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FUNCTIONAL AND MUSCULAR GAINS IN OLDER ADULTS: MULTICOMPONENT VS. RESISTANCE EXERCISE

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Abstract: *Background:* Progressive resistance training (PRT) and multicomponent training, the latter incorporating neuromotor exercises such as balance, agility and coordination, are currently recommended to maintain functional ability in older individuals. While PRT has proved effective, the efficacy of multicomponent training for healthy individuals is less certain. *Objective:* This study investigated the efficacy of group-based multicomponent training exercise compared to PRT for improving functional ability, muscular strength and power in healthy, older individuals. *Design and Participants:* Thirty-nine males and females aged 65 to 75 were allocated to either multicomponent or PRT training twice weekly for three months. They were tested at baseline (T1), following a four-week control period (T2), and post-intervention (T3). *Measurements:* Functional ability by habitual and maximal walking speeds and chair rise time; muscular strength by isometric hand grip and isokinetic knee extension and flexion, and lower limb peak power by countermovement jump. *Results:* Two-way repeated ANOVA showed effects irrespective of training type for maximal walking speed (+7%; F=11.4 p<0.000), chair rise time (-18%; F= 29.4 p<0.000) and peak power (+8%; F = 24.7; p<0.000). Knee extension (+26%; F = 7.6; p<0.001) and flexion (+35%; F = 11.1; p<0.000) torques increased only with PRT. *Conclusions:* Both forms of training improved functional ability in healthy older individuals. PRT was confirmed to be effective for the enhancement of both muscular strength and power. Multicomponent training did not enhance strength, although peak power was improved which may be relevant for the maintenance of independence in older people. The present findings add to the limited evidence on the efficacy of multicomponent training in healthy older adults and may help to define exercise recommendations for this population. This may represent an important element in the strategy for the postponement of functional decline and compression of morbidity in this population.

Key words: Walking speed, lower limb strength and power, group-based exercise, neuromotor exercise, progressive resistance training, elderly.

Introduction

With the over-65 population rapidly expanding, concerns have been raised about the humanitarian and economic costs associated with the future potential loss of independence in this age group. In order to find practical and effective ways of maintaining a "functionally capable" older population, the effects of aging, disuse and exercise have been extensively studied. In particular, the role of muscular strength and power training for independent living has undergone considerable scrutiny. It is well documented that the age related reduction in strength and power observed with aging is mainly caused by the progressive reduction in muscle mass due to loss in muscle fibers and atrophy of remaining muscle fibers especially fast twitch ones (1) as well as infiltration of non contractile tissue (collagen, fat). As concerns muscle power this has been proved to be more affected by aging than muscle strength (ibid) a phenomenon which has been reported having profound consequences for motor performance (2).

Progressive resistance training (PRT) has been clearly shown effective for both strength and power enhancement in older individuals and has been widely used in this population (3). However, it may not be optimal for all functional outcomes (ibid) and, more importantly, may not represent the first choice of exercise for the over 65's, especially women, who may prefer other kind of activities (4, 5). It is of interest, therefore, to establish the functional and physical fitness benefits of

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alternative exercise regimes for the elderly (6).

One such alternative, often described as multicomponent exercise, incorporates broad fitness objectives such as improved flexibility, balance, coordination, agility and strength, and may take the form of group-based classes, frequently performed to music (7, 8). While the efficacy for functional outcomes has been investigated in frail, older individuals (9, 10), little is known about the responses in healthy older populations. The prescription of such skill-enhancing exercises incorporating balance, agility and gait have been recently categorised in the ACSM exercise guidelines as "neuromotor" (6). However, the specific benefits for healthy older adults and the necessary evidence to formulate exercise delivery guidelines and prescription are still lacking. Nevertheless, considering that in daily life the moving person is subjected to environmental requests stimulating proprioceptive, auditory, visual, vestibular and tactile systems, neuromotor exercise may help reproduce such demands and enhance the ability to perform daily activities more than exercising singly muscular strength or power.

To the best of our knowledge no previous studies have investigated the effectiveness for improving functional ability, muscular strength and power in older populations, of multicomponent training, including neuromotor exercises, compared to the more established PRT.

