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Original Article

EFFECT OF RESISTANCE TRAINING ON PHYSICAL PERFORMANCE AND FUNCTIONAL RESPIRATORY CAPACITY OF ELDERLY WOMEN

EFEITO DO TREINAMENTO RESISTIDO NO DESEMPENHO FÍSICO E CAPACIDADE FUNCIONAL RESPIRATÓRIA DE MULHERES IDOSAS

Vanderson Cunha do Nascimento[1], **Renato da Costa Teixeira**[1], **Evitom Corrêa de Sousa**[1], **Evelim Leal de Freitas Dantas Gomes**[2] and **Dirceu Costa**[2]

[1]Universidade do Estado do Pará, Belém-PA, Brasil.
[2]Universidade Nove de Julho, São Paulo-SP, Brasil.

ABSTRACT
In the aging process, additionally to other functional losses, there are reductions in physical and functional respiratory performance.It is known that resistance training (RT) is effective at developing trophism and muscle strength; however, little is known about the influence of RT on respiratory variables. To compare maximal inspiratory and expiratory pressures (MIP; MEP), Axillary, Xiphoid and Abdominal ranges – AxR, XiR and AbR –, Peakflow and performance in theIncremental Shuttle Walk Test (ISWT) of elderly women participating in an RT program with those of untrained ones. Methods: 53 women, aged 66 ± 5.2 years –28 participants of an extension project at Pará State University, with a minimum of 6 months of practice in a RT program, composing the trained group (TG), and 25 volunteers who composed the untrained group (UG). Assessments consisted of measurements of MIP, MEP, AxR, XiR, AbR, Peak Flow and performance in the ISWT. As results, significant differences were found, with better values in the TG as to all variables assessed, except for AbR. In conclusion, elderly women subjected to anRT program showed favorable and significant differences in MIP, MEP, XiR, Peakflow and ISWT compared tountrained ones.
Keywords: The elderly. Resistance training. Respiratory muscles. Breathtests. Stress test.

RESUMO
No processo de envelhecimento, entre outras perdas funcionais, ocorrem reduções no desempenho físico e capacidade funcional respiratória. Sabe-se que o treinamento resistido (TR) é eficaz no desenvolvimento do trofismo e força muscular, contudo, pouco se sabe sobre a influência do TR em variáveis respiratórias. Este estudo comparou as pressões inspiratórias e expiratórias máximas (PImáx; PEmáx), as amplitudes Axilar (AAx), Xifoideana (AXi) e Abdominal (AAb), o Peak-Flow e o desempenho no Incremental ShuttleWalk Test (ISWT) de idosas praticantes de um programa de TR, com os de idosas não treinadas. Foram avaliadas 53 mulheres idosas, idade de 66±5,2 anos, sendo 28 participantes de um projeto de extensão da Universidade do Estado do Pará, com mínimo de seis meses de matrículaem um programa de TR, que compuseram o grupo de treinadas (GT) e, 25 voluntárias que compuseram o grupo de nãotreinadas (GNT). As avaliações constaram de medidas de PImáx, PEmáx, AAx, AXi, AAb, Peak-Flow e de desempenho no ISWT. Constataram-se diferenças significativas, com valores favoráveis ao GT em todas as variáveis avaliadas, exceto AAb. Conclui-se que mulheres idosas do GT obtiveram diferenças favoráveis e significativas na PImáx, PEmáx, AAx, AXi, Peak-Flow e ISWT, quando comparadas com mulheres idosas do GNT.
Palavras-chave: Idoso. Treinamento de resistência. Músculos respiratórios. Testes respiratórios. Teste de esforço.

Introduction

The aging process brings some weaknesses toone’s physical performance and functional respiratory capacity, such as reduced respiratory muscle strength[1], thoracic compliance[2], peak expiratory flow[3] and performance in walking test[4,5].

It is known that regular physical exercise can contribute to delaying the degenerative effects of the natural aging process and that resistance training (RT) can be considered an effective intervention forproper performance of skeletal striated muscles, especially for strength production capacity[6]. However, little is known about the influence of RT on respiratory variables[7].

