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EFFECTS OF RESISTANCE TRAINING ON ACTIVITIES OF DAILY LIVING IN OLDER WOMEN

H.T.Rabelo, R.J.Oliveira, M.Bottaro
Graduate School of Physical Activity and Health, Catholic University of Brasilia, Brazil, Brasilia, DF

Abstract. Purpose: This investigation examined the effects of 10 weeks of different low- or high-intensity resistance-training programs on the ability of elderly women, aged 60 to 76 years, to perform daily tasks (ADL). Methods: The sample consisted of 61 volunteers who were randomly divided into 3 groups: G50 (n=21; 66.48±4.09 years), G80 (n=20; 63.90±3.78 years), and a control group CG (n=20; 63.65±7.17 years). The one-repetition maximum test (1-RM) was used for strength assessment, and the Andreotti-Okuma protocol [2] was used to evaluate ADL conduction. During the resistance-training program the G50 volunteers trained at 50% of 1-RM, and the G80 at 80% of 1-RM, thrice a week. The Split-Plot (SPANOVA) variance design, followed by the Post-hoc Scheffé test, was used for statistical analysis, with a significance level set to $P \leq 0.05$. Results: 1-RM and ADLs performance increased for all exercises tested for the G80 and G50 groups ($P \leq 0.05$). Also, the improvements experienced by the G80 group for muscular strength was significant higher (Lat-pulldown, Shoulder abduction and Calves) as compared to the G50 group, but in two exercises (Bench press and Leg press) G50 showed higher improvements in 1-RM. Besides that, relative improvement (Δ%) in muscular strength and ADL was similar for both G80 and G50. No significant change occurred in the control group. Conclusion: The results demonstrated significant and similar improvements in muscular strength and functional abilities for both of the training groups. These data suggest that older women may obtain similar benefits using high or low-intensity resistance exercise.
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Keywords: Elderly - Muscular strength - Resistance exercise - Functional abilities

Reprint request to: Dr. Ricardo Jaco de Oliveira, UCB CAMPUS UNIVERSITÁRIO I, QS 7 Lote 1, Sala G-119, Águas Claras – DF, 71966 – 700, Brazil
Fax: +5561-356-9350; E-mail: rjaco@ucb.br

Introduction

Currently, there is evidence of structural and functional change in the neuromuscular system as a result of the aging process, particularly due to the fact that the nervous system begins to degenerate after 60 years of age [10]. This may ensue reduced muscular strength [6], which, in turn, is likely to give rise to significant effects on functional abilities – among them diminished motor skills for activities of daily living (ADL).

Normally, the highest muscular strength levels are achieved between 20 and 30 years of age. After this range, both strength and muscle mass begin to decrease. At the sixth decade of life, even more dramatic reductions take place in both men and women, although the latter seem to be affected more adversely [7]. An effect of the aging process on the neuromuscular system is sarcopenia, which contributes to decline muscular strength and functional abilities [6]. The impact of this process is directly associated with limited mobility and decreased efficiency of physical performance and conduction of ADLs in elders, making this population more vulnerable to long periods of morbidity.

Although much focus has been placed on aerobic exercise as one of the more important means to promote physical activity and help elders be healthier, recent investigations have reported that reduced muscular strength may limit their ability to conduct a number of daily tasks, resulting in a loss of function and restricted independence. Because weight training as a means to achieve muscle mass has been an effective way to increase muscular strength in elders, weight exercise should be among the priorities at this age range[7].

An in-depth investigation of resistance training in elders and how it relates to the performance of ADLs becomes more imperative, as motor performance is a major element in the prevalence of disability and dependence in elders. The optimum weight load to improve muscular strength in elderly people is disputed, with most investigations suggesting that high intensity training at 80% of one repetition maximum (1-RM) provides strength gains within 12-16 weeks in elders [11]. Disputes notwithstanding, a strength training program at 50% of 1-RM for 12 weeks has been found to yield significant gains in muscular strength [13]. And as there is no research available comparing a moderate intensity resistance-training program and a high intensity one based on one protocol, involving especially independent elders and their conduction of ADLs, disagreement becomes sharper. In an attempt to fill this gap, this study was designed to determine the effects of two resistance-training programs on both muscular strength and performance of ADLs in independent elderly women.

Material and Methods

Sixty-one sedentary women, aged 60 to 76 years, were recruited to join the study. They were determined to be independent based on Spirduso's classification [16], and were assessed for physical exercise readiness using the Physical Activity Readiness Questionnaire - Par-Q [1].