Therefore, the present study compared group-based multicomponent (including neuromotor exercises) training and PRT for improving functional ability, muscular strength and power, in healthy older individuals. Based on available evidence, it was hypothesized that PRT would improve strength, power and functional ability while MCT including neuromotor exercises, by stimulating coordinative/perceptive elements, would improve functional ability more effectively than PRT.

Materials and Methods

Participants

Following institutional ethics approval, 316 men and women aged between 65 and 75 were contacted. Of these, 77 met the following inclusion criteria: a) not taking part in regular physical exercise more than once weekly, b) being "medically stable" established via a medical history questionnaire (11) and including any pathological conditions that could potentially influence study outcomes. Moreover, they were screened for daily living independence using the Lawton and Brody (12) questionnaire. Finally, 50 (30 women and 20 men) were selected to participate based on interest and availability. After written informed consent was obtained, they were allocated to a multicomponent or PRT group. For recruitment purposes not all participants (20 out of 42) were randomised. The first 14 recruited participants formed a MCT group, the following 6 a PRT group and the remaining were randomised to either training group balancing age and gender composition of the different groups (e.g. if more women than men were present in the first MC group, more men were allocated to the second MC group and similarly for age).

Measurements

Following familiarization with all testing procedures, participants were tested three times; at baseline (T1), following a four-week control period (T2, during which they were asked not to change their lifestyle), and at post-intervention (T3). Body mass and stature were measured following standard anthropometric protocols. Body composition was measured via dual energy x-ray absorptiometry (DEXA; GE Healthcare Diagnostic Imaging, UK) to obtain percentage of body fat (%), and lean mass (g).

Isometric hand grip strength of the dominant hand was measured after adjustment for hand size, with the participant standing and relaxing their arm along their body (Baseline Hydraulic Hand Dynamometer Fabrication Enterprise Inc. Irvington NY). Two trials were performed with 1 minute rest in between and the highest score used for statistical analysis.

Peak power of the lower limbs was assessed with a countermovement jump performed on a force platform (AMTI's BP400600-2000, Advanced Mechanical Technology, Inc. MA, USA) following widely used procedures (13,14). From an upright posture, with feet shoulder width apart and hands on hips, participants flexed their knees as fast as possible to a knee angle of about 90°, before forcefully extending to perform a vertical jump. Peak power, normalized for body mass (PPkg=W/kg), was calculated as previously described (15). ICC for this test (4 weeks interval) was 0.95.

Maximal knee extension and flexion torques (Nm) were measured on the dominant limb during a maximal voluntary contraction using an isokinetic dynamometer set at an angular velocity of 60°s (Biodex System 3 Pro, Biodex Medica System Inc. NY). Subjects performed from a starting position approximately 90° at the knee, four consecutive maximal flexions and extensions of the limb. Verbal encouragement was given throughout the test. Peak torque of the best flexion and extension was calculated. ICC were respectively 0.96 for knee extensors and 0.90 for knee flexion torques.

Lower body flexibility was assessed using the chair version of the sit & reach test (16). ICC for the right and left side measurements test were 0.96 and 0.95 respectively.

Functional ability assessment included walking speed measurements under different conditions reproducing some of the possible challenges of daily life (adapted from 17) and chair rise time (18). Walking speed was measured on a 10 metres indoor course using measuring gates (Smartspeed, Fusion Sport, Coopers Plains, Australia). Participants were asked to walk at "the speed at which they would walk to the shops" and "as fast as possible without running" respectively for habitual and maximal walking speeds assessement. Subsequently, maximal walking speed was measured while walking the same course, but a) stepping over two plastic hurdles (45 cm wide and 15 and 45 cm height) placed in succession on the mid line of the track at 2 and 4 m distance from the 1st timing gate, and b) picking up two hand weights of 250 gr. each placed at 2 m and 4 m from the 1st timing gate at about 50 cm distance from the mid line of the track. Each walk was performed twice. Habitual walking speed was averaged, while the best time of the maximal walks was used for the subsequent analysis. Times were recorded to the nearest millisecond and transformed into m/s. ICC computations confirmed the stability over time (habitual walking speed 0.87; maximal walking speed 0.85: picking up walking speed 0.87; obstacle walking speed 0.84) generally reported in the literature (17).