It is also known that in the aging process there is a decline in skeletal muscle mass and strength, including in the strength of respiratory muscles[8] and, consequently, in gas exchanges[9]. However, most studies on this topic have been developed in individuals with respiratory disorders, and there is a lack of information about the behavior of these variables in elderly but healthy people participating in RT programs[7].

Respiratory muscle strength, recorded through static pressures, such as maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), has been used with great frequency[1,10,11] and acceptance, consisting of a simple method of measurement to assist in diagnosis, having an important prognostic role in neuromuscular and pulmonary diseases[1,11]. It should be noted that reduced strength of respiratory muscles in aging is usually associated with changes in thoracic morphology and decreased pulmonary elasticity, probably caused by a progressive calcification of involved joints and by a reduction of intervertebral spaces, which also reduces one'scapacity to expand the rib cage[12].

Considering that reductions in the performance of these muscles and in rib cage expansion capacity can lead to pulmonary hypoventilation, decreased tolerance to physical exercise, respiratory insufficiency and lower capacity to produce strength for coughing[3,13], the exploration of this variableis also justified in the elderly population.

In this context, another important aspect related to decreased respiratory capacity is reduced exhaled air flow, measured by peak expiratory flow (PEF) or Peak flow, which provides information on speed of exhaled air by means of a portable device, which is also a simple, quantitative and reproducible way to detect possible airway obstructions[14].

Another simple but reproducible method of assessing physical performance, and which has been widely employed, is the Incremental ShuttleWalk Test (ISWT). It is a test that assessescovered distance at increasing speed, providing cardiorespiratory responses to physical exertion[4,15]. It is a simple, incremental test developed in 1992, with speed controlled by beeps, and whose purpose is to assessa person's physical performance[16].

The ISWT was created as an assessment instrument for individuals with chronic obstructive pulmonary diseases[4], but its application is possible to individuals with different health conditions and age groups[17], and can be used to assess the physical fitness of the adult population in general[18] and, particularly, in elderly individuals.

In summary, over the years, senior citizens tend to have reduced general strength and find in RT a methodological alternative forthe maintenance of proper conditions for muscular trophism in general[19] and, possibly, for the development of their functional respiratory capacity.

The assessment of respiratory functional capacity and physical performance variables is important as it provides important information on the health of the elderly, who normally present respiratory fragilities and reduced physical performance[5,9], justifying studies that allow a joint exploration of these variables in a practical, non-costly and feasible way, but with consistent and reproducible methodology. In this sense, the objective was to compare maximal inspiratory and expiratory pressures, thoracoabdominal ranges, peak expiratory flow, and performance in the incremental shuttlewalk test of elderly women participating in anRT program with those of untrained ones.

Methods

A prospective, cross-sectional study conducted in the Resistance Training and Health Laboratory [*Laboratório de Exercício Resistido e Saúde*] (LERES) of Pará State University (UEPA), from June to September 2016, in compliance with ethical precepts and approved by the Ethics and Research Committee under legal opinion No 1.589.905/16.

Participants

Fifty-three elderly women were assessed, all aged between 60 and 79 years old (66±5.2 years) – 28 participants of a LERES-UEPA extension project, with a minimum of six and a maximum of eighteen months in an RT program, who composed the trained group (TG), and 25 volunteers, classified as sedentary or underactive active as per the International Physical Activity Questionnaire (IPAQ)[20], short version, composingthe untrained group (UG).

Using the G* Power software, the sample calculation was based on 23 individuals, with respiratory muscle strength as outcome, considering an alpha risk of 0.05 and a beta risk of 0.1.

Procedures

Adopted inclusion criteria were: being female; 60 years old or over; not having cardiorespiratory, neurological, musculoskeletal and other diseases that could cause acute or chronic changes in physical performance and functional respiratory capacity; not smoking; having a medical certificate; accepting to participate in the study; and signing an acceptance and free consent form.

