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Impact of an Oriented Resistance Exercise and Endurance Training on the Health of Elderly Men

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Abstract The purpose of this study was to evaluate the effects of a resistance exercise training versus an endurance training on the morpho-functional aspects of elderly men. The sample was made of 31 elderly men, divided into two groups, where 17 subjects (66.35±3.82 yrs) performed resistance exercise training (RET) and 14 subjects (69.21±6.90 yrs) performed endurance training (ET), for 12 weeks. The variables assessed were muscle thickness, body composition, electromyographic muscle activity (EMG), force production and functional mobility. A two-way ANOVA (by group and by intervention) for repeated measurements (pre- and post-) was used for the comparison of EMG. The remaining variables were analyzed intra-group (pre- and post-) using paired Student's t-test. The significance level adopted was of 5%. The ET showed significantly higher reduction in total body mass and body mass index (BMI) in comparison to the RET group. The RET group showed significantly greater gains in force production and muscle thickness when compared to the ET. Our results suggest that the combination of RET using Swiss balls and rubber bands, in other words, low cost materials, in addition to easy adherence ET, as walking, can improve the neuromuscular system and body composition.

Keywords: *aging, resistance exercise, endurance exercise, sarcopenia, body composition*

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1. Introduction

The advances in medicine and the relatively recent incentives to the prevention of diseases on the population have caused an increased longevity and life expectancy of the individuals. On the other hand, the technological advances have facilitated the adoption of a sedentary lifestyle, which makes it so that these individuals not always reach old age with the expected health and quality of life.

So, it is necessary to study the Brazilian elderly person, that in 2012 already accounted for over 20 million people [1]. Specially, to study the phenomenon that may incapacitate the elderly individuals making them functionally dependent of other people is particularly important, not only to the older adults autonomy but also to the Brazilian Health Care System.

Several evidences have pointed to the fact that ageing is associated with a phenomenon known as Sarcopenia [2], that according to the European Consensus on Definition and Diagnosis involves a decrease in muscle mass and muscle function, causing loss of force production and physical performance [3].

Sarcopenia affects the muscle architecture directly, decreasing the anatomical cross sectional area (ACSA), muscle fiber length, volume and penation angle, in addition to reducing the specific force production capacity, in other words, the amount of force produced by each unit of muscle mass [4].

According to Hepple [2], the Sarcopenia process begins approximately at 50 years of age. Individuals, specially the elderly, when submitted to a strength training program, present attenuation of the atrophy effects of aging, indicating that sedentary behavior is associated with the loss of muscle mass [5,6,7,8,9].

The analysis of the influence of physical activity on the loss of muscle mass in the elderly may elucidate a more effective course of action when planning physical training programs for elderly individuals. The objective of this study was to evaluate the effects of a resistance exercise training (RET) versus an endurance training (ET) on muscle thickness, force production, muscle activity, body composition and functional mobility in elderly men.

2. Material and Methods

2.1. Ethical Aspects

This study was approved by the Research Ethics Committee of the PUCRS, protocol number 09/04696.

2.2. Sample

The sample was voluntary, composed of 31 male subjects, calculated using the following equation:

$$N = \frac{4\sigma^2 (Z_{crit} + Z_{pwr})^2}{D^2}$$

This equation indicates the sample size according to the significance level, statistical power, expected difference between groups and standard deviation of previous studies that used a similar methodology [10,11]. The subjects were divided in two groups: RET and ET. The RET group was composed of 17 elderly men, with average age of 66.35±3.82 years and the ET group was composed of 14 elderly men with average age of 69.21±6.90 years.

Table 1. Periodization of the RET program

Variable month	1	2	3	4	5	6	7	8	9	10	11	12
Series	1	1	2	2	3	3	4	4	4	5	5	5
Repetitions	15	15	12	12	10	10	8	8	6	5	5	5
Rubber band	UL, L e M	AI	AI	I	I	MI	SI	SI	SI	UI	UI	UI
Interval (s)	30	60	120	120	120	120	180	180	300	300	300	300

Key: Ultra Light (UL), Light (L), Medium (M), Average Intense (AI), Intense (I), Very Intense (MI), Super Intense (SI) and Ultra Intense (UI).

2.3. Exercise Program

The RET program consisted of training sessions using Swiss balls and rubber bands, and was overseen by one of the researchers at all times. The duration of the training program was of 12 weeks, 3 days per week (Monday, Wednesday and Friday) and the training sessions had an increasing duration of 30 to 60 minutes, depending on which phase of the program the subjects were in. The training sessions were preceded by a 5 minutes warm-up, made of active and static stretching for the main muscle groups, each performed for 10-20 seconds. By the end of the training sessions, subjects performed a cool-down made of the same stretching exercises performed on the warm-up. The training program was made of exercises for the following muscle groups: horizontal shoulder flexors, shoulder extensors, elbow flexors, elbow extensors, spine flexors, hip extensors, knee flexors and extensors. The evolution of the training program during the 12 weeks can be seen on Table 1, where the volume and intensity of training are controlled by series, repetitions, rest intervals between series and the rubber band's intensity.