The time required to rise from sitting five times as fast as possible from a standard 43 cm height chair was measured with participants folding arms across their chest. Recordings were made using a stopwatch starting at the initiation of the movement and stopping when subjects stood upright for the 5th time (18). The calculated ICC for this test was 0.79.

Exercise programmes

Exercise classes started immediately following the control tests (T2), with both training groups exercising for one hour and 15 minutes twice weekly for 12 weeks. Exercise classes of both groups were guided by qualified and experienced personnel.

The multicomponent class incorporated 15 min of general warm-up leading to a 30 minute conditioning period of coordination/balance/ strength/ agility, followed by 30 min of floor exercises including stretching, strengthening and relaxation exercises.

During the general warm-up which included walking in different directions, varying step length, width, contact of foot to the floor (toes, heels), participants progressively stretched (while walking) all major joints i.e. shoulders, elbow, wrists, spine, hips, knees and ankles. Thereafter, the classes aimed to stimulate overall function concurrently with perceptive and co-ordinative components of movement, in order to reproduce as far as possible the different challenges encountered in daily life exercises. Most exercises required moving through space and stressed distance, time, terrain, traffic, postural transition, external load, attentional demands and ambient conditions (17). Walking, light skipping and jogging were utilised, with increasing degrees of difficulty by, for example, avoiding obstacles or people, picking objects off the floor, negotiating steps or obstacles or reducing visual input. A variety of hand held equipment was used during the classes to provide external loads/focii of attention i.e. foam balls, medicine balls, bean bags, sticks and dumbbells. In addition, alternate classes involved exercises in stations, with 2 to 4 participants in each with different objectives (static/dynamic balance, agility, hand-eye coordination and attention e.g. tossing a ball with a partner while alternatively walking through an obstacle course or sitting down and subsequently standing up from a contiguous line of chairs e.g. postural transitions). Floor exercises included strengthening of the major muscle groups i.e. abdomen, back, upper and lower limbs and stretching and relaxation exercises were performed at the end of each class.

The PRT session consisted of an initial 10 minutes during which participants actively warmed up by performing, while walking, movements of flexion, extension and rotation of the joints to be used in the conditioning session. Thereafter, at each exercise session, participants completed in a circuit, a total of twelve strength exercises alternating muscle groups and machines with free weights/floor exercises. These included machine exercises for knee extension, knee flexion, lateral pull-down, chest press and front rowing; free weights/floor exercises for biceps, triceps and deltoids, lower limbs (ie, squats, stepping), abdominals and back extension. At the machines, three sets of eight repetitions at 60% of one repetition maximum (1RM) for the first two weeks and 80% 1RM thereafter were performed for the entire training period. For a double check, participants were instructed to keep intensity at 15-17 of the rate of perceived exertion (RPE) as this has been reported to correspond to about 80% of 1RM (19). To maintain constant training intensity after the initial two weeks, the 1RM test was repeated every four weeks. For the other exercises, the same volume (sets by repetitions) was applied using body weight initially and then progressively overloading with external devices (ie, weights disks or dumbbells) with intensity controlled by requiring participants to exercise at 15-17 of the rate of perceived exertion (RPE).

Statistical Analysis

Power calculations to estimate the minimum sample size were performed using the following outcome variables obtained from previous studies adopting test retest analysis: 1RM of knee extensors (sd 11, pre/post mean difference 11.5 kg, estimated 8 participants within group effects; [20]), maximal walking speed (sd 2.2, pre/post mean difference 1.2s, estimated 21 participants within group effects [7]). Taking into account an 85%

power that the study will detect a treatment difference at a two-sided alpha (probability) level of $p<0.05$ to reject the null hypothesis and an anticipated drop-out of 30%, the calculations indicated sample sizes between 7 and 21. We therefore aimed to form two exercise groups of 25 participants each to have final number of 20 in each group.

