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Impact of Association between Functional Training and Respiratory Muscle Training in Elderly: A Randomized Controlled Trial

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ABSTRACT

The elderly population in Brazil has been growing exponentially according to data presented by the IBGE. It is estimated that by 2025 the population will have reached 32 million, placing the country sixth in the world in the population of elderly people. To assess the results of respiratory training associated with functional training on respiratory muscle strength, lung function, and functionality of the elderly. The sample was composed of 40 elderlies, divided into four groups, the experimental group with functional training, one experimental group with functional training associated with respiratory training, one experimental group with respiratory training, and the fourth group, the control group. After the initial and final evaluations, the variables measured were: The Breathing Test, Sit to Stand Test, the SF-36 Quality of Life Questionnaire, and Spirometry. Twenty appointments were conducted twice a week. There were significant differences for variables maximum inspiratory and expiratory pressure; more accentuated in the associated group when compared to the respiratory group; forced vital capacity and forced expiratory volume in the first second/forced vital capacity were meaningful in the associated group; peak expiratory flow means values increased after the intervention; in the six-minute walk test, we noticed a trend to increase values after the intervention. Functional training as well as associated respiratory muscle training provide the most beneficial changes compared only to functional and respiratory training. Therefore, this may be an effective clinical training method for patients' elderly.

1. INTRODUCTION

The ageing of the population has become a reality in most of the world in recent decades. Changes in the living conditions and advances in medicine, reduced early mortality and promoted the increase in life expectancy [1]. The number of elders in Brazil is growing rapidly according to data from the Brazilian Institute of Geography and Statistics (IBGE), which estimates that by 2025 this population will have reached 32 million, placing Brazil as sixth in the world in the number of elderly people [1, 2].

As the population increases, the incidence of pathologies grows proportionally, and respiratory diseases are among the most important causes of death [3, 4].

With the aging process, there is a reduction in skeletal muscle strength and in respiratory muscle strength, resulting in a functional decline and decreasing performance in activities of daily living (ADL) [5].

Preventive physical exercise should be stimulated aiming at maintaining the independence of the elderly, increasing their functional performance, and providing the preservation or recovery of the organic functions affected by the aging process, preventing several pathologies [3].

Respiratory physical training provides results such as an increased ability of the inspiratory muscles to generate force and greater sustainment of a given inspiratory pressure level and may reduce sensations of respiratory effort [3].

The POWERbreathe K-series trains the inspiratory muscles using a resistance, with the possibility of automatically adjusting its load to follow the evolution of the individual [6]. Functional training originated from rehabilitation when movements were used to recover from injuries and postural changes [7].

Thus, the study aimed to assess the effects of respiratory training associated with functional training on respiratory muscle strength, lung function, and functionality of the elderly.

2. MATERIALS AND METHODS

2.1. Participants

Initially, the general characterization of the profile of individuals in each group was performed, and the variables age, gender, weight, height and BMI were evaluated. For age, weight, height and BMI, a one-way ANOVA analysis was performed to compare the values of these quantitative variables between the experimental groups. For the gender variable a Chi-square test for independence was performed. The data were evaluated for the assumptions of normality of residuals and homogeneity of variances, applying the Shapiro-Wilk Test and Cochran's Test, respectively. Finding the variables in normality and homogeneity of variances, the mixed model of Factorial Analysis of Variance for Repeated Measures was then applied, followed by the LSD-Fisher follow-up test. All tests were performed in the statistical program Statistica 7.0, assuming a significance level of 0.05.

Forty (40 male and female) elderlies aged between 60 - 80 years old confirmed their voluntary participation in the study. Inclusion and exclusion criteria comprised: aged under 80 years, without lung disease, and with independent gait (without aid device), wheelchair users, patients with COPD, decompensated arterial hypertension, orofacial injuries, smokers, and sufferers of neuromuscular diseases. Recruitment occurred through the Physiotherapy Clinic of the Positivo University, and participants gave written informed consent before taking part. The research protocol was approved by Positivo University Research Ethics Committee (Reference ID: 2,195,756/2017).

2.2. Study Design

This randomized controlled trial, was conducted between June 2018 and October 2018. The sample was divided into four groups, through randomization by random numbers, as follows: an experimental group with functional training (n = 7), an experimental group with functional training associated with respiratory training (n = 8), an experimental group with respiratory training (n = 8) and control group (n = 6). A flow diagram of this study is presented in **Figure 1**.

