Barros et al. Int J Sports Exerc Med 2017, 3:050
DOI: 10.23937/2469-5718/1510050
Volume 3 | Issue 1

International Journal of
Sports and Exercise Medicine

ISSN: 2469-5718

Research Article: Open Access

The Effect of High-Speed Resistance Training on Movement Speed and Power of Older Women

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Abstract

Introduction: The capacity to generate muscle power is a major factor in maintaining the physical and functional independence of older persons.

Objective: Evaluate the effect of a High Speed-Resistance Program (HSRP) on the power and movement speed of elderly women in motor tasks.

Methods: 58 elderly women were stratified into two groups: an Intervention Group (IG), n = 31, mean age of 68.7 ± 5.2 years old and a Control Group (CG), n = 27, mean age of 67.7 ± 3.8 years old. A High Speed Resistance Program (HSRP) was applied. Power and speed were evaluated using motor tests: chair stand (CS), and displacement time in comfortable gait speed (CGS) and maximum gait speed (MGS). Individuals in the CG maintained their daily activities, while the IG underwent the HSRP. For statistical analysis, paired t-tests were used to compare Pre and Post-Intervention. For comparing Groups (IGversus CG) t-tests for two samples were used. Data were presented as mean ± standard deviation and analyzed using R software, with the value α = 0.05.

Results: According with the CS test, there was a significant increase in power generation (370.71 ± 106.26 W/434.52 ± 107.15 W; $p < 0.05$) and in speed (0.61 ± 0.14 m/s/0.72 ± 0.14 m/s; $p < 0.05$) in the IG group; with CGS and MGS tests, a significant reduction in displacement time was noted (4.56 ± 0.63 s/4.20 ± 0.50 s; $p < 0.05$) and (3.45 ± 0.40 s/3.23 ± 0.34 s; $p < 0.05$), respectively. No significant improvements were noted in the CG.

Conclusion: The IG significantly improved the muscle power and performance of motor tasks.

Keywords

Aging, Elderly, Physical exercise

Introduction

The relationship between physical fitness and functional capacity in the aging process is notable. Functional capacity determines the degree of independence to remain socially included and its decline is an effective indicator of poor quality of life. Significant scientific evidence support that an active lifestyle helps to prevent and minimize the negative effects of aging. Physical exercise is an important goal for Health Promotion [1-8].

Decreased muscle strength results both from progressive sarcopenia and less mobility, increasing the risk of falls and accidents due to muscle weakness, early fatigue and precarious body balance conditions [9-15].

With muscle strength training, one can aims maximum strength, endurance and power. Muscle power is a derivative of muscle strength and relates to the ability of muscles to produce fast contractions. This ability is important when one needs rapid and effective responses to different motor tasks, aggravating the bodily mobility of the elderly person, especially at sudden loss of balance [1,7,10,15].

There is evidence that, with aging, the ability to generate power declines at a more pronounced rate than the ability to generate maximum strength. McArdle, Katch and Katch (2011) sustain that power is more strongly associated with the loss of functional capacity than maximum strength [9].

High Speed-Resistance Programs (HSRP) are health promotion strategiesthat have been proved effective at reducing the rate of advance of the aging profile described above [7,8,10,15].

The present study aims to analyze the effect of a High Speed-Resistance Program (HSRP) for lower limbs of elderly women, using the following motor tasks: chair stand and movement speed, measured in two distinct gait situations.

Methods

This intervention study was performed with 64 women ≥ 60 years old who attended the Social Center of Rio de Janeiro State University, randomly allocated by lottery at an Intervention Group (IG) and ata Control Group (CG). The study had three stages: a preliminary assessment, an intervention and a subsequent reassessment.

The choice for this age as the cut point was based in the World Health Organization (WHO) statement that 60-years-old is a criterion for considering a person as aged, in developing countries [16].