The subjects that composed the ET received a program composed of a stretching routine and a protocol of endurance training that should be performed 3 days per week, preferable with a 48 hours interval between days, during the 12 weeks of the study, without direct overseeing of the researchers.

The program predicted active static stretching for the main muscle groups, with indications to be performed at the beginning and in the end of the ET sessions. The ET protocol was composed of an interval walking program, alternating moments of light and vigorous intensity, predicting gradual increase in time, from 30 minutes on week 1 to 100 minutes on week 12. The subjects were oriented to control their intensity using a perceived exertion scale of faces [12], which had a key for their interpretation.

2.4. Measurement of Muscle Thickness

The subjects were assessed while seated, with the knees and hips at 90 degrees of flexion. An ultrasound (M5, Mindray Bio-Medical Eletronics Co.) with a linear array transducer was used to measure muscle thickness of the vast lateral at rest [13,14,15]. The protocol was performed according to previous studies [16,17]. Anthropometric measurements were performed to guarantee the proper repositioning of the transducer at the post- assessments.

2.5. Measurement of Force Production

Muscle force production was measured using a load cell (Miotec Equipamentos Biomédicos LTDA) fixed on one extremity and attached to the tibia of the subjects with Velcro straps. The subjects were oriented to try to extend their knees exerting maximum force while in static contraction of the knee at 90 degrees of flexion. Corrections were made using video recordings to calculate force production through identification of the joint angles and lines of power.

2.6. Measurement of EMG

A 4 channels surface EMG system (*Miotool, Miotec* Equipamentos Biomédicos LTDA) was used to acquire EMG signal from the vast medialis, vast lateral, rectus femoris and biceps femoris muscles using bipolar electrodes arrangement (*Ag/AgCl, Meditrace*) and analyzed using the root mean square (RMS) of the signal. The placement of the electrodes and the preparation of the skin was done according to the recommendations of the *Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles* [18]. During the first session of data gathering, notes on the anatomical points were taken to ensure that the electrode placement was the same during pre- and post- assessment.

2.7. Measurement of Functional Mobility

Functional mobility was assessed using the Timed up and go test (TUG) [19].

2.8. Statistical Analysis

Statistical analysis was done with the GraphPad Instat 3.06 (*GraphPad Software, San Diego, California, USA*). A two-way ANOVA (by group and by intervention) for repeated measurements (pre- and post-) was used for the comparison of EMG. The remaining variables were analyzed intra-group (pre- and post-) using paired Student's t-test. The significance level adopted was of 5%. Based on Altman [20], values of p between. 05 and. 10 were considered borderline. The data is showed as mean ± standard deviation.

3. Results

After the pre- tests, we have observed no statistically significant differences between groups on anthropometric measurements as total body mass, height, body fat percentage and lean body mass, as well as age.

No statistically significant changes were observed on the RET group in functional mobility (TUG test), total body mass, and vast lateral maximal and average activation.

Table 2. Pre-training results

Variable	RET group (n=17)	ET group (n=14)	p
Age	66.35±3.82	69.21±6.90	p>0.05
Total Body Mass (kg)	84.06±14.14	83.75±12.23	p>0.05
Height (cm)			p>0.05
Body Fat (%)	39.62±9.30	39.59±12.07	p>0.05
Lean Body Mass (kg)	49.93±6.81	49.81±9.37	p>0.05

Resistance Exercise Training (RET); Endurance Training (ET)

Table 3. Resistance Exercise Training Group

Variable	Pre-	Post-	p
Total Body Mass (kg)	84.06±14.14	83.82±14.27	0.0116*
BMI (kg/m^2)	28.26±3.94	28.22±3.91	>0.10
TUG test (seg)	7.02±1.34	6.33±0.96	0.0210*
Abdominal circumference (m)	1.02±0.11	1.02±0.11	0.64
∑Skin folds (mm)	142.26±31.36	138.12±33.63	>0.10
Lean Body Mass(kg)	49.93±6.81	55.09±7.05	0.0024**
Fat Mass (kg)	34.13±12.10	28.73±12.14	0.0027**
Body fat (%)	39.62±9.30	33.14±10.06	0.0013**
Muscle Thickness (mm)	19.64±3.43	20.98±3.01	0.0714[1]
Force (N)	420.94±117.28	486.25±108.66	0.0044**
Vast Lateral Max	1198.60±455.90	1181.44±337.63	>0.10
Vast Lateral Average	168.45±92.15	179.15±61.14	>0.10
Vast Medial Max	988.21±401.92	1253.57±623.79	0.0395*
Vast Medial Average	144.02±69.40	197.64±121.35	0.0267*
Biceps Femoris Max	282.53±149.83	358.59±162.64	>0.10
Biceps Femoris Average	56.29±40.38	71.90±4419	>0.10