The criteria that excluded participants from the TG were: being less than six months in the LERES RT program and being participating in another physical activity program; for the UG, the exclusion criteria were: being classified as active or very active as per the International Physical Activity Questionnaire - short version (IPAQ)[20].

Tests and Assessments

All elderly women in the TG and UG were subjected to tests and assessments for MIP, MEP, thoracoabdominal cirtometry, Peak flow, ISWT, weight and height.

Respiratory Muscle Strength

Respiratory Muscle Strength was measured from MIP and MEP by manovacuometry, using an analog Gerard manovacuometer, ± 300 cmH_2O. For the measurement, all the elderly women remained seated, with feet resting on the ground, using a nasal clip.

By means of disposable oral adapters and a nasal clip, MIP was obtained through maximal inspiratory effort sustained for 2 seconds, starting from maximal expiration, at residual volume (RV) level, while MEP was obtained through maximal expiratory effort, which was held for at least 2 seconds, starting from maximal inspiration, at total lung capacity (TLC) level. The measurements were done at least three and at most six times for technically correct movements, with the highest value obtained being computed, provided that it equals another measure or had a difference up to 10% in relation to the immediately lower value[21].

To obtain the reference values of MIP and MEP, the following equations were used: MIP = - 0,49 (age) + 110.4; MEP = -0.61 (age) + 115.6.

Range of Thoracoabdominal Motion

The ranges of thoracoabdominal motion were measured using thoracoabdominal cirtometry, which was done with a Wiso anthropometric measuring tape, in centimeters (cm), in the Axillary (AxR), Xiphoid (XiR) and Abdominal (AbR) areas[22,23], in orthostatic position, with the thorax as bare as possible. To do so, the women performed a maximal inspiration and then a maximal expiration, and the value obtained for each of the reference points was recorded[23]. With the measures collected, the value obtained in the inspiration was subtracted from the value obtained in the expiration, with the difference in centimeters being therefore considered as the range of motion for each of the three measured points or levels (AxR, XiR and AbR).

Peak Respiratory Flow

Peak flow was measured by means of a Vitalograph portable devicescaled in liter/minute; the subject held it horizontally in front of her and, after maximal inspiration, put its disposable nozzle in her mouth, holding it firmly with her lips, and exhaled as hard, fast and deep as possible. A minimum of three and a maximum of six measures were taken, with an interval of 30 seconds each, computing the highest value obtained, provided that it is equal to another measure or 10% lower than the immediately inferior measure[24].

To obtain Peak flow reference values, the following equation was used: Peak flow = (-1.18 x Age) + (274.03 x Height).

Incremental Shuttle Walk Test (ISWT)

The ISWT was executed on a 10-meter track demarcated by two cones. The following materials were used: Speedo digital timer; two cones; stereo and CD containing the recording of the ISWT sounds; a NTL Pressure sphygmomanometer; a Polar hear rate monitor; a Rossmax pulse oximeter;and the Borg scale for assessment of subjective perception of effort[16].

For this test, all of the women were instructed on clothing and meals[25], and before and after the ISWT their blood pressure (BP), heart rate (HR), peripheral oxygen saturation (SpO2), respiratory rate (RR) and subjective perception of respiratory effort and lower limbs[26] were all measured. After the initial measurements, they walked on the track at increasing speed, which varied according to the pace determined by beeps, always receiving a standardized verbal command at the end of each course[4]. It is worth highlighting that the walking speed in the ISWT is determined by two different types of beeps: a single beep, indicating change of direction, and a triple beep, indicating change of direction and stage[16].

The criteria for interrupting the test were: fatigue or presence of limiting symptom, such as inability to keep the pace of displacement, failing to reach the subsequent cone for two consecutive times within the time established by the beeps; HR values higher than 85% of the maximal HR predicted by the equation HR = [210 - (0.65 x age)][4], or SpO2 decrease ≥ 4% of the resting value[26]. At the end of the test, in addition to the physiological variables already noted, the stage at which the test was interrupted was recorded, and the distance covered was computed in meters[4].

To obtain ISWT reference values, the following equation was used[18]: ISWT = 347.7 - (7.2 x Age) - (3 x Weight) + (472.3 x Height) + (137.2 x 0).