The effects of the two training formats were compared through two-way repeated ANOVA. When a main Time effect was observed, post hoc analysis was performed with multiple t-tests (Bonferroni correction). In case of an interaction effect, a one-way repeated ANOVA was carried out separately for the two groups followed by post hoc multiple t-tests (Bonferroni correction).

Cohen's d was used to evaluate the magnitude of the treatment effect, with 0.2, 0.5, 0.8 considered respectively small, moderate and large effect sizes. A significance level of $p<0.05$ was used in all statistical analysis using PASW (SPSS Inc, Chicago, IL, USA)" (18).

Results

Participants' compliance with the training programmes was 87% for both groups. The exclusion threshold for low attendance was set at missing more than 25% of the total number of classes. Eight participants were either lost at follow up or dropped out (4 belonging to the PRT and 4 to the MCT). Reasons for discontinuing the intervention included the development of knee pain (one), anticipation of a scheduled operation (one), partner sickness (one) and no explanation (one). Two PRT participants and one MCT participant, although completing the allocated intervention, were lost at follow-up due to sickness on the day of testing. A further MCT participant had to be excluded for low compliance leaving the sample to 42.

Age and physical characteristics of participants at baseline are reported in Table 1. No significant differences between the groups at baseline in any measurements were observed.

Table 1

Age and physical characteristics of participants (MCT= multicomponent group; PRT= progressive resistance training)

Variables	MCT x,¯ ± SD (n=21)	PRT x,¯ ± SD (n=18)	All x,¯ ± SD (n=39)
Age (years)	69.9 ± 3.0	69.9 ± 3.5	69.9 ± 3.2
Body mass (kg)	74.0 ± 9.4	70.4 ± 9.7	72.3 ± 9.6
Stature (cm)	167.6 ± 7.9	167.1 ± 7.8	167.4 ± 7.7
Body Fat (%)	35.9 ± 7.6	31.6 ± 8.3	34.0 ± 8.1
Lean mass (kg)	45.5 ± 7.9	46.4 ± 9.7	45.9 ± 8.7

Following training significant improvements in most of the functional ability and fitness parameters were apparent in both groups.

Regarding functional ability (Table 2) a main Time effect was observed in habitual walking speed ($p<0.001$; d = 0.75), maximal walking speed ($p<0.001$; d = 0.60), picking up ($p<0.001$; d = 0.39), stepping over hurdles ($p<0.001$; d = 0.47), and chair rise time ($p<0.001$; d = 1.01).

For the muscular fitness variables (Table 2) a main Time effect was observed for PPkg ($p<0.001$; d = 0.40), and hand-grip ($p<0.01$; d = 0.12).

The post hoc analysis of all these variables, except habitual walking speed, showed no change following the control period (T1 versus T2) but significant improvements following training (T1 versus T3 and T2 versus T3).

Table 2

Data of walking speeds (WS), chair rise time, peak power and hand-grip for all participants at baseline (T1), control (T2) and following training (T3) and ANOVA results of main effect for time are reported (MCT= multicomponent training group; PRT= progressive resistance training; PPkg= lower limbs peak power normalised to body mass)

