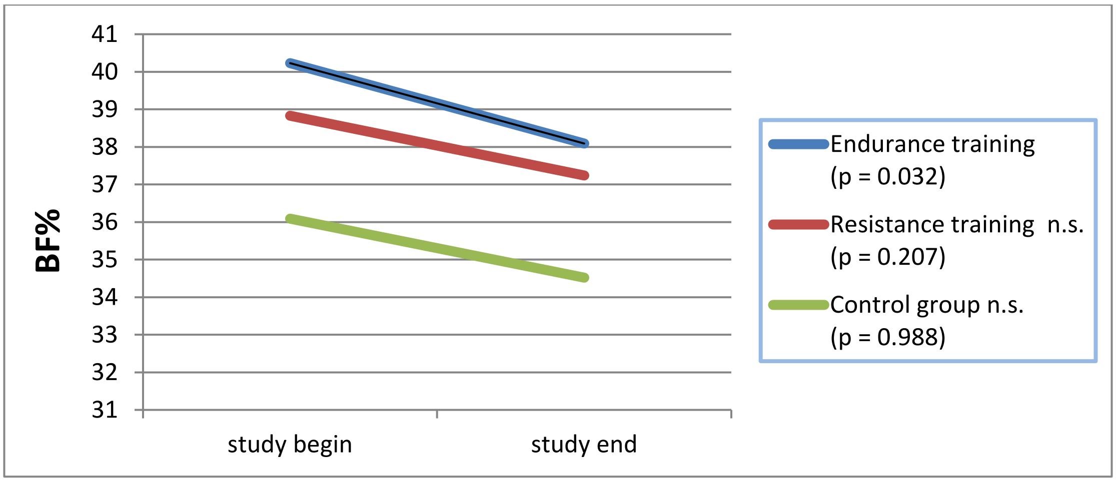

Fig. 3. Percent of body fat (%BF) before and after endurance training, resistance training and control

The effects of RT on cardiorespiratory parameters were only moderate and not significant; the strength stimulus is too short lived to improve mitochondrial density and therefore aerobic power. These findings are a direct result of the specificity of the training stimulus and show that the training was adequate in both groups [11, 21]. In some studies of healthy elderly people, aerobic power also increased after a period of RT [12, 15, 22, and 23]. However, improvements in VO2max were probably related to increased leg strength and were within the range of normal biological and/or methodological drifts as reported in inactive control groups during similar *time periods [24]. Furthermore, when VO2max values were corrected for gains in fat-free mass the increase was markedly reduced. Nevertheless, RT may elicit other more generalized adaptations that might benefit the cardiovascular systems of older adults. Parker and coworkers reported that 16 weeks of RT significantly decreased HR, blood pressure and rate pressure product, as an index of myocardial oxygen uptake, during a submaximal treadmill-walking test in women aged 60–77 years [25]. Possible explanations for these submaximal cardiovascular adaptations include changes in recruitment of fiber types, reduced occlusion of blood flow and increased lactate threshold [26, 27]. Before the training period, no significant differences in body composition were observed between the training groups and the control group, and after the training program was completed, there were no significant differences in weight loss between the groups. However, a significant reduction in body-fat percentage was observed within the ET group. This change was not significant between the groups. It was not surprising that ET resulted in greater fat losses compared with RT because the RT program required less than a third of the energy required for the ET program. It has been shown that RT can increase resting metabolic rate as a result of a greater muscle protein turnover and may complement the increase in caloric expenditure produced by ET [28]. An increase in the rate of muscle protein synthesis has been observed following regular RT even in frail elderly individuals (>70 years) [16, 29].*

RT tends to increase lean body mass, therefore if body weight remains constant there will be a loss of fat or adipose tissue [30]. In our study we found an increase in lean body mass with RT, together with a moderate but not significant reduction in the percentage of body fat so that body weight remained constant. Thus the main effects of RT on body composition are a breakdown of body fat and a simultaneous build up of muscle mass. These results are most important in the older adult, since decreases in the mass and strength of muscles directly affect functional ability [31]. Reduced lower extremity strength independently contributes to an increased risk of falling [32], as well as to increased mortality after bone fractures [33]. A recent study has demonstrated that RT in older persons can result in an increase in muscle mass and quality, and that these changes are not age dependent but tend to be less in women than in men [9]. In our study lean body mass was increased by approximately 1.0 ± 0.5 kg in the RT group and, interestingly, we found no sex differences in the response to RT. Similarly to our results, a study published by the American Geriatrics Society indicates that neither age nor sex affect muscle size and strength response to whole-body RT [34]. However, a recent study demonstrates limited skeletal muscle plasticity at the level of the single muscle fiber following a RT program for the very old [35] and confirms the results of an earlier study showing that the gain in muscle mass with RT is greater in younger than in older adults [36]. Our study has at least two limitations, namely the limited number of volunteers recruited for the study and that the majority of them were women. Clearly, sex differences in the response to RT do exist [9, 37, and 38]: older women have a blunted hypertrophic response to RT at the whole muscle and my cellular level [37]. However, another study in healthy 75-year-old women and men has clearly demonstrated that at this age the sex related differences in muscle strength are extensively reversed [23]. It was found that, if the differences in body mass between women and men were taken into consideration, the commonly known sex-related differences in muscle strength are partially nullified [39]. Muscle strength, therefore, probably has an aging effect similar to that reported for aerobic power, whereby the sex differences in aerobic power approximately cancel each other out at 75 years of age [40, 41]. In summary, RT leads to a genuine increase in muscle *mass and muscle strength in healthy elderly adults. Systematic RT is, therefore, a method for the treatment of amyotrophic and can be highly recommended in the elderly [42, 43]. However, pure muscle training cannot significantly increase maximum oxygen uptake. Owing to specificity of training effects, a combination of both RT and ET might be best for optimal physical function and health in the elderly. Further research is needed to clarify synergistic adaptations or potential impairments with combined training on functional ability and health in the elderly. ET appears to be the most efficacious training mode for maintaining and improving maximum aerobic power and cardiovascular function in this age group [44]. Nevertheless, we suggest that RT might be the best training method for improvements in physical function and frailty in the elderly. First, most functional tasks used in normal day-to-day activities are of relatively short duration and therefore more strongly related to muscular strength [45]; second, previous studies in older adults have shown that performance of daily- living activities is improved following RT [16, 46, 47].*

Conclusion

Although both RT and ET can favorably modify many health and fitness variables, the expected magnitude of the benefits is substantially different. ET induces improvements in maximum aerobic power and may more effectively modify cardiovascular risk factors. RT enhances muscular strength and muscle mass to a much greater extent and tends to contribute to the prevention of metabolic risk factors associated with reduced muscle mass in advancing age. Furthermore, RT in older adults markedly enhances body composition with a breakdown of body fat and a simultaneous build-up of muscle mass. These findings are most important in the older adult, since decreases in muscle mass and strength directly affect functional ability. These beneficial adaptations are dependent upon the training stimulus. We offer some basic guidance for designing programs based on results from our lab [23, 48]. Thus, the loading intensity to promote hypertrophy should approach 60–80% of 1-RM with an exercise volume ranging from 3 to 6 sets per muscle group per week of 10–15 repetitions per exercise. ET should be viewed as a complement to RT and should be performed on two days per week and controlled by an HR according to 60% of VO2max and an exercise volume ranging from 30 to 60 minutes per week.

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