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Citation: Barros CC, Caldas CP, Batista LA (2017) The Effect of High-Speed Resistance Training on Movement Speed and Power of Older Women. Int J Sports Exerc Med 3:050. doi.org/10.23937/2469-5718/1510050

Received: October 29, 2016: **Accepted:** February 09, 2017: **Published:** February 13, 2017

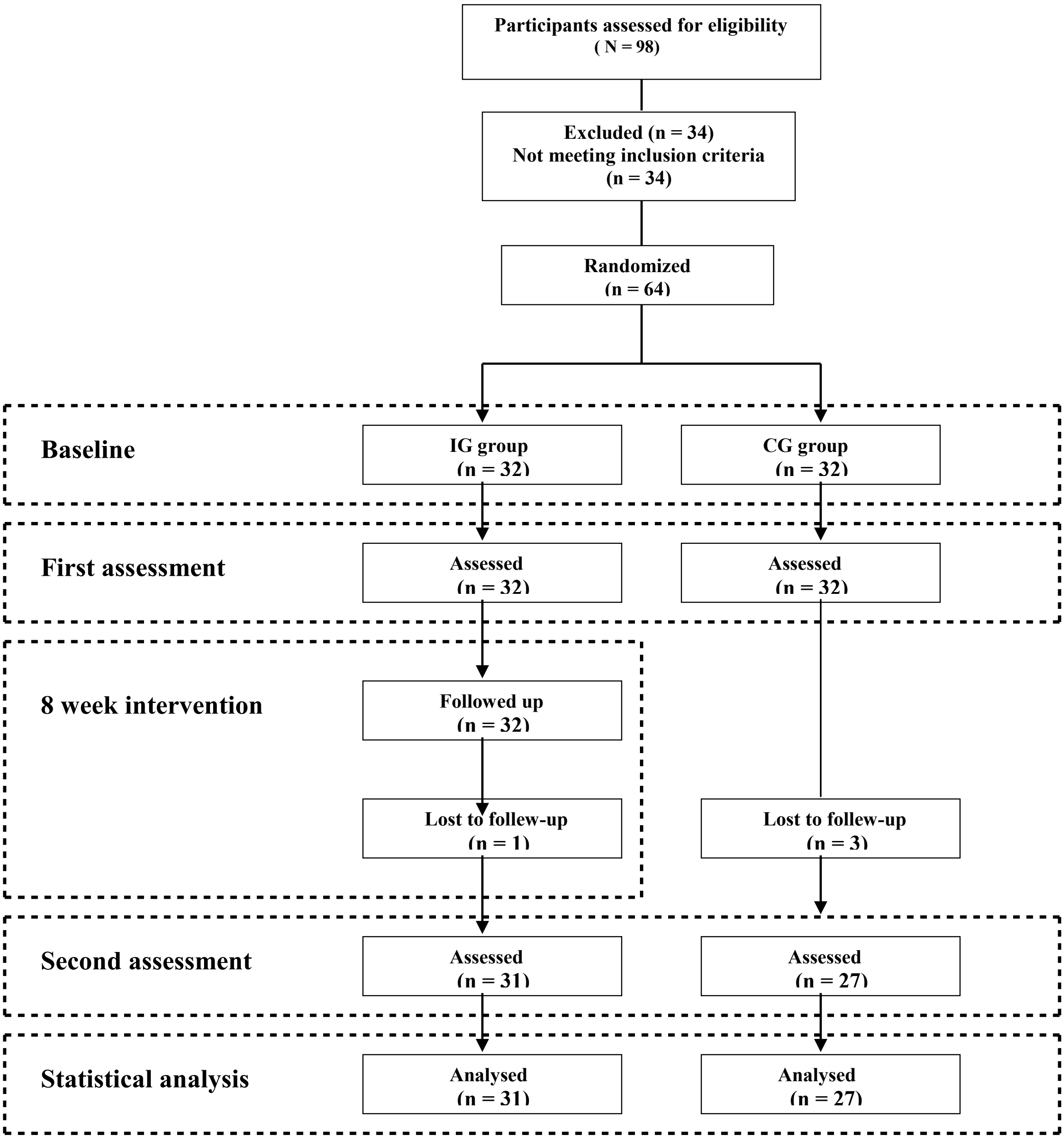

Figure 1: CONSORT diagram of recruitment and randomization process.
Abbreviations: IG: intervention group; CG: control group.

The sample size was based on a total population of 403 women attending the social center. Considering a margin of error of 5% with 95% confidence level,the minimum sample required was 52 individuals.

The study was approved by the Ethics Research Committee of the Hospital Universitário Pedro Ernesto (UERJ) under nº CEP/HUPE 1413. All the participants signed a Free and Informed Consent Form in accordance with CNS Resolution 466/12.