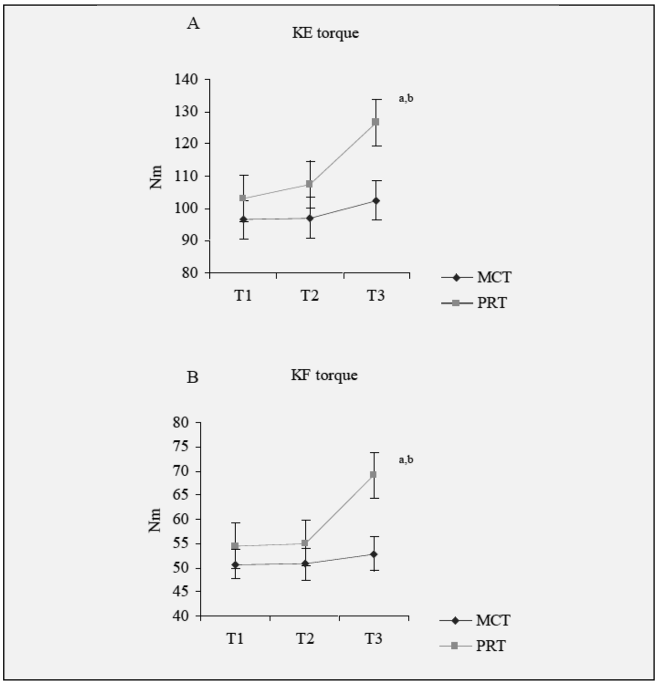
Variables		MCT x,¯ ± SD (n = 21)	PRT x,¯ ± SD (n = 18)	All x,¯ ± SD (n = 39)
PPkg (W/kg)	T1	23.9 ± 4.6	24.4 ± 4.4	24.2 ± 4.5
	T2	23.9 ± 4.9	24.5 ± 5.9	24.2± 5.3[b]
	T3	25.8 ± 5.4	26.4 ± 4.6	26.1 ± 5.0[a]
Hand grip (kg)	T1	30.8 ± 9.1	34.1 ± 11.1	32.3 ± 10.0
	T2	30.9 ± 9.4	35.0 ± 10.5	32.8 ± 10.0[b]
	T3	31.2 ± 10.0	36.3 ± 11.8	33.6 ± 11.0[a]
WS Habitual (m/s)	T1	1.4 ± 0.2	1.4 ± 0.2	1.4 ± .2 [b]
	T2	1.5 ± 0.2	1.4 ± 0.2	1.4 ± .2[b, a]
	T3	1.5 ± 0.2	1.5 ± 0.2	1.5 ± .2[a]
WS Maximal (m/s)	T1	1.9 ± 0.2	1.9 ± 0.2	1.9 ± .2
	T2	1.9 ± 0.2	1.9 ± 0.3	1.9 ± .2[b]
	T3	2.0 ± 0.2	2.0 ± 0.2	2.0 ± .2[a]
WS Picking up (m/s)	T1	1.2 ± 0.2	1.4 ± 0.2	1.3 ±.2
	T2	1.2 ± 0.2	1.4 ± 0.2	1.3 ± .2[b]
	T3	1.3 ± 0.2	1.5 ± 0.3	1.4 ± .3 [a]
Ws Hurdles (m/s)	T1	1.6 ± 0.2	1.7 ± 0.2	1.7 ± .2
	T2	1.7 ± 0.2	1.7 ± 0.3	1.7 ± .3[b]
	T3	1.8 ± 0.3	1.8 ± 0.3	1.8 ± .3 [a]
Chair Rise (s)	T1	9.6 ± 1.6	8.9 ± 1.8	9.3 ± 1.7
	T2	8.9 ± 1.8	8.6 ± 1.9	8.8 ± 1.9[b]
	T3	7.8 ± 1.6	7.4 ± 1.6	7.5 ± 1.2 [a]

a. Significantly different from T1; b. Significantly different from T3; p<.017 (Bonferroni correction)

A Training*Time significant interaction was observed for the isokinetic muscle strength variables: knee extension (KE; $p<0.001$; d = 0.45) and flexion (KF; $p<0.001$; d = 0.43) torques. One-way repeated ANOVA results carried out separately for the two groups followed by post-hoc multiple t-tests and Bonferroni correction are reported in Figure 1. For multicomponent exercise, KE and KF torque significance values were p = 0.051 and p = 0.30 respectively. In the PRT group, these were $p<0.001$ for both KE and KF torque. The post hoc analysis for these variables demonstrated a non significant increase in the multicomponent at any measuring time but a significant change between T2 and T3 in the strength training group (Figure 1 A,B). Effect sizes for the significant changes in PRT were for KE and KF variables .69 and .70 which are categorised as large.

Body fat and lean mass did not reveal any significant main effect and only measurements at T1 are reported (Table 1).

Figure 1
Mean ± SE of maximal voluntary isokinetic (60ºs-1) contraction torques during knee extension and flexion in the two groups



PRT = progressive resistance training group; MCT = multicomponent training group; a. significant difference between T1 and T3; b. significant difference between T2 and T3.

