Original Article

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Respiratory muscle trainning with flow incentive spirometer compared with linear resistor: controlled clinical trial

Treinamento muscular respiratório com espirômetro de incentivo à fluxo comparado com o resistor linear: ensaio clínico controlado

Erikson Custódio Alcântara[1]
Orcid: https://orcid.org/0000-0003-1960-2231

Elizabeth Rodrigues de Morais[2]
Orcid: https://orcid.org/0000-0002-2944-4751

Anna Beatriz Gomes Barbosa[3]
Orcid: https://orcid.org/0000-0001-6898-8463

Cristina Ferreira do Carmo[4]
Orcid: https://orcid.org/0000-0003-2963-4683

Adriana Márcia Monteiro Fantinati[5]
Orcid: https://orcid.org/0000-0001-7703-9390

Marcelo Silva Fantinati[6]
Orcid: https://orcid.org/0000-0002-1070-0014

Abstract

Introduction: Respiratory muscle training (RMT) is indicated when the maximal inspiratory and expiratory muscle strength values are lower than expected, however it can be indicated in individuals with normal muscle strength, including athletes, aiming to increase performance. Muscle training with linear resistors is considered the gold standard, however, linear resistors, especially the flow incentive spirometer, are controversial and require clarification. **Objective:** To verify the effect of PowerBreathe® (linear resistor) and Respiron® (alline resistor) on respiratory muscle strength and lung function in healthy adults. **Materials and Methods:** Randomized and controlled clinical trial carried out with 44 adult participants, both genders, aged 18 to 59 years. The maximal inspiratory and expiratory pressure (PImáx and PEmáx) and pulmonary function by spirometry and ventilometry were evaluated before and after the training protocol. Participants were divided into three groups: GR (Respiron® group), GPB (PowerBreathe®) and GC (control group). Training was carried out for 5 weeks, 3 times a week, using a load of 50% of PImáx for both equipment. **Results:** In the post-protocol intra-group analysis, there was an increase in PImáx and PEmáx in all groups ($p<0.05$). When comparing PImáx and PEmáx pre and post training between groups, there was also no significant difference ($p>0.05$). When comparing the delta (difference between post and pre), it was observed that there was no difference between the Respiron® and PowerBreathe® groups ($p=0.68$) and both equipment presented a greater delta than the control ($p<0.01$), indicating similarity between the two instruments. There was no intra-group and inter-group difference in lung function ($p>0.05$). **Conclusion:** PowerBreathe® and Respiron® similarly promoted increased inspiratory muscle strength in healthy adults, but there was no impact on lung function with either instrument.

Keywords: muscle strength; breathing exercises; respiratory therapy.

[1] Universidade Estadual de Goiás e (UEG) e Pontifícia Universidade Católica de Goiás (PUC Goiás). Goiânia (GO), Brasil. E-mail: eriksonalcantara@hotmail.com
[2] Universidade Católica de Goiás (PUC Goiás). Goiânia (GO), Brasil. E-mail: elizabeth.r.morais@hotmail.com
[3] Pontifícia Universidade Católica de Goiás (PUC Goiás), Goiânia (GO), Brasil. E-mail: anainovadora@hotmail.com
[4] Pontifícia Universidade Católica de Goiás (PUC Goiás), Goiânia (GO), Brasil. E-mail: cristinadocarmo90@gmail.com
[5] Pontifícia Universidade Católica de Goiás (PUC Goiás), Goiânia (GO), Brasil. E-mail: drifantinati@gmail.com
[6] Universidade Estadual de Goiás (UEG), Goiânia (GO), Brasil. E-mail: prof.fantinati@gmail.com