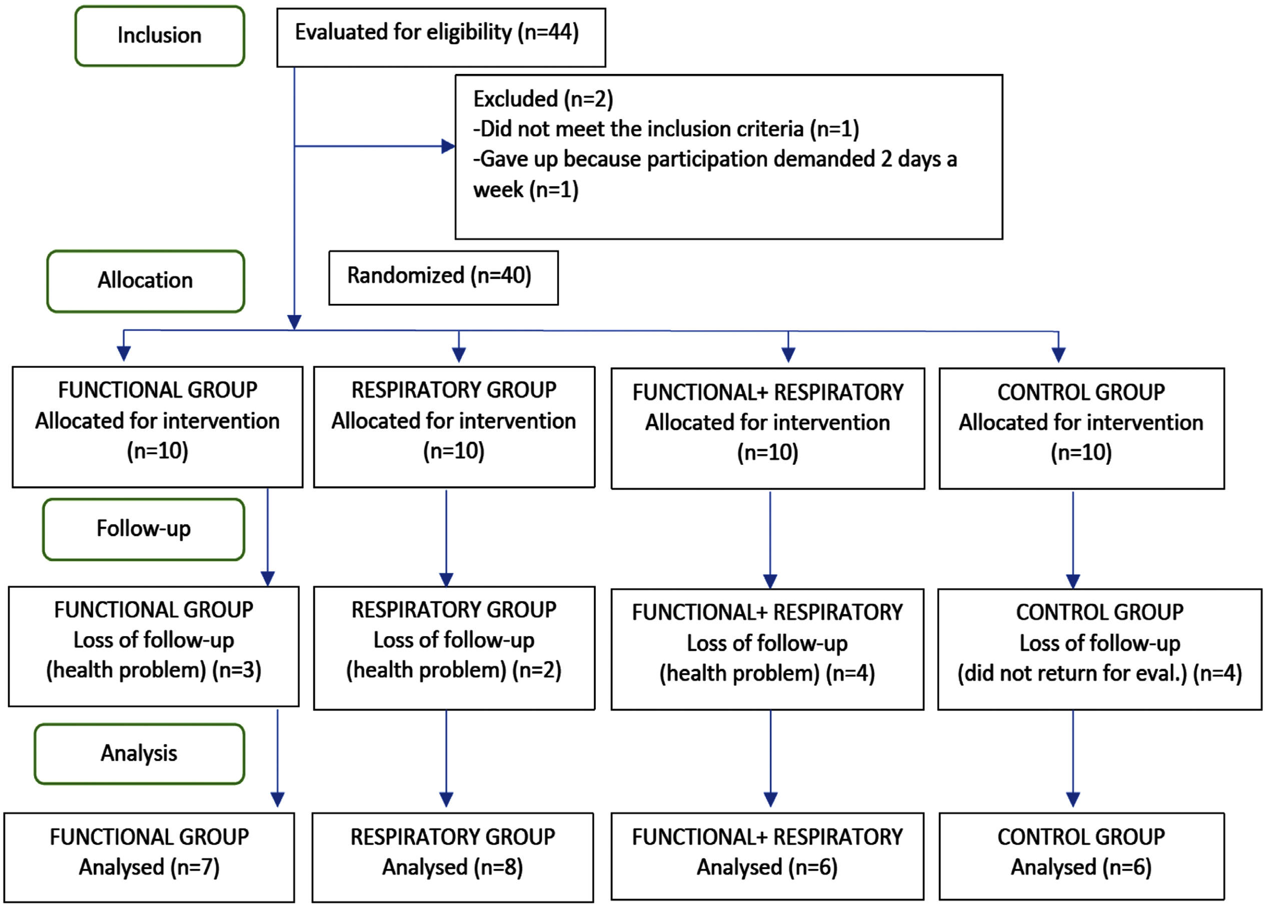

Figure 1. Flow diagram.

Subsequently, the sample was submitted to an initial evaluation at the Physiotherapy Clinic, where we took the anamnesis, respiratory tests, Sit to Stand Test, and applied the SF-36 quality of life questionnaire.

2.3. Evaluations Instruments

2.3.1. Respiratory Test

Respiratory muscle strength was assessed by determining the maximum inspiratory pressure (MaxIP) and maximum expiratory pressure (MaxEP) [8]. The analog manovacuometer used was from Murenas® (Murenas Produtos para Saúde Ltda., Juiz de Fora, Brazil).

2.3.2. Six-Minute Walk Test

This test evaluates the individual's level of physical fitness and aerobic capacity, performed in long corridors, with 30 meters markings [9].

2.3.3. Spirometry

This test measures the amount of inspired and expired air volume and the expiratory flows [10]. The equipment used was the CAREFUSION MICROLAB ML3500 Spirometer® (Micro Direct, Inc. 803 Webster Street Lewiston, ME).

Participants were instructed to sit upright, positioning the spirometer mouthpiece firmly between their lips and wearing a nasal clip. They received an energetic command for the effort to be explosive at the beginning of the maneuver, beginning with a deep inspiration, and then exhaling deeply as hard and fast as they could. They were positively stimulated so that such effort was maintained throughout the necessary time for the ideal reading of the device, ending with a new deep inspiration and followed by rest.

2.4. Interventions

After collecting the information, we began physiotherapeutic interventions in the Clinic and the Sports Centre, totalizing 20 consultations twice a week, through a treatment protocol based on functional training and respiratory training using the POWERbreathe K-5 (Technologies Ltd, Birmingham, United Kingdom) [11]. The software breathe-link, version 1.1, 2011, was used as a visual incentive to the participants. The functional training followed the protocol in stages (**Table 1**).

The evaluation and re-evaluation steps were carried out by the same assessors.

Table 1. **Treatment protocol.**

Respiratory Training Protocol	Functional Training Protocol
2 series of 30 respiratory incursions	Warm-up with fast walking for 10 minutes
Interval of 2 minutes between series	Mobility exercise (sitting rowing, hip mobility, ankle mobility, wall flexion) for 5 minutes
The device was parameterised with a standard log routine, the training level calibrated on automatic, and its resistance rated as V-Light	Muscular strength exercise, balance, coordination and agility. The series totalized 40 minutes, and for each strength exercise two series of 15 repetitions were performed, whereas for the balance, agility and coordination exercises, we conducted five series of 30 seconds
Verbal incentives every 5 breaths to increase respiratory depth	Stretching for the groups of muscles worked during the attendance for 5 minutes

3. STATISTICAL ANALYSES

All data collected in this study were analyzed using the Statistical Package for the Social Sciences ver. 7.0 (SPSS Inc., Chicago, IL, USA). We evaluated the variables of age, gender, weight, height, and BMI of all individuals. A one-way ANOVA analysis was conducted to compare the values of the quantitative variables between the experimental groups. For the gender variable, we carried out the Chi-square test for independence.