[1] p<0.10; *p<0.05; **p<0.01; Σ = sum

Table 4. Resistance Exercise Training Group

Varible	Pre-	Post-	p
Total Body Mass (kg)	83.75±12.23	82.20±11.10	0.0116*
BMI (kg/m^2)	28.44±3.03	27.93±2.70	0.0155*
TUG test (seg)	6.79±1.24	6.42±1.26	0.2871
Abdominal circumference (m)	1.04±0.08	1.02±0.08	0.0407*
∑Skin folds (mm)	141.32±39.42	130.54±31.89	0.0185*
Lean Body Mass (kg)	49.81±9.37	55.92±5.57	<0.001**
Fat Mass (kg)	33.94±14.61	26.28±10.75	<0.0001**
Body fat (%)	39.59±12.07	31.14±9.22	<0.0001**
Muscle thickness (mm)	19.06±2.39	19.45±2.30	0.3575
Force (N)	447.37±177.17	443.98±148.44	0.8165
Vast Lateral Max	1041.47±352.30	1103.77±348.32	>0.05
Vast Lateral Average	142.04±44.53	153.63±41.58	>0.05
Vast Medial Max	1056.41±425.97	819.39±304.28	>0.05
Vast Medial Average	151.10±51.88	124.63±34.27	>0.05
Biceps Femoris Max	258.98±170.90	310.43±195.03	>0.05
Biceps Femoris Average	48.73±24.79	67.86±42.12	>0.05

*p<0.05; **p<0.01; Σ = sum.

We have observed changes in lean body mass, fat mass, body fat percentage and force production during maximal isometric voluntary extension of the knee. Muscle thickness of the RET group showed an average increase of 1,34 mm, which suggests that there was an increase in muscle mass, with a borderline statistical significance (p=0.07). No changes were observed on the vast lateral and biceps femoris activation, skin fold sum and BMI.

The ET group showed statistically significant reduction in total body mass, BMI, abdominal circumference and skin folds sum. A reduction in lean body mass, fat mass and body fat percentage was observed with great statistical power.

4. Discussion

When analyzing the effects of the two proposed exercise programs, we have observed that the variables related to force production, muscle thickness and knee extensor muscles were the ones that showed the biggest difference between groups, suggesting an advantage towards RET using rubber bands.

The increment in force production related to RET using rubber bands has already been demonstrated in other studies and reflects the morpho-functional adaptations of the musculo-skeletal system with the increase of the muscle fibers and penation angle, indicating an increase in the number of in-line and parallel sarcomeres, besides the increased of the maximal voluntary activation capacity and neural conduction, indicating a higher number of motor units recruited, or an increase of the frequency of stimulation of the motor units [21,22,23,24]. These adaptations are justified by the systematical use of the muscle groups, which induces alterations on the musculo-skeletal system, modifying its function and augmenting the capacity to produce force in young [25,26,27] and elderly subjects [28].

These same changes were not observed on the ET group, suggesting that this kind of activity would not be adequate to counteract the effects of Sarcopenia.

The results shown in this study elucidate the contribution of the RET on the increment of functional ability on the TUG test, probably related to the increased muscle force production in the lower limbs. Skelton, Young [29] verified that after 12 weeks of RET of moderate intensity with rubber bands, elderly subjects of ages 76-93 years showed mean increases of extension force and flexion force on the knees and hands grip strength. The authors observe that these strength gains determined the improvement of the functional ability of these elderly subjects.

The evaluation of force and power of the knee flexors and extensors is an important factor that must be taken into account when assessing functional capacity for several daily living activities, as walking, running, cycling and climbing stairs [30]. This way, the results found on the RET group seem to contribute to allow an increased functional independence in the elderly.

The ET group showed positive morphological adaptations related to body composition. These changes on the ET group, as well as on the RET group, have happened due to the insertion of physical exercises in a regular and systematic manner. These changes in body composition can be justified by the specificity of the proposed activity. Because the sample was of previously sedentary individuals, even with the execution of only endurance training, we have found significant changes on the lean body mass of the ET group.

Comparing the results obtained by the two groups, we have observed that the total body mass variation was not so big on the RET group because, as we can see on the comparison of measurements, this group suffered a bigger increase in lean body mass than the ET group. This was expected as a specific adaptation of RET [31].

The increase in lean body mass on both groups showed very close values, with a smaller change on the RET group. We believe that a 12 weeks period is too short to suggest that the results indicate that RET yields lesser lean body mass adaptations once the starting condition of sedentary individuals suggests they will have faster initial adaptations to training, in a way that it is expected that any systematic physical activity will produce lean body mass gains.

5. Conclusion

We have concluded that the RET group showed improvements in force production, muscle thickness and muscle activation, as well as in functional mobility. The ET group, on the other hand, showed positive results mostly on the anthropometric aspects. Our results suggest that the combination of RET using Swiss balls and rubber bands, in other words, low cost materials, in addition to easy adherence ET, as walking, can improve the neuromuscular system and body composition. Therefore, this combined strategy can be of great advantage to the Brazilian Health Care System, once it is of great effectiveness and easy to implement.

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