Resumo

Introdução: O treinamento muscular respiratório (TMR) é indicado quando os valores de força muscular inspiratória e expiratória máxima estão abaixo do previsto, entretanto pode ser indicada em indivíduos com força muscular normal, inclusive atletas, objetivando aumentar a *performance*. O treinamento muscular com resistores lineares é considerado padrão ouro, entretanto os alineares, sobretudo o espirômetro de incentivo a fluxo é controverso, necessitando de esclarecimentos. **Objetivo:** Verificar o efeito do *Power*Breathe® (resistor linear) e do *Respiron*® (resistor alinear) na força muscular respiratória e na função pulmonar de adultos saudáveis. **Materiais e Métodos:** Ensaio clínico randomizado e controlado realizado com 44 participantes adultos, ambos os sexos, idade de 18 a 59 anos. Foi avaliado pré e pós-protocolo de treinamento a pressão inspiratória e expiratória máxima (PImáx e PEmáx) e a função pulmonar pela espirometria e ventilometria. Os participantes foram distribuídos em três grupos: GR (grupo *Respiron*®), GPB (*PowerBreathe*®) e GC (grupo controle). O treinamento foi realizado durante 5 semanas, 3 vezes na semana, utilizou-se carga de 50% da PImáx para ambos os equipamentos. **Resultados:** Na análise intra-grupo pós-protocolo houve aumento da PImáx e da PEmáx em todos os grupos ($p<0,05$). Ao comparar a PImáx e a PEmáx pré e pós treinamento entre os grupos também não houve diferença significativa ($p>0,05$). Ao comparar o delta (diferença entre pós e pré), observou-se que não houve diferença entre o grupo *Respiron*® e *PowerBreathe*® ($p=0,68$) e ambos equipamentos apresentaram um delta maior que o controle ($p<0,01$), indicando semelhança entre os dois instrumentos. Na função pulmonar não houve diferença intra-grupo e inter-grupo ($p>0,05$). **Conclusão:** O *PowerBreathe*® e o *Respiron*® promoveram de forma semelhante aumento da força muscular inspiratória em adultos saudáveis, porém não houve impacto na função pulmonar com nenhum instrumento.

Palavras-chave: força muscular; exercícios respiratórios; terapia respiratória

Introdução

The respiratory muscles play an important role in maintaining adequate pulmonary ventilation. Its dysfunction contributes to exercise intolerance, dyspnea and respiratory failure[1]. Respiratory muscle training (RMT) is indicated when the values of maximal inspiratory and expiratory muscle strength (PImax and MEP) are lower than expected, however it can be indicated in individuals with normal muscle strength, including athletes, aiming to increase performance[2,3].

Studies[4,5,6,7,8,9,10] report the importance of RMT for conditions that limit respiratory work and pulmonary ventilation. Training promotes improved neural control of the respiratory muscles[4], decreases the respiratory muscle metaboreflex[5], promotes diaphragmatic hypertrophy and increases the proportion of type I fibers and an increase in the size of type II fibers in the external intercostals[6], these mechanisms translate into improved tolerance to efforts, decrease in the feeling of dyspnea[7,8,9], increase ventilatory efficiency[10] and ergogenic effect in athletes of various sports[3].

The RMT is performed through global physical training and specific instruments, classified as linear resistors, which are independent of the flow generated by the patient, and linear resistors, dependent on the patient's flow[11,12,1].Among the linear resistors, the Threshold IMT® (Respironics, USA) and the PowerBreathe® (HaB International, UK) stand out, which offer resistance to inspiration through a spring system with a unidirectional valve. And as an linear resistor, incentive spirometry stands out, oriented to flow or volume[1].

The incentive spirometer, which uses visual feedback, was developed with the aim of reversing and preventing pulmonary complications and promoting the strengthening of the respiratory muscles and, as a result, the dynamics of encouraging sustained inspiration to lung

expansion[12]. Maximum and sustained inspirations lead to an increase in transpulmonary pressure and, associated with the inspiratory pause, lung inflation is estimated[11,13]. Liu et al.[14], analyzing a database of a health insurance company involving 7549 patients who underwent lung resection for cancer treatment, observed a positive association between the use of incentive spirometry and a lower risk of hospitalization and pneumonia, however the therapeutic efficacy of these devices is much discussed and controversial, especially in the postoperative period of thoracic and abdominal surgeries[15,16,17,18]. Incentive spirometry for respiratory muscle training is reported by several studies[19,20,2,21], the lack of standardization of load adjustment (resistance) is the main limiting and problematic factor for the use of this equipment, since in this device, the charge generation is flow-dependent and, therefore, variable during inspiration[2]. The manufacturer of the Respiron® equipment has graduated the load generated by lifting its spheres based on the maximum inspiratory pressure (PImax), so the choice of difficulty levels (grade 1 to 3 on the regulator ring) and how many spheres should be lifted can be chosen based on the load you want to impose on the respiratory muscle system, however, studies are scarce and fragile in relation to this new methodology.