A Shapiro-Wilk Test for the assumptions of normality of residuals, and Cochran's Test for homogeneity of variances. Subsequently, we employed the mixed model of Factorial Analysis of Variance for Repeated Measurements, then the LSD-Fisher follow-up test. We used the data referring to Gender, Age, Weight, Height, and BMI tabulated as descriptive statistics subdivided into groups undergoing respiratory training and respiratory + functional training. The gender variable was compared between the groups employing the Chi-square test for independence and the other variables were compared using the t-Test. The level of statistical significance was set at $p < 0.05$ [12, 13].

4. RESULTS

Observing the physical variables of the sample with 27 individuals evaluated pre and post-intervention we found no significant differences regarding age, weight, height, and BMI among the groups ($p > 0.05$), with homogeneity of the individuals distributed among the groups (**Table 2**).

Table 2. **Groups distribution and variables.**

Variables		Control Group	Respiratory Training	Functional Training	Functional and Respiratory T.	p-value
Gender	F	66.67%	75%	42.86%	50%	0.58
	M	33.33%	25%	57.14%	50%	
Age		71 ± 4.86	68.63 ± 6.97	71.57 ± 8.56	66.5 ± 4.85	0.76
Weight		66.50 ± 9.48	75.63 ± 9.66	73.86 ± 11.39	75.83 ± 8.89	0.33
Height		159 ± 7.46	158.88 ± 7.74	160.71 ± 5.99	165 ± 10.86	0.51
BMI		26.73 ± 1.48	30.09 ± 4.34	29.43 ± 3.57	27.89 ± 2.38	0.26
N-Total		6	8	7	6	

4.1. MaxIP—Maximum Inspiratory Pressure

Regarding the MaxIP it was possible to observe a significant difference ($p < 0.05$), between the control group and those who did respiratory training ($p = 0.035$), where the control group presented a lower mean (41.85 ± 8.32) when compared to the group who did the respiratory training (57.71 ± 17.85). There was no significant effect for the groups that performed functional training ($p = 0.92$), nor for the interaction between the factors ($p = 0.91$) (**Figure 2**).

4.2. MaxEP—Maximum Expiratory Pressure

For the MaxEP variable there was no significant difference between the control groups and those who underwent respiratory training ($p = 0.50$), as well as for the groups who underwent functional training ($p = 0.65$), nor for the interaction between the factors ($p = 0.91$) (**Figure 3**).

4.3. SF-36—Quality of Life

There was no significant difference between the control groups and those who underwent respiratory training ($p = 0.87$), nor for the groups who underwent functional training ($p = 0.70$), nor for the interaction between the factors ($p = 0.48$) (**Figure 4**).

4.4. Sit to Stand Test

There was no significant difference between the control groups and those who underwent respiratory training ($p = 0.94$), nor for the groups who underwent functional training ($p = 0.81$), nor for the interaction between the factors ($p = 0.28$) (**Figure 5**). However, in all groups, after the interventions there was a significant reduction in the time to sit down and stand up ($p = 0.0004$).

4.5. Six-Minute Walk Test (6 MWT)

No significant difference in the analyzed data. The subjects belonging to the control and respiratory training groups were considered statistically equal ($p = 0.23$), as well as the groups that performed functional training ($p = 0.13$), and in the group with the interaction of factors ($p = 0.12$) (**Figure 6**). Even though no statistical differences were detected, there was a tendency for the values of the 6-minute walk test to rise after the intervention procedures ($p = 0.00095$).

For the variables S Index, Forced Inspiratory Pressure (FIP), and Volume there were no significant differences for the data analyzed ($p = 0.42$/$p = 0.39$/$p = 0.37$) respectively.

4.6. Forced Vital Capacity (FVC)

No significant difference between the control and respiratory training groups (p = 0.74), nor for the

