Volume-oriented *versus* flow-oriented incentive spirometry over respiratory parameters among the elderly

Espirometria de incentivo a volume versus *a fluxo sobre parâmetros respiratórios em idosos*

Espirometría de incentivo a volumen versus a flujo sobre parámetros respiratorios en añosos

Fernanda dos Santos Pascotini[1], Mônica de Castro Ramos[2], Antônio Marcos Vargas da Silva[1], Maria Elaine Trevisan[1]

ABSTRACT | In the aging process, the individual goes through physiological changes, especially the decline in lung function. The incentive spirometry, used in many populations, not yet makes clear the difference between the methods and the volume flow on respiratory variables in older subjects. This study aimed to compare the effects of incentive spirometry — volume and flow, on pulmonary function, respiratory muscle strength and thoracoabdominal mobility in healthy elderly. It was a clinical trial with 48 elderly between 60 and 84 years old, randomized to the incentive spirometry by volume (n=23) or by flow (n=25). We evaluated the maximum inspiratory pressure (MIP) and the maximum expiratory pressure (MEP), volumes and pulmonary capacities and thoracoabdominal cirtometry before and after home training. The data were analyzed by two-way repeated measures analysis of variance. There was an increase in MIP, MEP, forced vital capacity (FVC), forced expiratory volume in one second, minute volume, tidal volume and xiphoid and umbilical cirtometry level in both groups (p<0.001). When comparing both groups, the increase in FVC was higher in flow group (p=0.03) and there was a greater increase in axillary cirtometry in volume group (p=0.02). Both incentives were effective in improving lung function, respiratory muscle strength and thoracoabdominal mobility in healthy elderly, being good allies of respiratory therapy.

Keywords | Breathing Exercises; Respiratory Muscles; Lung Volume Measurements; Aging; Physical Therapy Specialty.

RESUMO | No processo de envelhecimento, o indivíduo passa por mudanças fisiológicas, destacando-se o declínio da função pulmonar. A espirometria de incentivo, utilizada em diversas populações, ainda não deixa clara a diferença entre os métodos a volume e a fluxo sobre variáveis respiratórias em sujeitos idosos. O objetivo do estudo foi comparar os efeitos da espirometria de incentivo – volume e fluxo, sobre a função pulmonar, força muscular respiratória e mobilidade tóraco-abdominal de idosos saudáveis. Trata-se de um ensaio clínico com 48 idosos, entre 60 e 84 anos de idade, randomizados para espirometria de incentivo a volume (n=23) ou a fluxo (n=25). Foram avaliadas as pressões inspiratória (PImáx) e expiratória (PEmáx) máximas, volumes e capacidades pulmonares e cirtometria tóraco-abdominal pré e pós-treinamento domiciliar. Os dados foram analisados pela análise de variância de duas vias com medidas repetidas. Houve aumento da PImáx, PEmáx, capacidade vital forçada (CVF), volume expiratório forçado no primeiro segundo, volume minuto, volume corrente e cirtometria a nível xifoide e umbilical em ambos os grupos (p<0,001). Na comparação entre os grupos, o aumento na CVF foi maior no grupo fluxo (p=0,03) e maior cirtometria axilar no grupo volume (p=0,02). Ambos os incentivadores foram eficazes na melhora da função pulmonar, força muscular respiratória e mobilidade tóraco-abdominal em idosos saudáveis, mostrando-se bons aliados da fisioterapia respiratória.

Descritores | Exercícios Respiratórios; Músculos Respiratórios; Medidas de Volume Pulmonar; Envelhecimento; Fisioterapia.

Study conducted at the Physical Therapy and Rehabilitation Department of Universidade Federal de Santa Maria (UFSM) – Santa Maria (RS), Brazil.
[1]UFSM – Santa Maria (RS), Brazil.
[2]Universidade Luterana do Brasil (ULBRA) – Santa Maria (RS), Brazil.