Subjects were randomly divided into 3 groups: 1) G50 (n=21; 66.48±4.09 years), engaged in a resistance-training program at 50% of one repetition maximum (1-RM); 2) G80 (n=20; 63.90±3.78 years), engaged in a resistance-training program at 80% of 1-RM; and 3) CG (n=20; 63.65±7.17 years) was the control group. Participants were instructed not to attend other physical exercise programs and not change their daily activities throughout the study.

Participants were briefed on the objectives, procedures involved, and possible risks and benefits as per the standards enforced by Catholic University of Brasilia's Ethics Committee. Also, a free acceptance agreement in writing was obtained from each participant whereby each was informed of the voluntary nature of the study, the secrecy of the data, and the right to leave the program at will.

The persons in the samples were subjected to an anthropometrical assessment designed to measure their height, body mass, and estimate body composition. A mechanical Filizola scale with 100g graduation was used for body mass. A Cescorf skinfold with one (1) millimeter resolution and the Jackson, Pollock, and Ward [12] protocol were used to determine body composition.

Cardiorespiratory capacity was measured using the one-mile walk test, which was designed by the Rockport Walking Institute in 1986 for estimation of maximal oxygen uptake (VO_2max) in the elderly. The Andreotti-Okuma [2] protocol developed and validated for the Brazilian population, which includes specific ADL testing for independent elders, was used to assess activities of daily living (ADL).

Muscular strength was assessed using the one-repetition maximum test (1-RM), suggested by Fleck and Kraemer [7]. This test is intended to measure maximum dynamic strength and precisely determine training intensity. The maximum exercise weight was the last weight an individual was able to successfully lift. The 1-RM test was applied at each exercise (leg-press, bench press, knee extension, lat-pulldown, calf, arm curl, triceps, and shoulder abduction).

Following an adaptation periods and testing, the G50 group was subjected to the resistance-training program at 50% of 1-RM for 10 weeks, thrice a week, every other day, including 3 sets of 8 repetitions for each exercise, with 1-min intervals between sets and 2-min intervals between exercises and movements conducted at moderate rates. The method consisting of inspiration at the concentric phase and expiration at the eccentric phase was used to monitor breathing. The procedure for the G80 group was the same as the G50 group, but at 80% of 1-RM.

The method of segment alternations was used to determine the order of distribution of exercises during resistance-training sessions, with the same exercises for all groups. After the fifth week, a new assessment of groups was conducted for workload adjustment (1-RM test).

Parametric procedures were employed for statistical analysis, including inferential statistics and using the Split-Plot (SPANOVA) analysis of variance. Levene's test was used for analysis of homogeneity, and the Post-hoc Scheffé's test for comparison of group results. A significance level of P≤0.05 was utilized for all groups.

Results

Table 1 shows the descriptive characteristics of the volunteers in the sample, which consisted of 61 women (G50=21, G80=20, and CG=20), mean age 64.81±5.3 years.

Table 1
Mean and standard deviation for Body Mass (BM), Height (HGT), Relative Body Fat (%BF), and VO_2max for experimental groups (G50, G80) and control group (CG).

Variables	G50	G80	CG
BM (kg)	63.0±9.3	63.4±10.2	66.1±7.3
HGT (cm)	152±7.3	155±5.4	158±4.8
BF (%)	30.6±4.3	29.3±5.4	32.9±4.4
VO_2max (ml/kg·min^{-1})	18.1±8.4	22.5±5.6	17.6±6.2

G50 = 50% of 1-RM; G80 = 80% of 1-RM; GC = control group

Table 2 shows muscular strength results. When the SPANOVA was applied to bench press, leg-press, and calf exercise, groups were found to differ to a great extent from each other (P≤0.001). Using the Post hoc Scheffe test, a significant difference was found between groups G50 and G80 (P≤0.001), between groups G50 and CG (P≤0.001), and between groups G80 and CG (P≤0.001).