The American Thoracic Society (ATS) does not present protocols for the use of incentive spirometry, but according to the Association for Respiratory Care (AARC) the benefits and clinical applicability of this resource are for patients who already present or have risk factors for loss of lung capacity or reduced inspiratory capacity[22,23,24,25].

The use of Respiron®, adopting this new proposal for load regulation compared to the linear resistor, gold standard, has not yet been tested, thus the following research question arose: The flow incentive spirometer (Respiron®) with load-based MIP strengthens respiratory muscles and impacts lung function compared to linear resistor (PowerBreathe)? Therefore, the study aimed to evaluate the acute effect of RMT with two devices, the PowerBreathe® (linear resistor) and Respiron® (allinear resistor) on respiratory muscle strength and lung function in healthy adults.

Materiais e Métodos

This is a randomized and controlled clinical trial carried out at Life School Clinic (LSC) of the Pontifical Catholic University of Goiás (PUC Goiás) in 2019. This study was conducted in accordance with the ethical standards established in the Declaration of Helsinki (1975, revised in 2000), met the ethical aspects of research involving human beings, according to Resolution n. 466/2012 of the National Health Council[26], submitted and approved by the Ethics and Research Committee of PUC Goiás (2.869.978/2018). It was registered in the Brazilian Registry of Clinical Trials (ReBEC) under the number: n.RBR 6nrt3x. All participants signed Term of Free and Informed Consent - (TFIC).

Study participants met the following inclusion criteria: age between 18 and 59 years, sedentary (performing less than 150 minutes of moderate activity per week or 75 minutes of intense activity)[27], or being active but having started physical activity more than three months, with normal spirometry. Individuals with heart, lung and neurological diseases, as well as cognitive impairment, smokers, users of corticosteroids, bronchodilators and ergogenic supplements were excluded.

The sample calculation was carried out using the G Power 3.1 program based on the method of obtaining the posterior sample power. The mean difference and standard deviation of the primary outcome difference (MIP and MIP delta) were used to determine the sample size to obtain a minimum sample power of 80%. A sampling error of 5% and a confidence interval of 95% were considered. Thus, the minimum representative sample of the RG,

PBG and CG groups were 9, 9 and 11 respectively.

Of the 56 participants, 49 were eligible, five did not complete the protocol, therefore 44 completed the study, 15 from the RG (Respiron Group), 15 from the PBG (PowerBreathe® Group) and 14 from the CG (Control Group).

The assessment of Respiratory Muscle Strength took place in a calm environment, the individual was seated with legs at 90° angles, feet flat on the floor and trunk aligned. The instrument used for measurement was a digital manovacuometer, model GlobalMed MVD 300®, with a measurement range between 0 ± 300 cmH_2O, using a nose clip and an anatomical mouthpiece attached to the equipment and positioned firmly between the lips to prevent leakage, with a hole leak of 1mm in diameter.

Three to five measurements of expiratory and inspiratory pressures were performed with a rest of 60 seconds between them, a reproducible value was considered a difference of less than 10% between measurements. For the analysis, the highest MEP and MIP measurements were considered. MEP was measured from total lung capacity and MIP from residual volume[28].

Pulmonary function was assessed using a One Flow® portable spirometer (Clement Clark, United States), performed in accordance with the recommendations of the Brazilian Society of Pulmonology and Tisiology[29]. The following were recorded: forced vital capacity (FVC) in liters (L), forced expired volume in one second (FEV_1) L/min, FEV_1/FVC ratio.

Vital capacity was assessed using the Wright Respirometer Ferraris Mark 8® ventilometer. In a calm environment, the individual remained seated in a comfortable position, breathing quietly within his breathing pattern. A nose clip was placed to prevent air leakage, then the ventilometer was attached to the patient's mouth through a mouthpiece, so that there was no perioral leakage. To measure the Vital Capacity (VC), the individual was instructed to perform a maximum and slow expiration maneuver up to the Residual Volume (RV) and then a quick and total inspiration up to the Total Lung Capacity (TLC)[30]. Three measurements were taken, with a one-minute interval between them, and the highest value was considered.