Inclusion criteria were be physically independent; not have participated in a resistance-type strength-based physical exercise program for six months before the experiment and be able to perform all the exercises and tests. The exclusion criteria were: suffering from muscle or joint diseases, physical or mental disabilities or heart disease. One participant of IG was excluded because had more than three consecutive absences. Five participants of CG who did not attend the final test, were excluded.

Each group had 32 participants at the beginning, but with the losses, at the end of the experiment, the IG had 31 participants with a mean age of 68.7 ± 5.2 years and CG had 27 individuals with a mean age of 67.7 ± 3.8 years (Figure 1 and Supplementary file).

All subjects were submitted to a prior medical evaluation, which attested to the health conditions of each participant. Both groups underwent the same routine testing, being subjected to two measurements: one before the intervention (pre) and the other after the intervention (post). The control group had the same measurement procedures, before and after the period of intervention.

Both groups were previously prepared for the tests they were to undergo, as it was found that a lack of familiarity with the exercises would be an important intervening variable, affecting the quality of measurement and consequently the test results. Three meetings were held.

Gait and chair stand tests from Williams and Greene´s battery described by Matsudo [17] were performed to evaluate speed of movement.

The body mass of the volunteers was measured using a Filizola® (São Paulo, Brazil) digital electronic scale, with a capacity of 150 kg and a precision of 100 g, previously calibrated. Body mass was monitored throughout the study.Differences between evaluations wereno significant (0,160 for IG and CG -0,150 kg $p > 0.05$ for CG).

To measure speed and power in the chair stand test (CS), we used a device comprising the Tendo Weightlifting Analyzer Model V 104 (TWA) (Tendo, Slovakia) equipment, a 0.43 m high wooden bench, a 0.45/0.45 m base and a Toshiba® A10-S169 model microcomputer (Toshiba Corporation, ChinaCS). For each test performed, the measuring apparatus was adjusted according to the body mass of the volunteer in question. The volunteers sat in the standard position for the test until they received the command to perform the motor task. At the beginning of the measurement step, the volunteers responded to the start command, getting up from the chair at the fastest possible speed and rising to a standing position. Each participant made three attempts, and the outcome with the greatest power value was considered.

The gait execution time was analyzed in two manner, according to movement speed: comfortable gait speed (CGS) - the speed that the individual usually moves, on a daily basis, from one point to another; and maximum gait speed (MGS) - where the subject moves as quickly as possible, maintaining the biomechanical pattern of gait movement.

To measure CGS, a strip 0.30 m wide and 3 m long was marked on the floor. The volunteers were instructed to follow the path marked, moving at the speed they normally used in their daily activities, without running or moving away from the predetermined trajectory. Some degree of lateral deviation was allowed so that the normal gait pattern was not changed. The stopwatch was activated when the initial voice command was given and stopped when the last foot passed the finish line marked on the ground, 3 m from the starting point. The participants examined were advised not to leave the path and to continue walking, even after passing the finish line, to prevent them from reducing speed when they were near the end of the course. Each participant made three attempts, and the best result was registered.

For the measurement of the MGS variable, the same procedures as for the CGS test were adopted, and the volunteers were asked to perform the 3 m route at the maximum movement speed possible without running.

The control group was instructed to maintain their normal daily activities and not participate in any training involving muscle strength exercises with weights during the two-month period. The IG underwent the HSRP, performing 24 exercise sessions three times a week on alternate days for a period of approximately two months.

At the end of the experiment the volunteers in the CG received the benefits of the training sessions.

To establish the load used in the training program, muscle power was measured using the power curve test method for all the HSRP exercises. The Tendo Weightlifting Analyzer - Model V 104 (TWA) was used for this, based on the strategy validated by Jennings and Viljoen [18]. The TWA is a portable and easy to use piece of equipment which is used to measure and monitor the training of strength and power through a computerized system in which a sensor connected to the weight or the individual being examined captures speed of movement, making the calculation of power possible. The system also has a processor that stores the collected data and calculates mean values and peak power and speed.

For each HSRP exercise, three sets of eight repetitions with individualized resistance were carried out, performed at the highest possible speed in the concentric phase. The HSRP was composed of eight exercises: leg press, knee flexion, knee extension, hip abduction, hip adduction, triceps curl, performed on Righetto machine (São Paulo, Brazil). Biceps curl and lateral elevation of the upper limbs were performed withdumbbell sets. The resistance was 80% of the value associated with the best curve obtained in the power test.