In Table 3 the results of paired sample t-tests performed on the 1RM values of the strength training group show significant performance improvements for all tests from week 2 of training to week 12 when the final 1RM was performed. These results refer to 21 participants as 1RM was performed the week before the final tests when 3 participants dropped out.

Table 3
1RM data of PRT group and changes following training

kg	Initial 1RM $\bar{x}$ ± SD (n=21)	Final 1RM $\bar{x}$ ± SD (n=21)	Δ%	t	p
Leg curl	44.1 ± 16.4	52.9 ±18.2	+20	-3.98	.001
Leg extension	57.7 ± 21.2	73.1 ± 26.0	+27	-4.40	.000
Lateral pull-down	37.2 ± 14.4	40.6 ± 13.3	+9	-3.60	.002
Chest press	37.0 ± 14.4	42.6 ± 15.3	+15	-5.92	.000
Rowing	42.8 ±12.6	49.5 ± 14.9	+16	-5.87	.000

Effect sizes were moderate for all functional ability measures (except chair rise which was large), small to moderate for PPkg and large for isokinetic measurements.

Discussion

To the best of our knowledge this is the first study to have directly compared the muscular fitness and functional outcomes of PRT and group-based multicomponent training in healthy, independent older adults. Of particular note is the finding that group-based multicomponent training with the inclusion of skill enhancing neuromotor exercises (i.e., balance, agility and coordination) is an effective alternative to PRT for improving functional ability and lower limbs muscle power. Both forms of training, with minor differences, induced muscular and functional benefits in the participants. In fact, participants in both groups increased their walking speeds between 5 and 8%, decreased chair rise time by 15% and gained lower limb PPkg by about 8% (Table 1). The only difference between the groups was the gain observed in lower limbs strength (+27% and 16% for knee flexors and extensors respectively) in the PRT participants only (Figure 1). Therefore, PRT proved somewhat superior to multicomponent exercise and confirmed its efficacy for muscular fitness gains providing further evidence of inducing functional benefits.

Both forms of training were applied at the same weekly frequency (twice). In relation to PRT, this frequency is known to be optimal to induce muscular and functional gains in older individuals (3). Regarding multicomponent exercise, specifically including neuromotor exercises, information on its benefits is relatively scarce and prescription and effective training frequency have yet to be identified (6). The present findings represent a step forward to accumulate the necessary evidence to establish guidelines for muscular and functional benefits of this form of training.

Multicomponent training has been successfully used in older frail individuals, with different exercise contents, for various functional and fitness outcomes (9, 10). In healthy, independently living populations, studies on the application of this form of exercise are fewer. The available studies demonstrate enhanced functional ability (21, 7, 10), lack of increase in strength (7, 8, 22) and muscular power (22), or gains in strength (23), and muscular power (14). To date, data are so mixed possibly in response to the varied nature of the delivery. Despite these discrepancies, the present findings are overall in keeping with previous studies, and together point to the usefulness of multicomponent training for functional ability improvements in healthy independently living populations. The exercise recommendations for this population, although emphasizing the adoption of a lifestyle promoting independence through multicomponent training including neuromotor exercise, do not specify the content of the programme for maintaining functional ability (24, 6). Optimal volume, pattern of exercise performance and methods of progression are still unknown, possibly due to the lack of evidence on the dose response relationship of this kind of multiple exercise combination and in particular of neuromotor exercises (6).

The absence of strength gains in the present multicomponent exercise group could be due to a number of factors including inadequate training intensity. On the other hand, it is interesting to note that knee extension variables did show a tendency to increase (see Fig.1B), thus at least counterbalancing possible age-related deteriorations.

Regarding peak power of lower limbs, both training groups following the training period showed improvements by about the same amount (8%), likely achieving this through improved strength the PRT and improved neural activation, better coordination and speed of movement the multicomponent training. In fact as power is the expression of force and velocity, increases in maximal power production can be obtained by increasing either velocity or force (or both). The multicomponent training group did not show significant strength improvement while the PRT group significantly enhanced knee flexion and extension torques.