After the evaluations, 49 eligible participants were numbered and randomized by lot to compose the RG (n=17, Respiron® group), PBG (n=17, PowerBreathe®) and CG (n=15, control group). The control group did not perform any respiratory muscle training. The duration of the protocol was 5 weeks, with a frequency of 3 times a week, on alternate days, as shown in Figure 1.

Figure 1 - Respiratory Muscle Training Protocol.

Participants Assessment:
Week 1 and 2: 50% PImax 3 sets of 10 repetitions (load 1) MIP reassessment for load adequacy (load 2) **Week 3 and 4:** 50% PImax 4 sets of 10 repetitions (load 2) MIP reassessment for load adequacy (load 3) **Week 5:** with 50% of MIP 4 sets of 10 repetitions (load 3) Total: **5 weeks**
Reassessment of participants

The control group was instructed that during the study period they could not start any type of exercise or modify training if they were doing any physical activity. After the end of the training, all groups were reassessed.

To perform the RMT, a load of 50% of MIP was stipulated, in the PowerBreathe® by means of spring

regulation and in the Respiron® with type of equipment (Easy, Classic or Athletic 1, 2 or 3), level of difficulty adjusted in the ring (0 -3) and elevation of the spheres in the column as recommended by the manufacturer:

Figure 2 - Respiron® Intensity.

LEVEL	BALL	EASY*	CLASSIC*	ATELTIC 1*	ATLETIC 2*	ATLETIC 3*
0	1	4	10	15	20	25
0	2	5	12	20	30	40
0	3	8	15	25	40	55
1	1	5	15	25	40	55
1	2	8	20	35	50	70
1	3	12	25	45	60	85
2	1	8	25	45	60	85
2	2	12	28	55	70	100
2	3	16	30	65	85	120
3	1	12	30	65	85	120
3	2	16	35	75	100	140
3	3	20	40	90	120	190

Source: Adapted from datasheet, Respiron® NCS manufacturer's manual, *Estimated load in cmH_2O.

The training had a one-minute rest between sets. On all training days, the level of difficulty in performing the RMT (perceived exertion) was collected using a quantitative and subjective scale ranging from 0 to 10, the higher the value, the more difficult the training and perceived exertion.

Descriptive statistics were presented as mean, standard deviation, absolute and relative frequency. For normality, the Shapiro Wilk test was used and for comparison of means paired t Student test or Wilcoxon, simple t test or Mann Whitney test. For correlation, Pearson or Spearman tests were used. A significance level of 5% was adopted.

Resultados

Table 1 describes the characteristics of the participants, the average age of the RG was 23.20 years, the PBG 22.71 years and the CG 22.85 years. Homogeneity was observed at baseline in relation to inspiratory and expiratory muscle strength, age and BMI (p>0.05).

Table 1 - Participant characteristics and manovacuometry data.

	RG Mean ± SD	PBG Mean ± SD	CG Mean ± SD	p
Age (years)	23.20 ± 2.11	22.71 ± 2.01	22.85 ± 2.71	0.84
BMI (kg/m²)	23.13 ± 2.18	23.68 ± 4.12	22.06 ± 4.06	0.25
Sex Women	14(93.3%)	14(93.3%)	10(71.4%)	
Sex Male	1 (6.7%)	1(6.7%)	4(28.6%)	
RPA/Sedent	12 (80.0%)	9 (60.0%)	10 (71.4%)	
RPA/Active	3 (20.0%)	6 (40.0%)	4 (28.6%)	
MIP pré	78.93 ± 19.68	78.20 ± 23.35	90.21 ± 29.25	0.34
MIP pós	110.73 ± 22.69	112.46 ± 25.26	97.14 ± 28.68	0.22
p.	0.00*	0.00*	0.01*	
Δ MIP	31.80 ± 18.25 [ab]	36.53 ± 17.00 [ac]	7.78 ± 8.67 [bc]	0.00*