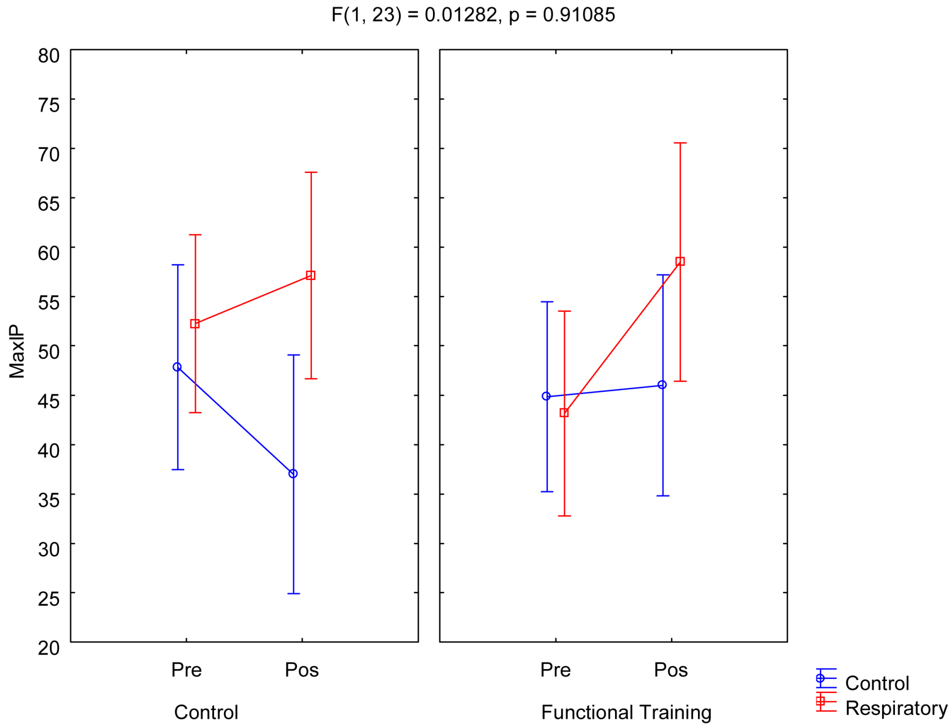

Figure 2. **MaxIP—maximum inspiratory pressure (cm/H_2O).**

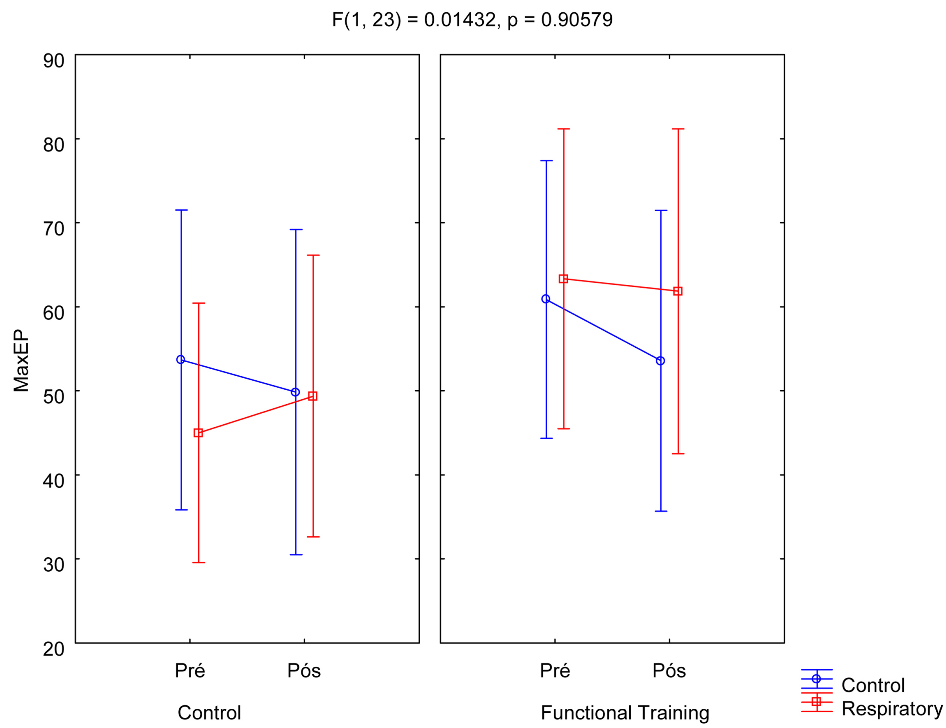

Figure 3. **MaxEP—maximum expiratory pressure (cm/H_2O).**

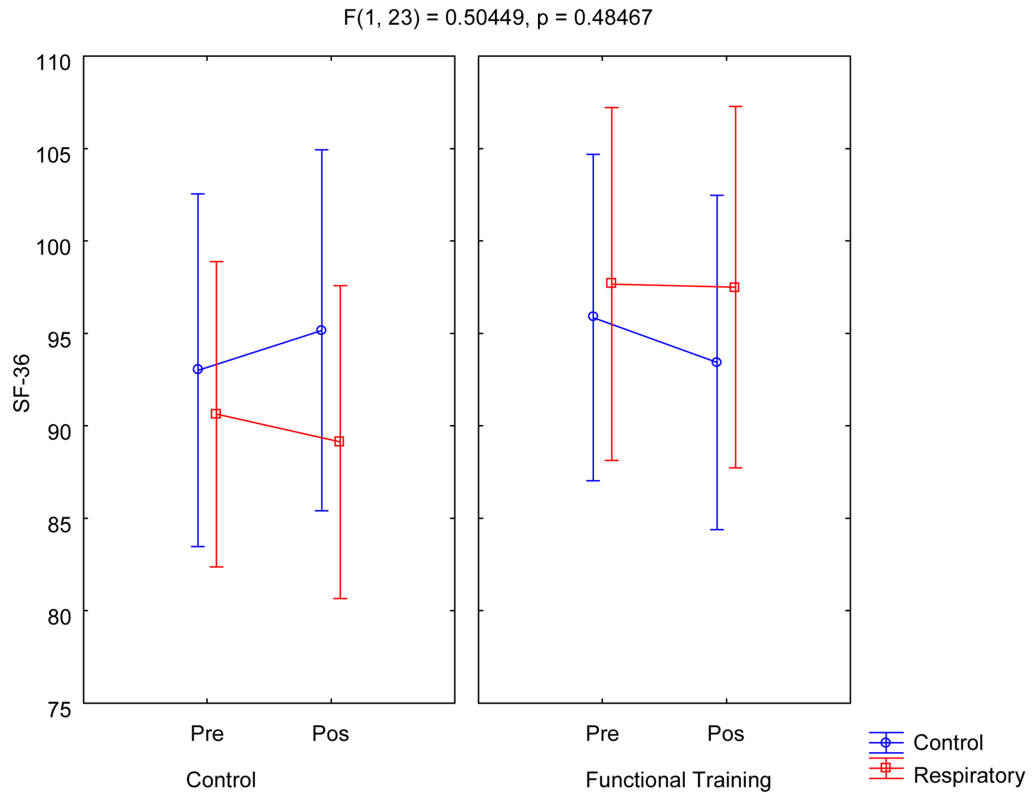

Figure 4. **SF 36—short form (36) health survey.**

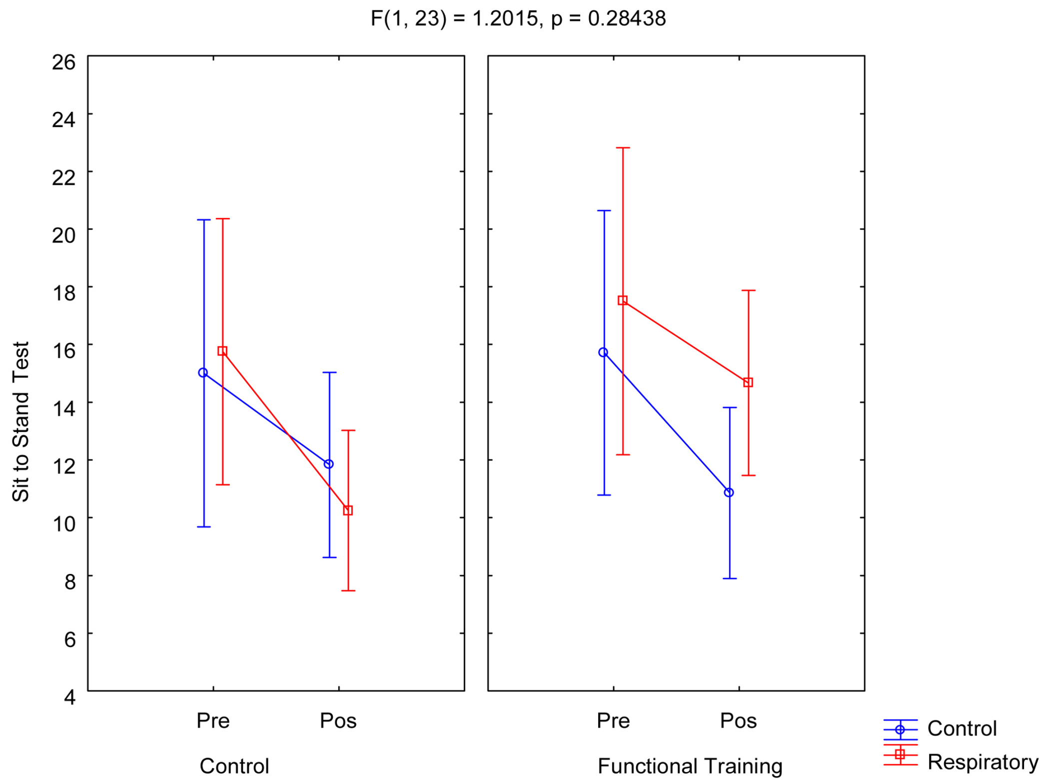

Figure 5. **SST—sit to stand test (repetitions).**

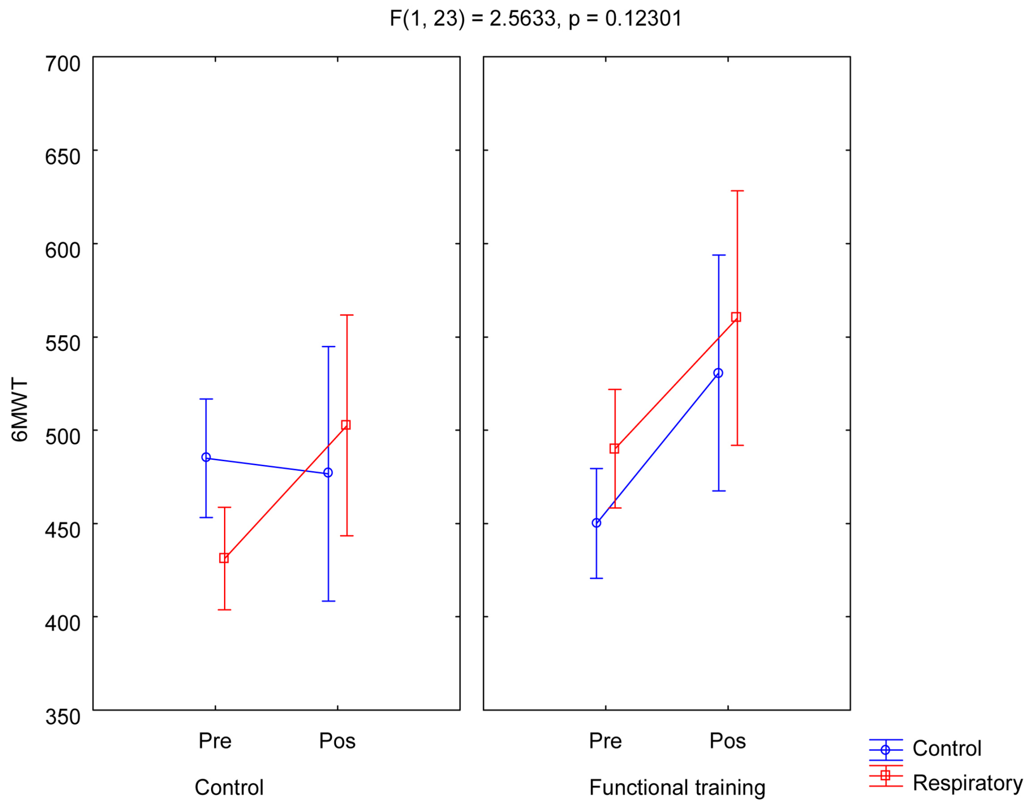

Figure 6. **6 MWT—six-minute walk test (meters).**

groups who underwent functional training (p = 0.59). However, it was possible to observe a significant difference in the group with the interaction of the factors (Breathing + Functional Training) (p = 0.01), showing a significant reduction concerning the means between the pre and post-intervention moments (**Figure 7**).

4.7. Forced Expiratory Volume in the First Second/Forced Vital Capacity (FEV1/FVC)

There was no significant difference between the control group and respiratory training (p = 0.13), nor for the groups who underwent functional training (p = 0.77). However, it was possible to observe a significant difference in the group with the interaction of the factors (p = 0.02). There was an increase concerning the mean values for the control group compared to the other groups, at the post-intervention moment (93.66 ± 6.05) in relation to the pre-intervention moment (85.33 ± 7.68) (**Figure 8**).