Table 2
Mean and standard deviation for muscular strength (kg) in experimental groups (G50, G80) and control group (CG), before and after resistance training

Exercise	G50			G80			CG			
	Pre (kg)	Post (kg)	Δ%	Pre (kg)	Post (kg)	Δ%	Pre (kg)	Post (kg)	Δ%	
Bench press	16.5±6.4	21.8±6.9	31.5	21.8±3.5	28.0±3.5	27.9	16.8±4.8	15.66±4.5	-7.2	$\dagger^{a}$
Leg press	77.8±16.5	104.8±24.2	34.6	99.3±7.5	132.5±26.2	33.4	65.0±22.3	63.0±21.3	-3.2	$\dagger^{a}$
Lat-pulldown	31.8±5.1	38.3±4.8	20.5	34.4±4.3	42.6±5.3	23.8	26.3±6.7	24.7±5.8	-6.15	$\dagger^{c}$ $*^{b}$
Shoulder abduction	2.57±0.7	3.2±1.1	25.6	3.05±0.8	4.8±1.4	57.4	3.0±0.7	3.0±0.7	0.0	$\dagger^{d}$
Knee extension	27.2±10.4	33.6±11.2	23.3	34.3±11.4	41.6±15.8	21.4	21.1±5.9	20.4±5.9	-3.6	$\dagger^{c}$
Triceps	21.4±4.5	25.4±4.4	18.6	21.1±5.3	24.9±5.9	17.9	16.8±4.0	15.6±4.0	-7.1	$\dagger^{c}$
Arm curl	15.9±2.7	19.1±2.9	19.7	15.7±2.7	20.9±2.5	32.9	14.7±5.3	14.0±5.1	4.5	$\dagger^{c}$
Calves	36.1±3.1	39.8±3.2	10.1	39.5±1.7	48.7±2.3	23.3	35,3±3.3	34.2±3.1	-3.1	$\dagger^{a}$

[*] Significant effect $P \le 0.05$; [†] significant effect $P \le 0.001$; [a] significant difference ($P \le 0.001$) between groups G50 and G80, G50 and CG, G80 and CG; [b] significant difference ($P \le 0.05$) between groups G50 and G80; [c] significant difference ($P \le 0.001$) between groups G50 and CG, G80 and CG; [d] significant difference ($P \le 0.001$) between groups G50 and G80, G80 and CG

Table 3
Mean and standard deviation for the activity of daily living – ADL variables, for the experimental groups
(G50, G80) and control group (CG), before and after the resistance training

ADL	G50			G80			GC			
	Pre	Post	Δ%	Pre	Post	Δ%	Pre	Post	Δ%	
800-meter walking (s)	496.7± 18.3	456.3± 49.3	-8.1	458.4± 56.0	405.3± 51.8	-11.6	472.2± 61.3	485.1± 60.7	2.7	†[a]*[b]
sit-down-and-stand-from-chair (s)	34.10± 2.6	32.1± 3.0	-5.8	32.7± 3.1	29.4± 2.5	-10.0	31.5± 4.0	31.1± 2.0	-1.2	*[b]
bench-climbing (cm)	49.7± 11.8	51.0± 10.0	2.6	59.2± 7.8	61.2± 7.2	3.8	55.5± 8.4	54.6± 7.9	-1.6	**[c]
stand-from-ground (s)	5.4± 1.1	4.7± 1.2	-12.9	4.4± 0.8	3.4± 0.5	-22.7	4.2± 0.9	4.8± 0.8	-14.2	†[d]
Stair-climbing (s)	6.8± 1.0	5.8± 0.7	14.7	6.0± 0.8	5.3± 0.5	-11.6	5.7± 0.7	5.9± 0.6	-3.5	**[c]

[*] Significant effect P≤0.01; ** significant effect P≤0.05; [†] significant effect P≤0.001; [a] significant difference (P≤0.001) between groups G80 and CG; [b] significant difference (P≤0.01) between groups G50 and G80; [c] significant difference (P≤0.05) between groups G50 and G80; [d] significant difference (P≤0.001) between groups G50 and G80, G80 and CG; [e] significant difference (P≤0.05) between groups G80 and CG

For the lat-pulldown exercise, differences between groups were determined to be significant ($P \leq 0.001$). The test indicated a significant difference between groups G50 and G80 ($P \leq 0.005$), groups G50 and CG, and G80 and CG ($P \leq 0.001$).

For the shoulder abduction exercise, differences between groups were determined to be significant ($P \leq 0.002$). Differences were found between groups G50 and G80, and G80 and CG ($P \leq 0.001$).

For the knee extension, triceps, and curls exercises, differences between groups were determined to be significant as well ($P \leq 0.001$). Significant differences were found between groups G50 and CG, and G80 and CG ($P \leq 0.001$).