MEP pré	94.00 ±13.62	92.86 ± 22.35	95.64 ± 31.30	0.95
MEP pós	111.73 ± 23.87	109.86 ± 27.59	105.50 ± 32.25	0.83
p.	0.00*	0.00*	0.00*	
Δ MEP	17.73 ± 15.27	17.00 ± 18.41	9.85 ±10.81	0.32

RG: Respiron® group; PBG: Power Breathe® group; CG: control group, BMI: Body Mass Index, RPA: Reported Physical Activity, Sedent: sedentary, MIP: Maximum inspiratory pressure (cmH_2O), MEP: Maximum expiratory pressure (cmH_2O) *: $p<0.05$, Δ: difference between the final and initial values of the protocol, a: comparison between RG and PBG ($p=0.68$), b: comparison between RG and CG ($p=0.00$), c: comparison between PBG and CG ($p=0$,00).

As for the level of physical activity, sedentary participants predominated and the predominant sex was female in the three groups (RG: 93.3%, PBG: 93.3% and CG: 71.4%). MIP and MEP values after intervention did not differ between groups ($p>0,05$).

Regarding MIP and MEP pre and post training, it is observed that the three groups increased respiratory muscle strength ($p<0.05$), however when comparing the MIP delta (difference between final and initial values) it is noted that the Respiron® group and the Power Breathe® group obtained a similar increase (delta greater than 30 cmH_2O), with no significant difference between the two muscle training instruments ($p>0.05$). The MIP delta of the control group was only 7.78 cmH_2O.

Both training methods obtained MIP delta values greater than the control ($p<0.05$). The Respiron® group increased MIP by 40.28%, the PowerBreathe® group by 46.71% and the control by 7.75%. As for MEP delta, there was no difference between the three groups ($p>0.05$).

With regard to lung function (spirometry) it is observed that there was no significant change pre and post within groups or between groups ($p>0.05$). In the assessment of VC by ventilometry, there was an increase in values, however with a trend towards significance only in the Respiron® ($p=0.09$) and PowerBreathe® ($p=0.07$) groups.

Table 2- Spirometry and Ventilometry Results

	RG Mean ± SD	PBG Mean ± SD	CG Mean ± SD	p
%CVF pre	96.35 ± 10.71	107.30 ±15.26	103.38 ±13.23	0.12
%CVF post	95.00 ± 13.67	103.30 ±11.96	99.76 ± 7.77	0.19
P	0.62	0.17	0.18	
$\%VEF_1$ pre	93.30 ± 8.34	94.84 ±11.85	96.65 ± 10.06	0.70
$\%VEF_1$ post	91.38 ± 10.51	92.38 ± 11.80	94.69 ±10.62	0.73
p.	0.35	0.07	0.35	
FEV_1/FVC pre	84.84 ± 7.41	77.69 ± 8.85	81.61 ± 8.13	0.09
FEV_1/FVC post	85.00 ± 7.44	80.53 ±10.84	82.15 ± 7.55	0.43
P	0.92	0.31	0.83	
%PFE pré	95.95 ± 12.32	90.76 ±17.21	97.69 ± 14.27	0.47
%PFE post	97.76 ± 16.40	86.92 ±15.44	99.23 ± 12.85	0.07
P	0.70	0.16	0.73	
Ventilometry pré	2.97 ± 0.45	2.96 ±0.50	3.36 ± 0.75	0.12
Ventilometry post	3.13 ± 0.47	3.15 ±0.61	3.36 ± 0.66	0.53
p.	0.09	0.07	0.95	
Δ Ventilometry	0.16 ± 0.36	0.18 ± 0.37	0.00 ± 0.36	0.31

RG: Respiron group; PBG: Power Breathe® group; CG: control group FVC: Forced Vital Capacity, FEV_1: Forced Expired Volume in one second FEV_1/FVC: ratio between Forced expired volume in one second and Forced vital capacity, PEF: Peak expiratory flow, Δ: pre- and post-protocol difference , SD: Standard deviation

In the correlation between lung function and respiratory muscle strength, it was observed that VC (ventilometry) correlated from weak to moderate intensity with MIP (r=0.35, p=0.02), with MEP (r=0.46, p=0.00) and %FVC (r=0.32, p=0.04), that is, the greater the VC assessed by ventilometry, the greater the respiratory muscle strength and the %FVC assessed by spirometry.