4.8. Peak Expiratory Flow (PEF)

No significant differences for the data analyzed, and the control and respiratory training groups were considered statistically equal (p = 0.49), as well as the groups who underwent functional training (p = 0.62) and the group with the interaction between the factors (p = 0.28) (**Figure 9**). Nonetheless, there was an increase in the means after the intervention in all groups.

5. DISCUSSION

The statistical analysis evidences a significant difference in the respiratory group. MaxIP is considered the highest pressure generated during an inspiration, forced against an occluded airway [14, 15]. With age, there is a reduction of the diaphragmatic and accessory muscle mass associated with a decline in the production of respiratory work for the same level of neural stimulus, remodeling of motor units, and a

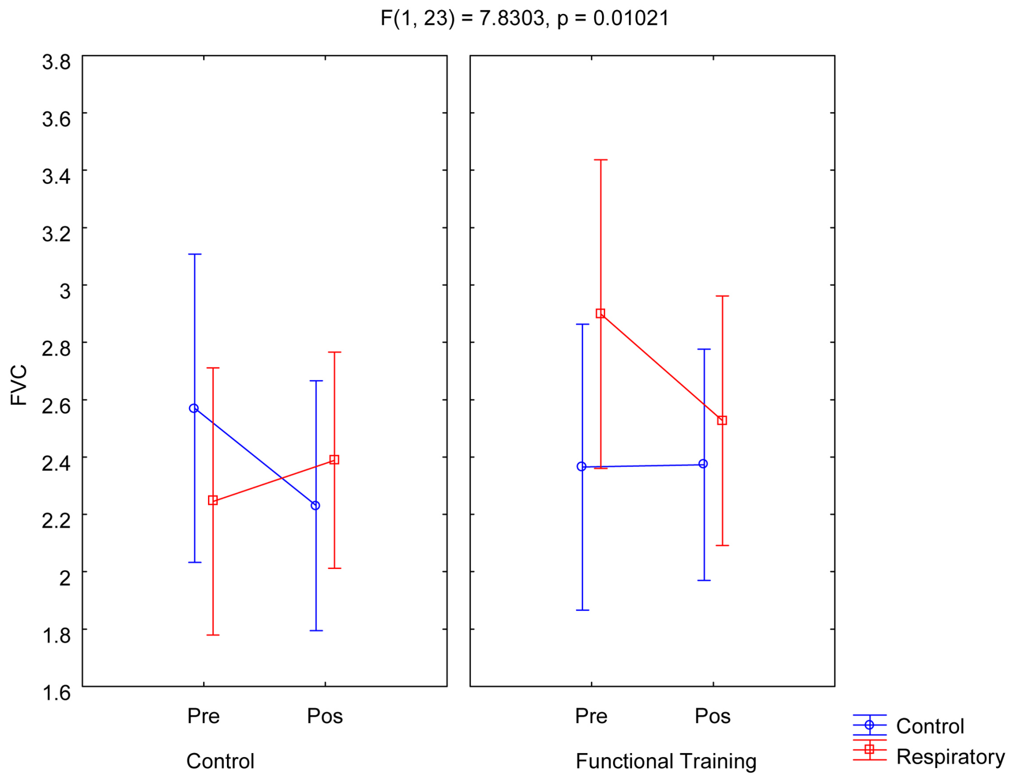

Figure 7. FVC—forced vital capacity (liters).

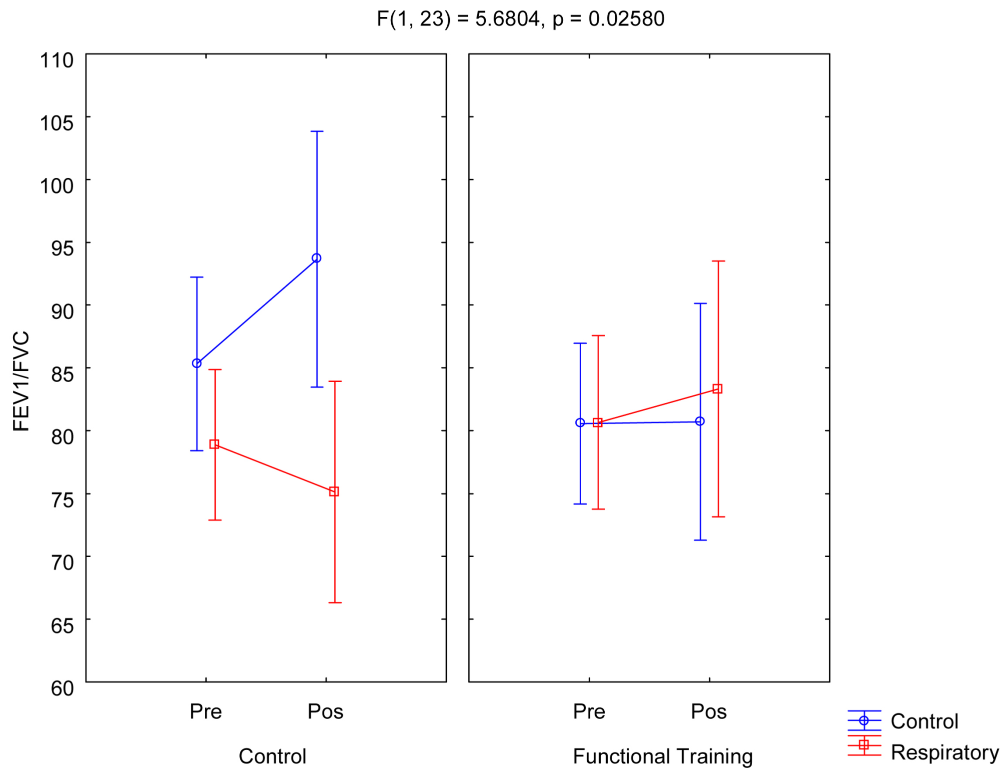

Figure 8. FEV1/FVC—forced expiratory volume in the first second/forced vital capacity (percentage of the FVC expired in one second).