Correspondence to: Maria Elaine Trevisan – Rua Silva Jardim, 2.141, apto 701 – CEP: 97010-493 – Santa Maria (RS), Brazil – E-mail: elaine.trevisan@yahoo.com.br –
Presentation: Mar. 2013. – Accepted for publication: Oct. 2013 – Financing source: none – Conflict of interests: nothing to declare – Approval at the Ethics Committee n. 0356.0.243.000-11.

RESUMEN | En el proceso de envejecimiento, el individuo pasa por cambios fisiológicos, destacándose la declinación de la función pulmonar. La espirometría de incentivo, utilizada en diversas poblaciones, aun no deja clara la diferencia entre los métodos a volumen y a flujo sobre variables respiratorias en sujetos añosos. El objetivo fue comparar los efectos de la espirometría de incentivo – volumen y flujo, sobre la función pulmonar, fuerza muscular respiratoria y movilidad tóraco-abdominal de añosos sanos. Este fue un ensayo clínico con 48 añosos, entre 60 y 84 años de edad, randomizados para espirometría de incentivo a volumen (n=23) o a flujo (n=25). Fueron evaluadas las presiones inspiratoria (PImáx) y expiratoria (PEmáx) máximas, volúmenes y capacidades pulmonares y cirtometría tóraco-abdominal pre y post entrenamiento domiciliario. Los datos fueron analizados por el análisis de varianza de dos vías con medidas repetidas. Hubo aumento de la PImáx, PEmáx, capacidad vital forzada (CVF), volumen expiratorio forzado en el primer segundo, volumen minuto, volumen corriente y cirtometría a nivel xifoides y umbilical en ambos grupos (p<0,001). En la comparación entre los grupos, el aumento en la CVF fue mayor en el grupo flujo (p=0,03) y mayor cirtometría axilar en el grupo volumen (p=0,02). Ambos incentivadores fueron eficaces en la mejora de la función pulmonar, fuerza muscular respiratoria y movilidad tóraco-abdominal en añosos sanos, mostrándose buenos aliados de la fisioterapia respiratoria.

Palabras clave | Ejercicios Respiratorios; Músculos Respiratorios; Medidas del Volumen Pulmonar; Envejecimiento; Fisioterapia.

INTRODUCTION

Due to the increasing growth rhythm of the elderly population in developing countries[1], it is predicted that, in 2025, 14% of the Brazilian population will be composed of elderly people[2]. The healthy aging is natural and progressive, with gradual functional changes that enable adaptations and maintenance of the quality of life[3].

The pulmonary function slowly decreases after the adult life[4], and, as a result of the aging process, there is the reduction of thoracic mobility, lung elasticity, respiratory muscle strength and vital capacity, thus leading to reduced cough effect and ciliary motility in the respiratory epithelium[5]. Besides, there is the reduction of pulmonary volume, the increase of residual volume, the early closure of small airways, the reduction of thoracic compliance and the increase of lung compliance, among other changes[6].

Facing these physiological adjustments, the role of physical therapy is to delay, or, eventually, to recover the inevitable pulmonary function loss among the elderly. Several therapeutic strategies may offer benefits, both by the use of voluntary ventilation patterns and of specific equipment. Incentive spirometry consists of the use of devicess designed to stimulate deep, slow and sustained inspirations, with visual stimulus, which can be oriented by volume or flow[7,8].

Studies related to the breathing exercise usually approach people with chronic cardiorespiratory diseases, and only a few of them focus on the elderly population with no pathologies[9]. Facing the growth of the elderly population, the deterioration of the respiratory system with age and the need to assess new therapeutic strategies, this study aimed at comparing the effects of volume-oriented and flow-oriented incentive spirometry over the pulmonary function and respiratory muscle strength of the healthy elderly subjects.

METHODOLOGY

This study was approved by the Research Ethics Committee of *Universidade Federal de Santa Maria*, CAEE 0356.0.243.000-11. All of the participants signed the Informed Consent Form.

The analysis included elderly subjects of both genders, aged between 60 and 90 years old, with no previous diagnosis of respiratory conditions. The study excluded elderly people with neurological and/or psychiatric conditions, symptoms of a cold and/or respiratory compromise at the time of evaluation, as well as alcohol consumers, current and former smokers (for less than ten years), and those who underwent abdominal and thoracic surgery for less than five years.