The reported physical activity (sedentary and active) did not influence the gain in inspiratory muscle strength in any group, so there was no difference between sedentary and active in the Respiron® group (p=0.37), nor in the PowerBreathe® group (p= 0.50) nor in the Control group (p= 0.85).

As for the level of difficulty in carrying out the training (0-10), the average of the Respiron® group was 4.17 ±1.49, while that of the PowerBreathe® group was 2.92 ±1.44, it is noted that the Respiron® group had greater difficulty when compared to the PowerBreathe® group (p =0.02).

Discussion

This study aimed to evaluate the acute effect of RMT with two devices, the PowerBreathe® (linear resistor) and Respiron® (alline resistor) on respiratory muscle strength and lung function in healthy adults. It was observed that respiratory muscle training with PowerBreathe® and Respiron® increased respiratory muscle strength similarly, but neither of them had an impact on the lung function of the analyzed population. The authors found no studies, to date, comparing a linear resistor with an incentive spirometer (Respiron®) based on MIP, making this study relevant to clinical practice.

Silva et al.[2], randomized 14 individuals into a sham group (SG, n=7) and an experimental group (EG, n=7). MIP and MEP, distance covered in the six-minute walk test and perception of dyspnea were evaluated. according to the pre and post RMT medical research council dyspnea score. Both underwent a Cardiopulmonary Rehabilitation Program (PRCR) after four weeks of surgery. The authors concluded that the RMT performed with the Respiron® increased the MIP and the distance covered in the 6-min walk test, since the EG increased by 22% (p=0.014) when associated with the conventional PRCR, while the GS did not obtain increase.

In the aforementioned study, the mean age of participants was higher than in the present study (EG=56 years, CG=54 years) and most were male. Participants completed the training for four weeks, seven times a week, twice a day. It is observed that in the present study, the training took place less times a week, but for a longer time, the mean age was significantly lower, and the young people were not post-surgical participants, justifying the greater gain in inspiratory strength of the group that performed training.

The study by Esteves et al.[31] aimed to verify the effect of inspiratory muscle training with linear resistor (PowerBreathe®) on the aerobic capacity and inspiratory muscle strength of healthy individuals who practice regular physical activity. This study, as well as the present study, obtained results in the intragroup comparison, where an average increase in MIP of 37% was observed in the EG and an increase of 7% in the CG. In this study, the majority were young, as in the present study (18 to 21 years old), but most were male (EG: 66% and CG: 60%) and practiced physical activity. The training took place during five weeks, five times a week with a load of 75% of the MIP, therefore with a shorter duration and more intense than in the present research. Despite the differences in protocol and sample profile, healthy young people obtained gains in inspiratory muscle strength in percentages similar to the present study, indicating that only the

group that underwent training obtained expressive gains in MIP.

In healthy individuals, a clinically significant increase in muscle strength is considered to be an average increase of 20% in MIP. Thus, in the aforementioned study, as well as in the present study, only the Respiron® and PowerBreathe® groups increased inspiratory muscle strength[32]. This reinforces the hypothesis that the two instruments were similar in gaining inspiratory muscle strength.

It was observed that there was no difference in strength gain in relation to MEP when comparing the three groups, all increased MEP, however it is not known whether this increase translates into clinical improvement, as it was not the object of investigation in this study. The increase in MEP using an inspiratory resistor suggests that when air is directed to the diaphragm, it can provide greater mobility of the abdominal muscles and, as a consequence, recruitment of the abdominal wall muscles, which act as accessories for expiration. This explains the gain in expiratory force with the use of inspiratory resistors.

Pulmonary function assessed by spirometry and ventilometry did not show significant changes in any of the groups, there was only a tendency towards an increase in VC assessed by ventilometry in the Respiron® and Power Breathe® groups. As there was a correlation between the VC measured by ventilometry and respiratory muscle strength, it is presumed that the tendency towards an increase in VC can be explained by the increase in inspiratory muscle strength that occurred only in the groups that underwent RMT. It can be stated that the increase in inspiratory muscle strength allows greater pressure gradients to increase transpulmonary pressure[11-13], therefore, both instruments can increase lung volume, as a consequence of strengthening the respiratory muscles and not as a primary outcome. Perhaps this is the big mistake in indicating these devices to gain lung expansion, thus a more robust sampling is interesting to reassess and support this hypothesis, and that includes participants with limited lung function. It is expected that it will be difficult to find clinical benefits in the pulmonary function of the participants of this research, since none of them presented pulmonary dysfunction.