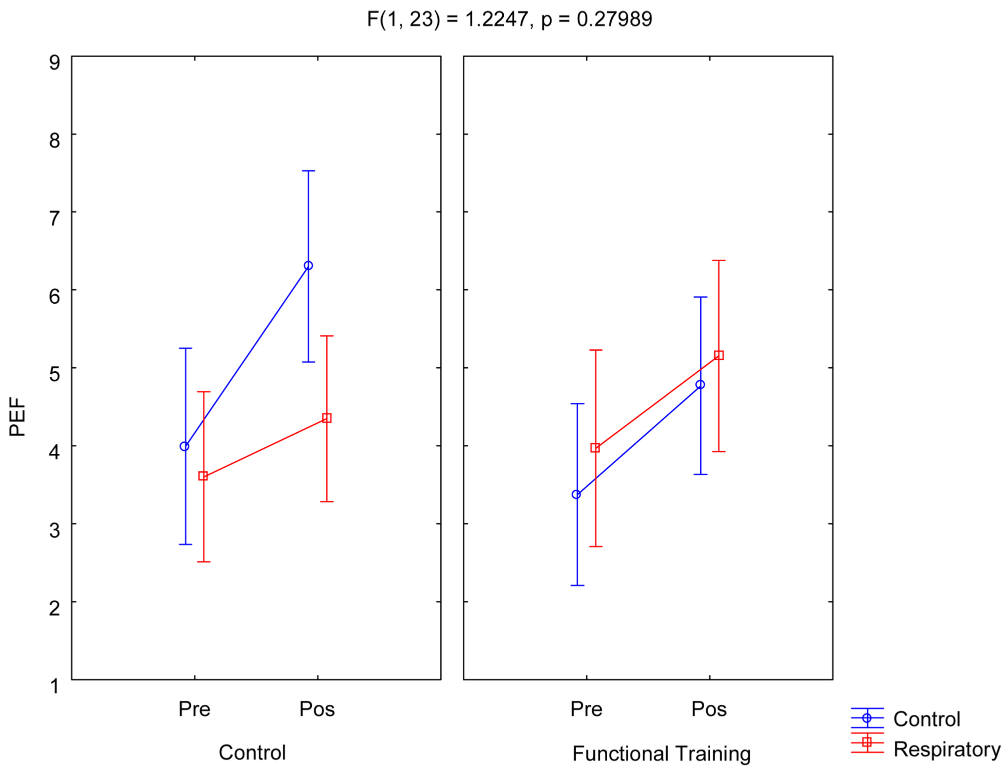

Figure 9. **PEF—peak expiratory flow (liters per minute).**

decrease in the levels of protein synthesis [15, 16].

Esteves *et al.* (2016) [17], when reporting the effects of inspiratory muscle training in healthy individuals who used the Power breathe device, observed an increase in MaxIP, and considered that this gain is due to neural changes that occurred in the inspiratory muscles, that these neural adaptations result in better recruitment of motor units, and in the speed at which the motor neurons are triggered. Furthermore, they state that these neural changes would only occur after five or six weeks of training, and muscle hypertrophy is not possible before eight weeks. This finding emphasizes our training protocol, carried out in 12 weeks, generating an increase in inspiratory muscle strength.

Souza (2014) [18] reports a different justification for the increase in MaxIP, citing that the increase in mechanical activity in the inspiratory musculature provides greater thoracoabdominal mobility, and stimulates the mechanical reorganization of all respiratory muscles, enhancing the variable measured.

For the MaxEP variable, we did not notice significant improvements in the groups. Vasconcelos *et al.* (2007) [19] carried out a study to verify the correlation between the strength of respiratory muscles through the maximum inspiratory pressure (MaxIP) and maximum expiratory pressure (MaxEP) and functional capacity by the 6 MWT. The results obtained were like our study where the values of the Pearson Correlation coefficients between the distance walked and the MaxIP and MaxEP were, respectively: $r = 0.44$ ($p = 0.005$) and $r = 0.27$ ($p = 0.11$). There was a positive correlation only for MaxIP, recommending the RMT for physical rehabilitation programs, aiming at improving functional capacity in the elderly.

These results may be due to the structure of the flattened mouthpiece used in both studies. With this mouthpiece, it is possible to observe a discrete air leak around it, even in healthy individuals who present adequate labial pressure.

Considering the SF-36 quality of life test, we did not observe significant differences in all its domains. Compolina *et al.* (2009) [20] assessing the impact of chronic disease on the quality of life of the elderly, concluded that in general, the lowest averages are found for limitations due to physical aspects, while the highest for limitations related to social and psychological aspects. However, the participants of our study performed their activities of daily living with excellence and did not present any depressive symptoms, discouragement, or complaints arising from chronic diseases, explaining our result. These findings demonstrate that aging may not be the main factor for the decrease in quality of life, but rather, social isolation and poor physical and mental activity.