There were three load adjustments during the HSRP period, each one after a muscle power evaluation. The first was in the seventh session, the second in the thirteenth session; the third and final adjustment in the nineteenth session. To perform these adjustments, the resistance levels were recalculated, respecting the same criteria as in pre-assessment.

Table 1: Mean values (in m/s) of the speed value for the CS motor test.

	Pretest-mean	Pretest-sd	Postest-mean	Postest-sd	Diff-mean	t	P_value
CG	0.67	0.15	0.62	0.17	-0.057	-2.62	P > 0.05
IG	0.61	0.14	0.72	0.14	0.108	5.58	P < 0.05

CG: Control Group; IG: Intervention Group; CS: Chair Stand; Diff-Gain Mean; sd: Standard Deviation.

Table 2: Mean values (in W) of variable power for the CS motor test.

	Pretest-mean	Pretest-sd	Postest-mean	Postest-sd	Diff-mean	t	p_value
CG	433.52	115.24	395.37	123.59	-38.148	-2.25	P > 0.05
IG	370.71	106.26	434.52	107.15	63.806	5.19	P < 0.05

CG: Control Group; IG: Intervention Group; CS: Chair Stand; Diff-Gain Mean; sd: Standard Deviation.

Table 3: Mean values of displacement time (in seconds) for the CGS motor test.

	Pretest-mean	Pretest-sd	Postest-mean	Postest-sd	Diff-mean	t	p_value
CG	4.79	0.59	4.62	0.62	-0.174	-1.9	P > 0.05
IG	4.57	0.64	4.27	0.51	-0.301	-2.4	P < 0.05

CG: Control Group; IG: Intervention Group; CS: Chair Stand; Diff-Gain Mean; sd: Standard Deviation.

Table 4: Mean values (in s) of the time variable for the MGS motor test.

	Pretest-mean	Pretest-sd	Postest-mean	Post test-sd	Diff-mean	t	p_value
CG	3.49	0.41	3.45	0.40	-0.035	-0.71	P > 0.05
IG	3.45	0.41	3.23	0.34	-0.217	-3.19	P < 0.05

CG: Control Group; IG: Intervention Group; CS: Chair Stand; Diff-Gain Mean; sd: Standard Deviation.

Table 5: Differences in gains between IG and CG.

Test	CG	IG	t	p_value
CS speed	0.108	-0.057	5.66	P < 0.05
CS power	63.806	-38.148	4.87	P < 0.05
CGS	-0.301	-0.174	-0.82	P > 0.05
MGS	-0.217	-0.035	-2.15	P < 0.05

CG: Control Group; IG: Intervention Group; CS: Chair Stand; CGS: Comfort Gait Speed; MGS: Maximum Gait Speed.

For statistical analysis, paired t-test was used to compare Pre and Post-Intervention. For comparing Groups (TP versus Control) t-tests for two samples were used. Data were presented as mean ± standard deviation and analyzed using R software package version 2.6.0 (R Development Core Team, Austria), with the value $\alpha = 0.05$.

Results

Speed and power were measured for the CS test, and the variable time was measured for the CGS and MGS motor tests. Table 1, table 2, table 3 and table 4 presents the results of the pre and post-test and the level of significance intra groups.

Chair stand motor test

Speed: A significant improvement in speed in CS was observed in the IG. The same occurred in intergroup comparison IG versus CG (Table 5), where the Diff-mean value of the IG was significantly higher. Significant changes were not observed for the mean speed variable in the CG (Table 1).

Power: A significant improvement in power in CS was observed in the IG. The same occurred in intergroup comparison IG versus CG (Table 5), where the Diff-mean (gain) value of the IG was significantly higher. Significant changes were not observed for the mean speed variable in the CG (Table 2).

Comfortable gait speed test

There was significant improvement in displacement time for CGS test in IG at the post-test in comparison with the pre-test. The CG showed no significant changes fordisplacement time in CGS test (Table 3).

Maximum gait speed test

The intragroup evaluation revealed a significant improvement in the time of execution of the MGS by IG individuals at the post-test stage compared to the pre-test. There was no significant change in the time variable of the MGS test for the CG ($p > 0.05$) (Table 4).