Body Mass Index (BMI)

For BMI, weight was recorded first, using a calibrated, analog Welmy scale, with maximum capacity of 150 kg and intervals of 100 grams. The women were instructed to empty their bladders first and, minimally dressed and barefoot, to stand on the center of the scale. Height was measured with a stadiometer attached to the Welmy scale, with a maximum limit of 2m in length, for which they were also standing straight and barefoot[27]. With their weight and height data, this equation was applied: BMI = W/H^2, where “W” is weight in Kg, and “H” height in meters.

The RT program in which the TG were participating had the following characteristics: 03 classes; 02 weekly sessions; morning sessions; maximum of 1 hour; 02 sets; 08 to 12 maximal repetitions (MRs); interval of 01 to 02 minutes between sets; exercises[6,28]: sitting bench press, 45° legpress, pulldown, deadlift, unilateral standing rowing, standing calf exercise, deadlift combined with rowing, sit-ups and shoulder press. It should be recalled that the term resistance training (RT) was adopted as synonymous with bodybuilding, which is commonly suggested by Physical Education teachers. After assessment, the UG women were offered enrollment in the RT program.

Statistical Analysis

After being organized in Excel spreadsheets, data were subjected to the Shapiro-Wilk normality test, and the variables were presented as mean/standard deviation. In inferential statistics, the Unpaired t-Test and Pearson's Correlation were applied. The level of significance was set at $p \leq 0.05$. For statistical analysis, the Bioestat 5.0 software was used.

Results

Regarding age and BMI, there was no significant difference between TG and UG. A significant and favorable difference was revealed in the TG as to physical performance through the ISWT, and as to respiratory muscle strength, assessed by MIP and MEP, as well as to functional respiratory capacity, assessed by Peak flow, AxR and XiR (Table 1).

Table 1. Anthropometric and physical and functional respiratory performance, as well as statistical results between TG and UT

	TG (n=28)	UG (n=25)	p
Age (years)	66.1±5.0	67.1±5.4	0.2511
BMI (Kg/m^2)	27.3±4.7	27.6±3.6	0.4223
MIP (cmH_2O)	92.5±25.0	59.8±19.5	0.0001*
MEP(cmH_2O)	91.1±21.9	75.1±21.5	0.0050*
Peak flow (l/min.)	351.6±56.4	305.6±72.0	0.0060*
AxR (cm)	0.9±0.6	0.5±0.3	0.0014*
XiR (cm)	0.7±0.5	0.4±0.3	0.0007*
ISWT (m)	393.4±93.4	264.6±72.8	0.0050*

Note: Data as mean ± standard deviation; (*) significant p≤0.05; (BMI) Body Mass Index; (MIP) Maximal Inspiratory Pressure (MIP); Maximal Expiratory Pressure (MEP); (AxR) Axillary Range; (XiR) Xiphoid Range; (ISWT) Incremental ShuttleWalk Test
Source: The authors

About AbR, no significant difference was found between TG and UG, and unlike AxR and XiR levels, negative values were detected in twelve (12) women in the TG, and ten (10) in the UG, which characterized them as having a paradoxical respiratory pattern, making a more accurate comparative analysis of these data impossible.

Table 2 displays obtained and reference values for MIP, MEP, Peak flow and ISWT, as well as statistical results between obtained values and reference values for TG and UG.

As one can see (Table 2), the results obtained from the ISWT and the Peak flow for the TG were even higher than the respective reference values, though not statistically different. These results can be considered clinically important for aging individuals, along with MIP and MEP values, which are significantly higher than the respective reference values.