When investigating the level of difficulty (respiratory work) in carrying out the instruments, it was found that the Respiron® was the equipment that had the greatest difficulty in carrying out the training, which demonstrates a greater perception of effort, by the patient with greater respiratory work, this can be explained by the fact that it is an linear resistor where the load is generated depending on the flow and therefore variable during inspiration[12].

A study carried out by Weindeler and Kiefe[33] evaluated the work of breathing performed between two incentive spirometers, one oriented to flow and the other oriented to volume. of sustained inspirations, influencing the performance of patients in the postoperative period. It is understood that the individual, when holding the spheres for as long as possible, can increase the level of difficulty, but this does not disqualify the intention and indication of the device to exercise and strengthen inspiratory muscles.

In the socio-economic aspect, the flow incentive spirometry has the advantage of low cost, which allows popularizing the access of this resource to less favored social classes to exercise the inspiratory muscles. There is little evidence to support its use as MIP-based muscle training equipment, so we consider this study a game changer in the science of inspiratory muscle training using flow incentive spirometry. Linear resistors, on the other hand, are considered the gold standard for RMT, however it is a more expensive piece of equipment to purchase, so both have advantages and disadvantages.

The clinical and functional benefits of incentive spirometry, minimally based on the physiology of the respiratory system[34,35]

are: (1) The expenditure of O_2 during quiet breathing using incentive spirometry can vary from 5 to 30%, which allows us to state that the overload the respiratory musculature is small. (2) The shorter the time for inspiration, the smaller the inspired volume. When properly conducted with incentive spirometry, it is possible to train the patient to perform smooth, long, deep and sustained inspiration. (3) Inequalities in lung ventilation can be the result of changes in both local lung distensibility and airway resistance. Guiding and training inspiration influences the regular pattern of breathing. (4) During incentive spirometry, physiologically, it shows that, before inspiration begins, intrapleural pressure is -5 cmH_2O due to lung retraction and alveolar pressure is zero; however, incentive spirometry sharpens an inspiratory flow causing a lower alveolar pressure allowing displacement of varied lung volumes. (5) The lung and rib cage are also elastic, incentive spirometry increases the dynamics of respiratory mechanics, a good sign for patients with shallow breathing and respiratory muscle weakness. (6) Finally, the lower lung regions ventilate more than the upper lung regions, encouraging inspiration through visual and auditory feedback during incentive spirometry stimulates and strengthens the contraction mechanism of the diaphragm muscle and other breathing muscles to gain strength muscle and secondarily improve pulmonary ventilation.

Limitations of this study were the scarcity of studies comparing linear and linear resistors, as well as studies using Respiron® with a load based on MIP, in addition, heterogeneity of protocols was observed in relation to training time and frequency, making comparisons difficult. This is a relevant factor to be pointed out, in order to understand how far one has to advance in research using the incentive spirometer, based on the functional limitation of the patient and not on the diagnosis of the disease. The indication for the use of this device applies to preventing and treating dysfunctions associated with respiratory muscle weakness and not disease.

This study indicates that this new way of using the Respiron® incentive spirometer may bring clinical benefits, however, it is recommended that protocols with longer training time and more times a week be performed in order to verify whether there will be replication of the results obtained by the present research.

Conclusão

Respiratory muscle training with linear resistor PowerBreathe® and flow incentive spirometer Respiron® increased inspiratory muscle strength in healthy adults. Regarding the spirometric variables, there was no significant improvement with any instrument. Thus, both devices appear to be similar in gaining inspiratory muscle strength, and it is up to the professional to analyze the advantages and disadvantages in choosing the equipment. It should be noted that in the present study, the linear resistor used was loaded based on the maximum inspiratory pressure, different from the conventional way that is commonly used. As this study was carried out with a healthy population, a future study in a population with pulmonary dysfunction is suggested to verify the reproducibility of the results presented in this research.

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