The sample was comprised of 48 individuals who were recruited through the media, randomized by raffle in the groups Voldyne® (GVold) and Respiron® (GResp). Respiratory muscle strength, thoracoabdominal mobility and pulmonary function were verified before and after training.

Respiratory muscle strength was analyzed by the digital manovacuometer *Microhard* MVD500 (Globalmed – Porto Alegre/RS), and participants were sitting down, using a nose clip and a mouthpiece between the lips. Two learning maneuvers were conducted, combined with the manual gesture that would indicate when the lungs were inflated/uninflated.

In order to measure the maximal inspiratory pressure (MIP), they were requested to expire at residual volume (RV) level, followed by a fast and strong inspiration at total lung capacity (TLC) sustained for one second, with the verbal stimulus from the examiner. For the maximal expiratory pressure (MEP), maximal inspiration was requested, at TLC, followed by maximal expiration, at RV, sustaining it for one second, with the verbal stimulus from the examiner[10]. Five maximal maneuvers were conducted, with a one-minute break and, afterwards, three acceptable and reproducible maneuvers were selected (difference of 10% or less between efforts), in order to register the highest value[11] and compare it to the value predicted by the equation of Neder *et al.*[12], according to age and gender.

In order to measure the thoracoabdominal extension with cirtometry, three measuring tapes were used and adapted with a cotton shoelace grip to function as a guide while the tapes slid during respiratory movements. In dorsal decubitus, the tapes were placed in three anatomical reference points — axillary fold, xiphoid appendix and umbilical line, and measurements were taken at rest, after maximal inspiration (TLC) and after maximal expiration (RV), commanded by the researcher. For each point there were three measurements, at three different moments, with one-minute intervals between them[13].

Current volume (CV), respiratory frequency (RF), Minute Volume (MV), Forced Vital Capacity (FVC) and Forced Expiratory Volume in the first second (FEV_1) were obtained with the spirometer *Respiradyne* II (Model 5-7930P Sher Wood Medical Co). For VC, RF and MV, the subject was supposed to breathe normally through the mouthpiece of the device for one minute. FVC and FEV_1 were obtained from maximal inspiration, followed by the fast and sustained expiration onto the mouthpiece of the device for at least 6 seconds. There was stimulus so that the effort could be "explosive" at the beginning of the maneuver, which was then repeated until there were three acceptable and reproducible maneuvers[14]. All of the measurements were taken in the sitting position, using a nose clip.

The training took place at the household, under the direct supervision of the researcher, with one daily session for 12 consecutive days. The training protocol was the same for both groups, except for the type of incentive. They were oriented to breathe slowly, from the Functional Residual Capacity (FRC) until reaching the level that was previously delimited in the Voldyne cylinder (GVold) or in the regulating ring (GResp), finally sustained for one second[15]. The protocol was elaborated by the researchers and counted on the following sequence: 3 series of 8 repetitions on the first three days, 3 series of 10 repetitions from the 4th to the 6th day, 3 series of 12 repetitions from the 7th to the 9th day and 3 series of 14 repetitions from the 10th to the 12th day. Individuals were sitting down, with verbal incentive to better execute the technique, previously trained diaphragm muscle pattern, with five-minute breaks between the series.

In the statistical analysis, the comparison between groups was made by the chi-square test (categorical variables) or with the unpaired Student's *t* test (continuous variables). The comparison inside and between groups was made by the repeated measures Analysis of Variance (two-way) and analyzed three effects (time, group, interaction), followed by the Bonferroni *post hoc* test, with significance level of 5%. The version 13.0 of the Statistical Package for the Social Sciences (SPSS) was used. The sample calculation based on the study by Burneiko *et al.*[16], in order to obtain the 5% significance level and power of 80% (beta), with estimates of 23 subjects in each group.