Table 2. TG's and UG's obtained and reference values for MIP, MEP, Peak flow and ISWT, and analysis of obtained means with reference values means

	TG (n-28)			UG (n=25)		
	Obtained	Ref. V.	p	Obtained	Ref. V.	p
MIP	92.5±25.0	78.0±2.5	0.0024*	59.8±19.5	77.5±2.7	0.3851
MEP	91.1±21.9	75.3±3.1	0.0004*	75.1±21.5	74.7±3.3	0.4652
Peak flow	351.6±56.4	337.3±15.9	0.0953	305.6±72.0	334.9±16.7	0.0265*
ISWT	393.4±93.4	399.3±52.1	0.3705	264.6±72.8	389.7±53.2	0.0001*

Note: (Ref. V.) reference values mean; (*) significant p≤0.05; (MIP) Maximal Inspiratory Pressure; (MEP) Maximal Expiratory Pressure; (Peak flow) Peak Expiratory Flow; (ISWT) Incremental ShuttleWalk Test
Source: The authors

Still in Table 2, for UG individuals, when it comes to reference values, smaller but not significant values were found for MIP and MEP, as well as significantly lower values for Peak flow and distance covered in the ISWT.

As for correlation of respiratory capacity variables with performance in the ISWT, no correlation was observed for any of the variables in the UG and, for the TG's variables, correlation was observed only for xiphoid range (Table 3).

Table 3. Correlation between the TG's ISWT and xiphoid range.

	ISWT	
	r	p
Xiphoid Range	0.5167*	0.0049

Note: (r) = Pearson's coefficient (*); significant p≤0.05; (ISWT) Incremental ShuttleWalk Test
Source: The authors

Discussion

In the group of elderly women regularly practicing RT, the distance covered in the ISWT was observed, and Peak flow values compatible with reference values and MIP and MEP were higher than the reference values. These data indicate that even though it is not a specific training for respiratory muscles, RT seems to maintain one's physical and expiratory capacity and increases the strength of this muscle group. The group of sedentary elderly women, in turn, presented MIP and MEP within the reference valuesand loss of functional capacity and pulmonary function, inherent to aging. In this case, it is suggested that RT can prevent this functional, pulmonary loss.

With respect to respiratory muscle strength, some studies addressing correlations between MIP/MEP and RT corroborate with our results, since in one of them[29], seeking to compare the effect of RT and sedentarism on indicators of strength normality in the respiratory muscles of male and female seniors, found significant and superior differences compared to normality values of MIP and MEP in the elderly who participated in a RT program.

Another study[30] intended for comparing the effects of different RT volumes on MIP, MEP, functional performance and muscular strength of elderly women concluded that simple and multiple sets of RT improve, among other variables, the respiratory muscle strength of older women after 24 training sessions, suggesting that female seniors who do not have the habit of or have little compliance with physical activity could start with simple sets of RT as a strategy in an exercise program for the health of this population.

In a more detailed analysis of correlations between respiratory muscle strength and RT program, it is possible that the significant difference of MEP in favor of the group participating in the RT was influenced by the specific exercise of abdominal muscle strength, which is constant in the RT program. In addition, all other exercises in their concentric and eccentric phases regularly demanded abdominal muscles to stabilize the trunk, contributing to their improved strength and resistance by isometric action[29]. Likewise, the significant difference in MIP in favor of the RT group may also have been influenced by a possible overload to the diaphragm muscle during the exercises, considering that request for expiration in the concentric phase and inspiration in the eccentric phase of the exercises, particularly in bench press and rowing, means, in the eccentric phase (stretching on contraction), a need for isometric contraction of abdominal muscles to maintain the stability of the trunk, promoting resistance against the action of the diaphragm muscle. Additionally, the shoulder press exercise demands a synergistic use of trapezius muscles (upper portion) and scalene muscles, important auxiliary muscles of inspiration[29].

Another aspect that may have contributed to a significant difference in MIP and MEP in favor of the group that practiced RT was that they were also advised to exhale in the concentric phase of the exercises, and inhale in the eccentric phase. Considering that the RT program consisted of 9 exercises with two sets of 8-12 MRs each, such orientation led to a range of 144 to 216 respiratory incursions per training session, which may have characterized an exercise directly related to inspiratory and expiratory muscles[29].