Table 5 compares the mean of gains observed in inter group testing. Comparing the means, there were significant improvement of CS speed, CS power and MGS in IG, related to CG.

Discussion

Most of the results obtained in this study confirm the findings of other scientific works which, though they used different methodologies, had similar objectives, aiming to evaluate the effectiveness of power training for the elderly [6,11-13,19].

The studies by Fielding, et al. [19] and Botaro, et al. [20] compared high and low speed resistance training in elderly men and women, respectively. The present study, however, did not contrast different types of training, but used the same training program as an intervention strategy, with the same number of sets, repetitions and methods of carrying out the exercises.

To evaluate strength, both studies [19,20] used the 1RM test at the beginning of the exercise process, whereas the present study verified changes in strength generation capacity by progressive development of loads. Moreover, when measuring power, the equipment used in this study did not limit the movement of the participants, an important feature considering that power is directly related to the speed of execution and that its magnitude may be impaired when there is restriction of movement. In both studies cited [19,20] isokinetic equipment was used to estimate muscle power.

While Fielding, et al. [19] and Botaro, et al. [20] measured strength and power by employing strategies that differed from those used in the present study, the results found were similar in terms of the significant gains in the capacity to generate muscular power.

Earles, et al. [21] trained elderly volunteers for 12 weeks. Individuals were stratified into two groups according to the type of exercise they undertook, and the results obtained in muscle power training were compared with those achieved with a walking program. The researchers also used different procedures from those used here. They compared different exercise strategies, namely power and walking. This study achieved similar results in terms of the significant gain in muscle power generation capacity in response to resistance training, with an emphasis on movement speed.

In the study by de Vos, et al. [22], which featured elderly volunteers, different intensities of the same type of speed resistance training were compared. The group that trained with an intensity of 50% of 1RM showed the best response in terms of increased average muscle power. The group that trained at 80% of 1RM exhibited the best response in terms of increased strength generation capacity. In the present study, training intensity was calculated from the load reached in the best power curve, and this value was adjusted during the exercise program. According to McArdle, et al. [9] the highest levels of muscle power generation are achieved with 60% of maximum 1RM load. Therefore, the present study used a training intensity equivalent to the 50% group of the study by de Vos, et al. [22].

In the motor tests, the results exhibited significant gains in movement speed in the chair stand test and also a significant reduction in execution time in the gait tests, results also obtained by Bean, et al. [23] and Hazeli, et al. [24].

A significant gain in the capacity to generate muscle power was observed in the chair stand test in the present study using Tendo Weightlifting Analyzer V-104 equipment. The gain in power generating capacity in this test probably occurred due to increased speed of movement, as the resistance displaced by the volunteers was their own body mass, which did not change significantly during the intervention period.

The results obtained in the course of the gait tests suggest that there was an increase in power generation capacity, as the increase in speed, confirmed by a reduction in execution time, was significant, considering that, the resistance and the distances remain unchanged. Similar results were obtained by Earles, et al. [21] and Bean, et al. [23].

The results of the present study are consistent with those found in literature, confirming the assumption that muscle power training among the elderly can be an important form of intervention to mitigate the negative effects of the decline in functional capacity that occurs during the aging process.

The decline of the speed on movement and gait is a risk factor for falls, immobility, fractures and consequent loss of autonomy and quality of life. The findings showed the improvement of this variable through the training of the muscular power. This achievement is important to delay the negative effects of the aging process, therefore this knowledge contributes to the Exercise Medicine field.

Limitations of Study

The limitations include the absence of equipment to standardize the speed of movements during the training sessions and a validated protocol of High Speed-Resistance training. Other limitation was not having measured: leg length for estimating the optimal walking speed through the Froude number; and the body fat percentage. Other possible limitation was the fact of both groups performed the same routine testing. This fact can interfere on the results due to the effects of taking a test on the outcomes of taking a second test.

Conclusion

High Speed Resistance training in the study group resulted in an increase in power generation capacity and muscle speed in the chair stand and gait tasks. Such training appears to have contributed to improve the performance of motor tasks of women in the group surveyed.

Further studies on this theme are required to examine the long-term effects of High Speed-Resistance Training in older persons.

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