Table 3 shows results of daily task testing. Analysis of ADL measures evidenced that differences between the groups were significant ($P \leq 0.01$) in relation to the 800-meter walking test. The Post hoc Scheffe test identified significant differences between groups G50 and G80 ($P \leq 0.01$), and groups G80 and CG ($P \leq 0.001$).

The sit-down-and-stand-from-chair test indicated significant differences between groups G50 and G80 ($P \leq 0.01$).

When the SPANOVA was applied, differences between groups were significant ($P \leq 0.04$) for the bench-climbing test. Significant differences between groups G50 and G80 ($P \leq 0.05$) were found under the Post hoc Scheffe test.

The stand-from-ground test produced significant differences between groups ($P \leq 0.001$). Since this analysis identified significant difference between groups G50 and G80, and G80 and CG ($P \leq 0.001$), the G80 group showed significant improvements in conducting this activity as compared to groups G50 and CG.

In the stair-climbing test, significant differences ($P \leq 0.01$) were found between the groups. Use of the Post hoc test thus proved necessary to find between which groups differences did occur. After this analysis, no significant differences were found between groups G50 and G80, and G50 and CG ($P \geq 0.05$).

Discussion

It is widely known that reduced muscular strength affects the motor conduction of ADLs and that strength training is the most effective way to increase muscular strength.

Although the general consensus in literature is that weight training may increase muscular strength, some resistance exists to applying high training loads to elders. Raso *et al.* [13] reported that low intensity strength training induces significant increases in muscular strength that may be similar to the heavy weight load program (80% of 1-RM), and as a result, it contributes to improve functional abilities in the conduction of ADLs. A light-weight load strength training is safer, particularly because it conserves morphological and functional integrity in elders by reducing their exposure to musculoskeletal and especially cardiovascular injuries.

The literature contains a diversity of methodologies to assess elders for the effects of resistance-training program on muscular strength. These methodologies may differ in training length, number of exercise sets, muscle group being trained, workloads, number of repetitions, and so on.

With this diversity, researchers have difficulty conducting an accurate comparison, especially when determining the effects of resistance training on the motor conduction of ADLs. In addition, there are only a few investigations in the literature relating resistance training and application of specific protocols with ADL characteristics, especially in independent elders. According to Rikli and Jones [14], it is important to take the levels of functional abilities of elders into account when selecting protocols to assess subjects for conduction of ADLs.

Therefore, an attempt was made in this study to neutralize said differences by building a resistance-training program that included the same training length, selection of muscle groupings, number of sets, number of repetitions, and interval between sets and exercises. Weight load was the only difference that was kept, on account of the disputes that were discussed earlier. The same protocol was used to assess subjects for performance of ADLs, whose tests are specific for independent elders and appropriate for the functional abilities of the sample being investigated.

The results obtained with improved muscular strength in the group that was subjected to 80% of 1-RM are in accordance with Campbell *et al.* [5], who found considerable increases in muscular strength in the elderly under short-length training (2-4 months). The results obtained with improved muscular strength in the group subjected to 50% of 1-RM are in agreement with those attained by Raso *et al.* [13].

Comparison of results of the experimental groups indicated that the G80 (80% of 1-RM) experienced significant improvements with 5 exercises of the resistance-training program (bench-press, leg-press, calf, lat-pulldown, shoulder abduction) as compared to the G50. This confirms the investigation by Humphries *et al.* [9], who found that significant gains from muscular strength training are achieved under heavy weight load training.

In this study, the group who underwent high intensity resistance training showed significant motor performance improvements in four tests out of the five tests of the ADL variable, as compared to the group subjected to moderate weight load resistance training. These four tests were: 800-meter walking, sit-down-and-stand-from-chair, bench-climbing, and stand-from-ground. These findings support the results obtained by Fleck and Kraemer [7] in that increases in muscular strength achieved by exercise under heavier workloads will provide more favorable conditions for conducting ADLs. In addition, muscle weakness and functional impairments are important risk factors for falls and are often interrelated [15]. Thus, improvements in muscle strength may help prevent falls.

The group who was subjected to heavy weight load resistance training (G80) had significant improvements in the muscular strength variable. Possibly, this had some effect on the performance of ADLs, as the functional abilities being assessed require balance, speed, strength, and power, which develop and improve under resistance exercise programs, especially high intensity ones.

The 800-meter walking test, which was best performed by the G80, confirmed the findings reported by Bendall *et al.* [4], who demonstrated the importance of strong plantar flexors and how this strength is associated with high walking speeds in both men and women by promoting favorable effects on the walking ability. In this study, the G80 showed significant improvements in the calf exercise under the resistance-training program, in which plantar flexors are developed, as compared to the G50.