RESULTS

There were 48 elderly subjects in the study, aged between 60 and 84 years old, randomized in GResp (n=25) and GVold (n=23). Groups were homogeneous (p>0.05) in relation to anthropometric and spirometric variables, respiratory muscle strength and thoracoabdominal extension (Table 1).

The comparison inside and between groups, in the pre and post intervention periods, is presented in Table 2. In the intragroup comparison, analyzed by the time effect, both groups presented increased MIP (Figure 1A), MEP (Figure 1B), FVC (Figure 1C), FEV_1 (Figure 1D), MV (Figure 1E), CV (Figure 1F), xiphoid and umbilical cirtometry. Axillary cirtometry and RF did not show any

Table 1. Basal characteristics of the groups

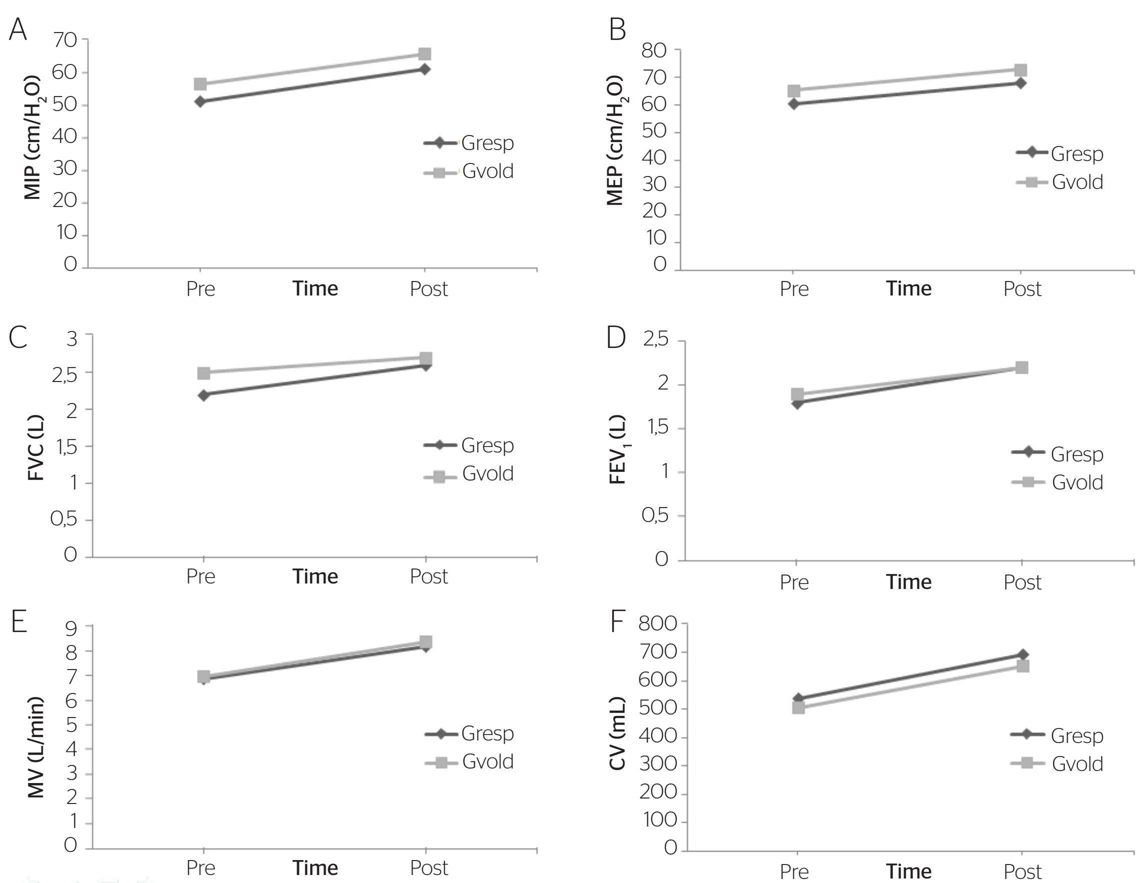
Variables	GResp (n=25)	GVold (n=23)	p-value
Age (years)	69.9±6.6	69.2±7.8	0.72
Gender (F/M)	20/5	15/8	0.21
BMI (kg/m²)	25.5±3.2	26.1±5	0.65
MIP (cm/H_2O)	51.4±12.6	56.7±19.7	0.27
MIP (predicted %)	64.1±15.6	67.3±22.5	0.57
MEP (cm/H_2O)	60.4±14.3	65.4±24.8	0.40
MEP (predicted %)	77.1±17.9	76.7±25.9	0.96
FVC (L)	2.2±0.5	2.5±0.7	0.07
FEV_1 (L)	1.8±0.4	1.9±0.6	0.62
MV (L/min)	6.9±2	7±1.5	0.85
CV (ml)	527.3±103	506±106	0.48
RF (rpm)	13.3±2.7	13.9±2.3	0.38
AC (cm)	4.3±1.8	3.9±1.6	0.40
XV (cm)	3.5±1.3	3±1.3	0.18
UC (cm)	3.7±0.9	3.3±1.3	0.21