In the Sit to Stand Test, there was no statistical difference between the groups, however, in all groups, there was a significant reduction in the performance time. The objective of the test is to quantify the muscular strength of the lower limbs through repeated performances [21]. Muscular weakening, characterized by Type II muscle fiber atrophy, results in a functional disability, whereas the strength of lower limbs can be used as a predictor of functional disability in the elderly [22]. Rabelo and Oliveira (2004) [23] argued that regular physical activity may delay declines associated with aging, in the processing speed of the central nervous system, enhancing its reaction speed, and may effectively contribute to its functional capacity.

Weiner *et al.* (2003) [24] observed an effective gain using the 6 MWT, concluding that the increase of respiratory muscle strength provides a reduction of dyspnea in maximal exercises, inducing a functional improvement. This explains the improvement of the individuals in our study who participated only in respiratory muscle training (RMT).

The 6 MWT showed no significant increase. We observed a tendency of elevation in the values of the test after the intervention procedures. With the physiological process of aging, the maximum force exerted (peak torque) decreases. The peak torque represents the point of highest torque (muscle strength) in the range of motion, that is, the value corresponding to the maximum functional muscle strength associating power to the highest speed. Felicio *et al.* (2015) [25] evaluated muscle function using the isokinetic dynamometer at angular velocities of elderly women to compare performance between different age groups. They observed that the elderly with a greater age range presented worse results in the variables when compared to the younger ones, confirming that with age there is a greater tendency towards a decrease in muscular function, even amongst active individuals.

Studies with similar anthropometric characteristics demonstrate that the variables sex, weight, height, and age influence the evaluation of distance [26, 27].

The spirometric variables FVC (forced vital capacity) and FVC1/FVC (Tiffeneau index), had a significant difference in the group with the interaction of the factors (Respiratory Training + Functional Training) ($p = 0.01$), between the moments pre and post-intervention.

Comparing each variable, we confirmed that air trapping is a characteristic of the elderly. This is aggravated even more by physical inactivity or the absence of respiratory muscle training [28].

Medical literature states that nothing can be looked at separately in the elderly. The aging process is a set of signs and symptoms or even biological, physiological, anatomical, and/or structural alterations. An individualized look at variables is not always coherent [22].

The study of FEV1/FVC showed a favorable result [29]. More air volume was exhaled, and vital capacity increased, consequently improving pulmonary ventilation [30]. This suggests that this is also likely to interfere with greater CO_2 elimination and improved elastic recoil [31]. Gas exchange with a greater possibility of effectiveness and improved expansibility of the bone and cartilaginous structure can be explored. More toned muscles effectively collaborate to achieve that [28, 32].

The FEV1/FVC ratio is indeed the most relevant variable according to the guidelines, which prescribe it and indicate spirometry for that purpose [29, 33]. Spirometry is still the main respiratory functional tool and is expected to remain so for decades. It is considered a test of easy applicability and high reproducibility [34].

Important aspects may be improved with this variable and may help in the longevity of the world population affected by respiratory complications. Longer time between exacerbations and a reduction in the number and frequency of hospitalizations [30, 35].

The significant results of this variable further enhance the results obtained, strengthen the theory, and corroborate the studies that show that the elderly need treatment and training together, from the functional aspect to the muscular.

Regular exercise provides a normalization of the relationship between tension and the length of muscles, an increase in blood supply, and an improvement of cellular metabolism [36]. Associated with RMT, it guarantees thoracic mechanical adequacy, decreasing the ventilatory necessity for submaximal exercises by increasing the oxidative capacity of muscle fibers, thus decreasing the senile restriction found in the elderly.

Professionals working with the elderly need to have a different look at the training of the respiratory muscles in a resisted manner, which sometimes is neglected. This fact can be verified in a meta-analysis published in 2020, global muscle training, without the use of respiratory muscle strengthening [37].

No study with this scope and methodology has managed to significantly alter this important spirometric data in the last 10 years with the use of the descriptors (((respiratory muscle resistance training) AND (elderly)) AND (lung function)) AND (spirometry) [38].

Annual spirometry is recommended to assess the natural response of the functional decline, as well as the response to the changes that will occur with the decision to replicate this model of treatment and others to which this proposal may contribute [34].

Studies comparing volumes and pulmonary capacities have stated that the vital capacity decreases while the residual volume increases. However, the total lung capacity presents few changes. These physiological changes, such as a decrease in pulmonary ventilation, reduction in the elasticity of the alveoli, subtraction of vital capacity, and thoracic rigidity and calcification of the ribs justify the non-significance in the spirometric variables [18, 22, 39].

PEF did not show any significant difference; however, all groups showed an increase in the means after the intervention. According to Fonseca *et al.* (2010) [40], the PEF is considered an indirect indicator of obstruction of the large airways and is affected by the degree of lung insufflation, thoracic elasticity, abdominal muscles, and muscle strength of the patient. With aging, there is a decrease in thoracic mobility due to the decrease in mobility of the costovertebral joints, the intervertebral disc becomes flat, resulting in a rigid thorax. The lung parenchyma, composed of elastic tissue (elastin), distends, and its hyperinflation generates a premature constriction in airways during expiration (point of equal pressure), favoring retention of air, and reducing the capacity of the elastic retraction of the lung. Both respiratory and functional training provided improvement in the strength and endurance of the respiratory muscles, improving thoracic-abdominal mobility and the capacity of physical exercise.

6. CONCLUSIONS

The functional training associated with respiratory training in the elderly population contributes to the gain of muscle strength and improvement of functional capacity, echoing the elderly functionality. It can also be concluded that physiotherapy, globally focused on the individual is of extreme importance for the elderly, allowing them to be independent in their everyday life activities.

The study had sample limitations, especially due to the dropout from the control group, hindering our criterion of efficiency of the training protocol. Another limitation was the inability of the participants to understand how to perform the breathing tests. We propose new studies with analysis of the variables studied for comparison with our results and validation of our methodology.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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