This could be explained by the fact that the multicomponent training was "unspecific" from the muscular point of view as it did not meet the specificity exercise prescription principle and did not involve significant external overload. On the other hand the exercises applied entailed for participants different movement control requests with respect to PRT. In fact classes included exercises for reaction time, space orientation, or for differentiating the use of muscle strength as for example when varying the distance to be covered or the space available while walking, the speed of execution or asking for sudden stopping/starting of the movement. These variations in the complexity of performance represent the overload method for coordination enhancement and may have caused improvement in movement speed and ultimately in muscle power. As aging seems to particularly affect speed of movement when complex actions are requested (25), it can be postulated that exercises specifically stressing movement complexity may be beneficial for movement speed. The multicomponent training by challenging performance particularly in terms of complexity, may have therefore affected the ability to better express force with speed. Similarly, a previous study utilizing an exercise protocol of stepping into contiguous squares marked on the floor in various directions at self selected speed has also elicited improvements in lower limb power and functional ability (26). Although more studies are needed to verify this finding on larger samples of individuals and tasks, it can be speculated that velocity may represent a more significant element in determining tasks effectiveness. In fact a recent cross-sectional study (27) has demonstrated that in women aged 72 to 96 years, velocity at maximal power is more significant than maximal power in explaining habitual walking speed and chair rise time reporting a variance explanation of 16 and 49% for power and velocity at peak power in walking and of 33 and 47% in chair rising.

It is also worth mentioning that the obtained strength gains in PRT were of comparable magnitude to those reported in the literature for older participants (28, 29). Similarly, the functional ability improvements obtained through PRT were comparable to previously reported ones (3, 30).

Several advantages can be described for the use of the jump test in healthy older subjects. With healthy older people without any serious physical impairment and with no particular jumping experience, as those taking part in the present study, this test did not show any contraindications. Moreover such test can be considered more functionally relevant with respect to, for example, a horizontally seated leg press as mimicking better vertical power production necessary in many daily activities i.e. getting up from a chair or stair climbing. This test has also shown high inter and intra session reliability (15).

The present study has limitations which need acknowledging. Firstly, participants were healthy volunteers who were not blinded to the purposes of the study and not completely randomised. As described in the methods to overcome some of the recruitment difficulties the study followed a scattered recruitment and it was not possible to completely randomise the sample. Despite this limitation, the authors believe the results of the present study are still informative and can help providing information on the effectiveness on functional ability of multicomponent training with neuromotor exercises for older people.

Although power calculations were used to estimate sample sizes, there is still the possibility that the number of participants might have been insufficient, at least for some of the considered variables. Also, the fact that all volunteers were fully mobile and likely close to their ceiling of performance in fitness and functional ability, could have limited the effects of exercise at least in some of the considered outcomes. Some of the applied exercises could possibly be unsuitable for frailer or mobility-limited individuals, reducing the generalizability of results to all older populations.

Conclusions

The present study confirms the efficacy of PRT for functional and muscular outcomes. In addition the present results indicate that functional ability gains and some muscular fitness benefits may be achieved in healthy older individuals through group-based multicomponent classes including neuromotor exercises, when conducted twice per week.

Generally to induce power gains overload coupled with fast action is recommended. The results of the present multicomponent programme show, however, that overload created by body weight alone can effectively induce peak power gains in older participants. It is possible that the nature of the applied exercises involving motor skills and coordination such as walking with unexpected changes in directions, avoiding obstacles, collecting objects from the floor or stepping at self paced and/or increased speed, could have been the main factor contributing to the effectiveness of the proposed exercise in increasing peak power.

Further studies should be carried out with the aim of integrating, in multicomponent and neuromotor exercises strength enhancing exercises for the optimal maintenance of muscular fitness. Similarly, the fitness mechanisms explaining the gains in functional ability following multicomponent with neuromotor exercises should be investigated in order to develop theory on the adaptations induced by multicomponent training and to prioritize key physical fitness elements in training practices for optimal functional outcomes.

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