GVold: Voldyne® group; GResp: Respiron® group; M: male; F: female; BMI: body mass index; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; FVC: forced vital capacity; FEV_1: forced expiratory volume in the first second; MV: minute-volume; CV: current volume; RF: respiratory frequency; AC: axillary cirtometry; XC: xiphoid cirtometry; UC: umbilical cirtometry; *significant difference (p<0.05)

Table 2. Respiratory muscle strength, pulmonar function and pre and post intervention thoracoabdominal cirtometry

Variables	Period	GResp	GVold	ANOVA (p-value)		
				Time	Group	Interaction
MIP (- cm/ H_2O)	Pre	51.4±12.6	56.7±19.7	<0.001*	0.18	0.82
	Post	61.3±15	65.9±19			
MIP (% do predito)	Pre	64.1±15.6	67.3±22.5	<0.001*	0.77	0.63
	Post	77.6±17.3	78.4±21.9			
MEP (cm/H_2O)	Pre	60.4±14.3	65.4±24.8	<0.001*	0.31	0.89
	Post	68.1±14	73±24.6			
MEP (% do predito)	Pre	77.1±17.9	76.7±25.9	<0.001*	0.63	0.90
	Post	91.4±18.8	88.5±28.9			
FVC (L)	Pre	2.2±0.5	2.5±0.7	<0.001*	0.26	0.03*
	Post	2.6±0.6	2.7±0.8			
FEV_1 (L)	Pre	1.8±0.4	1.9±0.6	<0.001*	0.83	0.49
	Post	2.2±0.6	2.2±0.7			
MV (L/min)	Pre	6.9±2	7.04±1.5	<0.001*	0.84	0.65
	Post	8.2±2.2	8.4±2			
VC (mL)	Pre	527.3±103	506±106	<0.001*	0.40	0.74
	Post	692±127	652±140			
RF (rpm)	Pre	13.3±2.7	13.9±2.3	0.15	0.80	0.15
	Post	14.4±1.9	13.7±2			
AC (cm)	Pre	4.3±1.8	3.9±1.6	0.72	0.66	0.02*
	Post	3.9±1.1	4.6±1.6			
XC (cm)	Pre	3.5±1.3	3±1.3	<0.001*	0.49	0.30
	Post	4.6±1.4	4.6±1.9			
UC (cm)	Pre	3.7±0.9	3.3±1.3	<0.001*	0.43	0.79
	Post	4.8±1.9	4.5±1.7			

GVold: Voldyne® group; GResp: Respiron® group; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; FVC: forced vital capacity; FEV_1: forced expiratory volume in the first second; MV: minute-volume; CV: current volume; RF: respiratory frequency; AC: axillary cirtometry; XC: xiphoid cirtometry; UC: umbilical cirtometry; *significant difference (p<0.05)



MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; FVC: forced vital capacity; FEV_1: forced expiratory volume in the first second; MV: minute-volume; CV: current volume; GResp: Respiron® group

Figure 1. Values presented in means. Maximal inspiratory pressure variations (A); maximal expiratory pressure variations (B); forced vital capacity variations (C); forced expiratory volume in the first second variations (D); minute-volume variations (E); current volume variations (F)

differences in the pre and post intervention periods. In the comparison between groups, GResp presented more growth in FVC (interaction effect), and GVold presented more elevation in axillary cirtometry (interaction effect). The groups showed no differences as to the other variables in the analysis of the group and interaction effects.