The resistance training results of the sit-down-and-stand-from-chair tests, designed to assess lower limb strength and power, balance, and walking speed, also evidenced that the G80 outperformed the G50, especially in the significant strength gains of plantar flexors, which play a key role in the walking ability, as well as the significant strength gains of knee extensors, which suffer extreme stress in this activity.

In the stair-climbing test, results were once again better for the G80. These results, in combination with those achieved under the leg-press exercise, which develops knee extensors, are believed to be a contribution, thus corroborating the results obtained by Bassey *et al.* [3], who reported a significant relationship between the power of knee extensors and climbing stairs. Additionally, this favorably impacts the rate at which elders stand from chairs and walk.

The stand-from-ground test, which must necessarily be conducted in two phases – first, turning around and placing their hands on the ground, then getting on their knees and standing up - requires more upper limb muscular strength on the first phase and more lower limb muscular strength on the second one. When subjects turn around, i.e., lift their back from the ground to lie on either their stomach or side and finally position their body on four bases (knees and hands), they are required to extend their elbows with a horizontal shoulder abduction. The second phase involves stressing the knee extensors. The G80 achieved greater results in this test, with better significant performance under the leg-press and supine exercises, which are intensively stressful to the muscle groupings required to conduct this activity.

For the stair-climbing test, the G80 was expected to show significant improvements over the G50, as climbing stairs requires strength of knee extensors and plantar flexors. These are the same muscle groupings as those stressed under the 800-meter walking and stair-climbing tests, in which the G80 obtained significant improvements as compared to the G50.

In the G80 versus CG comparison in connection with the ADL variable after the resistance-training program, the G80 was found to achieve significant improvements as compared to the CG under the 800-m walking, stair-climbing, and stand-from-ground tests, thus placing even greater emphasis on the importance of improved muscular strength, especially plantar flexors and knee extensors, in conducting these activities, as assessed earlier.

In the G50 versus CG comparison also regarding the ADL variable after the resistance-training program, no statistically significant differences were found between both groups, although the former was expected to achieve better significant performance in this variable, as it had showed significant increases in muscular strength as compared to the CG. Possibly, this is so because the CG had showed better results than the G50 when the pretest ADL variable means were analyzed.

Although this investigation has been conceived chiefly to construct an interface between groups and variables rather than examine each group's performance separately, it should be noted that the G50 made considerable improvements in all ADL variable tests, as evidenced by a comparison of pretest and posttest means. Also, substantial strength gains were seen in all exercises involving the muscular strength variable. This endorses the results attained by Raso *et al.* [13], who reported that low intensity strength training promotes significant gains in muscular strength, thus inducing improved ADL performance. Nevertheless, this is in contradiction with the results achieved by Hagberg *et al.* [8], who observed that low intensity strength training will yield only limited effects.

Also in all of the tests of the ADL and the muscular strength variables, the G80 showed significant improvements when comparing pretest and posttest means, thus corroborating the results by Campbell *et al.* [5], who reported that high intensity strength training is efficient and leads to significant improvements in muscular strength, and thus in ADL conduction.

In relation to the safety of the heavy weight load training, it should be emphasized that no injuries or complaints of osteo-muscular and joint discomfort were reported regarding the training sessions in this investigation. The CG showed slight improvements in the sit-down-and-stand-from-chair and stair-climbing tests and worse performance in the other ADL variable tests, when comparing pretest and posttest means. In connection with the muscular strength variable, the CG only achieved a slight improvement in the curls exercise, when comparing pretest and posttest means. The results suggest that the decline in muscular strength may limit an individual's ability to perform a number of ADLs. In this regard, it should be noted that failure to exercise as a means to increase muscular strength will adversely affect the ability to properly conduct ADLs.

Conclusion

This investigation demonstrated similar relative improvements (Δ%) in muscular strength and ADL performance for low-intensity (50% of 1-RM) as for high-intensity (80% of 1-RM) resistance exercise. This finding is important when prescribing resistance exercise for older women. Lighter loads may allow the exerciser to obtain adequate benefits while reducing the possibility of injury.

In summary, this investigation examined the effects of two different intensities of resistance exercise on ADL performance and muscular strength in older women. The results demonstrated significant and similar improvements in muscular strength and ADL performance for both of the training groups. These data suggest that older women may obtain similar benefits using high or low-intensity resistance exercise.

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