Concerning the significant difference in XiRbetween trained elderly women (TG) and untrained ones (UG), it should be recalled that among physiological adaptations in skeletal striated muscle tissue subjected to strength training, there is increase in sarcomeres – serial and parallel –, improvement in contractility, extensibility and elasticity, besides improved capacity to generate tension[31], factors that, together with guidance during the RT exercises of inspiration in the eccentric phase and expiration in the concentric phase as a dynamic action to mobilize the rib cage, may have assisted in the mechanics and, consequently, favored an increase in xiphoid range values.

Another important aspect observed in respiratory performance refers to higher Peak flow values in the TG in relation to the UG. In this study, because it was developed with elderly women without diagnosis of respiratory diseases, it is possible that the significant differences in peak expiratory flow in favor of the TGare not due to the internal resistance of the respiratory tract to airflow, but rather result from the effects of RT on respiratory muscles, in this case, the expiratory muscles, reducing the muscular hypotrophy condition[32].

Peak flow results are directly associated with the strength of respiratory muscles and thoracic mobility[3,12,13], therefore justifying better results in the TG, mainly due to better adaptations of expiratory muscles, which were effectively utilized throughout the whole RT program, either directly, through abdominal exercise, or bya continuous isometry required for these muscles as trunk stabilizers.

It is known that reduced respiratory muscle performance and rib cage expansion capacity, in addition to respiratory dysfunctions, may lead to reduced tolerance to physical exercise[3,13], and this intolerance can also be attributed to a dysfunction in gait skeletal muscles, characterized by decreased strength and muscle mass, contributing to difficulties in functional performance[31].

Elderly women's functional physical performance tends to decrease as a physiological response of senescence[15] and is worth being assessed whenever possible. In this case, the ISWT, which has been characterized as a valid, reliable and safe test for assessment of functional capacity in healthy individuals of varied age groups[16] is a good option for assessment of physical capacity at submaximal effort level, making its clinical applicability suitable for elderly women[15,16].

This study evidenced a significant difference in the distance covered in the ISWT by the elderly women who participated in the RT; it can be assumed, according to the literature on the theme[6,28], that RT, as a nondrug intervention, can help elderly women to have a better functional performance, naturally declining with advancing age.

Having verified a significant correlation between XiR and performance in the ISWT, a cause-effect relationship cannot be inferred; however, it points to a possibility that elderly women who practice RT, by presenting better thoracic mobility at xiphoid level and consequently better pulmonary ventilation[33], may be benefited concurrently with general strength adaptations[7] for a better physical and functional outcome.

Resistance training, as a method that favors improved muscle strength, power or resistance, has been for a long time related to development of sports skills and aesthetic indicators. In recent years, the volume of studies addressing health and quality of life have been growing, promoting investigations with special groups[29].

The set of information described in this study about correlations established about the effects of RT on the physical and functional respiratory performance of elderly women allowed evidencing significant performances in the TG compared to the UG, contributing to a better characterization of RT as a possible alternative and nondrug intervention for the development of better health conditions in this group, usually weakened by deficits in the joint musculoskeletal system, associated with painful conditions that prevent the practice of cyclical exercises of long duration.

As main limitations of our study we mention its transversality, the use of convenience sampling, and consequent impossibility to control and follow-up physical activities performed by the participants in the RT program, especially in the extra program. However, the results found contribute to the knowledge about RT and its correlation with the physical and functional respiratory performance of elderly women, as well as its possible applicability toone’s professional daily routine as a result of the utilization of validated and low-cost instruments of easy handling. The development of randomized clinical trials and correlations between test results considered gold standard are recommended as study focus.

Conclusions

Elderly women participating in an RT extension program showed favorable and significant differences as to MIP, MEP, axillary and xiphoid ranges, Peak flow and ISWT compared to older women classified as sedentary or underactive as per the International Physical Activity Questionnaire.

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Author address: Vanderson da Cunha do Nascimento. Av.Almirante Barroso, Conjunto Marex, Rua Vitória, 237, Bairro Val de Cães, Belém-PA, CEP [Postal code] 66617-040. E-mail: vanderson@uepa.br. Rua Vergueiro, 235/249 - Liberdade, São Paulo - SP, 01504-000. Phone: (11)2633-9000