DISCUSSION

After training, FVC increased in both groups, which corroborates a previous study[17] that compared lung volumes after the use of Respiron® and Voldyne® in the postoperative period of upper abdominal surgery. Until now, no reports were found in literature involving improved FVC among healthy elderly after the treatment with incentive spirometry, and this was one of the main findings in our study, which presents additional therapeutic tools for this population. Besides, the increase of FVC was greater with the use of the flow-oriented incentive, which suggests that the generated rapid and turbulent flow can provide more benefits in variables involving forced respiration maneuvers.

In this study, the elderly presented maximal respiratory pressures with lower values than the ones predicted for the age[12], which corroborates the studies[18-22] showing that respiratory muscle strength is lower among the elderly. After training, it was possible to observe the significant increase of MIP and MEP in both groups, which suggests that these therapies were efficient, as previously observed by Kotz[23], however, involving healthy young subjects.

Literature is scarce when it comes to the effects of incentive spirometry in the healthy population. Weindler and Kiefer[24] observed significant increase in MIP after therapy with flow and volume-oriented spirometers in patients submitted to abdominal and/or heart surgery. A recent study[25] compared the effects of flow and volume-oriented incentive spirometry over lung volumes, thoracoabdominal mobility and inspiratory muscle activity among the elderly and healthy adults, and concluded that both spirometers have similar effects on lung volumes and thoracoabdominal mobility, however, the flow-oriented spirometer demands stronger respiratory muscle activity.

The findings in this research reinforce the hypothesis that incentive spirometry, even when the specific therapeutic target is not the improvement of respiratory muscle strength, can have positive effects on the respiratory muscle performance, and it may be offered as a strategy for the treatment of patients with muscle weakness.

The level of thoracic mobility below normality parameters was also shown by Guimarães *et al.*[26]. After the intervention, there was significant diameter increase in the xiphoid and umbilical level in both groups. The normality of thoracic mobility in a healthy young adult is about 7 cm[26], and this value is reduced among the elderly due to the changes in the thoracic structure[26]. The expansibility at the axillary level was greater in GVold than in GResp, which may suggest more airflow distribution in the upper lobes with the volume-oriented incentive to the detriment of the flow-oriented incentive. However, it is not possible to state that this phenomenon is effective related to airflow distribution, because this study did not involve techniques to measure this variable. The increased thoracoabdominal extension was also reported in a previous study, however, in patients with chronic pulmonary disease, which observed that the volume-oriented incentive had better results when compared to the flow-oriented incentive[27].

The increased CV was shown in both groups, demonstrating the effectiveness to improve th pulmonary and thoracoabdominal expansion. Giovanetti *et al.*[17] showed significant volume increase, thus demonstrating the efficacy of the treatment with both devices. No changes were registered in RF, and previous studies[28,29] suggest that the reduced RF promoted by the volume-oriented spirometer is associated to longer inspiratory time, provided by the slow and deep inspiration, which favors the development of a laminar and uniform airflow. However, these studies assessed RF at a time when the subjects were using the incentive spirometer, and not after intervention.

The study is limited if we consider that a protocol with more sessions and repetitions could provide better results, thus suggesting that the treatment should not be limited due to time.

CONCLUSION

Both the flow and the volume-oriented incentives were eficiente and presented similar benefits with regard to respiratory muscle strength, pulmonary function and thoracoabdominal mobility, thus bringing contributions to physical therapy, especially in relation to the health of the elderly. Due to their easy handling and low cost, they can be useful to maintain the pulmonary health of the elderly subject, which may reduce the incidence of respiratory dysfunctions, hospital admissions and costs to the health system.

REFERENCES

1. Rebelatto JR, Morelli JGS. Fisioterapia Geriátrica: a prática da assistência do idoso. São Paulo: Manole; 2004.
2. Lima-Costa MF, Barreto SM, Giatti L. Condições de saúde, capacidade funcional, uso de serviços de saúde e gastos com medicamentos da população idosa brasileira: um estudo descritivo baseado na Pesquisa Nacional por Amostra de Domicílios. Cad Saúde Pública. 2003;19(3):735-43.
3. Soares LT. Comparação do padrão vocal de idosos com e sem doença pulmonar obstrutiva crônica [dissertação]. São Paulo: Universidade Federal de São Paulo; 2001.
4. Griffith KA, Sherrill DL, Siegel EM, Manolio TA, Bonekat HW, Enright PL. Predictors of loss of lung function in the elderly: the cardiovascular health study. Am J Respir Crit Care Med. 2001;163:61-8.
5. Francisco MSB, Donalisio MR, Barros MBA, César CLG, Carandina L, Goldbaum M. Fatores associados à doença pulmonar em idosos. Rev Saúde Pública. 2006;40(3):428-35.
6. Faria CN [Internet]. Alterações anatômicas e fisiológicas do envelhecimento. Grandes síndromes geriátricas [acesso maio de 2012]. Disponível em: http://www.ciape.org.br/matdidatico/anacristina/alteracoes_anatomicas.rtf
7. Hristara-Papadopoulou A, Tsanakas J, Diomou G, Papadopoulou O. Current devices of respiratory physiotherapy. Hippokratia. 2008;12(4):211-20.
8. Yamaguti WPS, Sakamoto ET, Panazollo D, Peixoto CC, Cerri GG, Albuquerque ALP. Mobilidade diafragmática durante espirometria de incentivo orientada a fluxo e a volume em indivíduos sadios. J Bras Pneumol. 2010;36(6):738-45.
9. Ide MR, Caromano FA, Dip MAVB, Guerino MR. Exercícios respiratórios na expansibilidade torácica de idosos: exercícios aquáticos e no solo. Fisioter Mov. 2007;20(2):33-40.
10. Rocha CBJ, Araújo S. Avaliação das pressões respiratórias máximas em pacientes renais crônicos nos momentos pré e pós-hemodiálise. J Bras Nefrol. 2010;32(1):107-13.
11. Souza RB. Pressões Respiratórias Estáticas Máximas. J Bras Pneumol. 2002;28(supl 3):155-65.
12. Neder JA, Andreoni S, Lerario MC, Nery LE. Reference values for lung function tests. II. Maximal respiratory pressures and voluntary ventilation. Braz J Med Biol Res.1999; 32(6);719-27.
13. Caldeira VS, Starling CCD, Britto RR, Martins JA, Sampaio RF, Parreira VF. Precisão e acurácia da cirtometria em adultos saudáveis. J Bras Pneumol. 2007;33(5):519-26.
14. Pereira CAC, Neder JA. Diretrizes para Testes de Função Pulmonar. J Bras Pneumol. 2002;28(Suppl 3):1-13.
15. Renault JA, Costa-Val R, Rossetti MB, Houri Neto M. Comparação entre exercícios de respiração profunda e espirometria de incentivo no pós-operatório de cirurgia de revascularização do miocárdio. Rev Bras Cir Cardiovasc. 2009;24(2):165-72.
16. Burneiko RCVM, Melatto T, Padulla SAT, Matta MV, Giacomassi IWS, Sato KT. Efeitos da inspiração fracionada ou incentivador a volume no pós-operatório revascularização do miocárdio. Rev Eletronica Fisioter da FCT/UNESP. 2009;1(1):124-138.
17. Giovanetti EA, Boueri CA, Braga KF. Estudo comparativo dos volumes pulmonares e oxigenação após o uso do Respiron e Voldyne no pós-operatório de cirurgia abdominal alta. Reabilitar. 2004;6(25):30-39.
18. Simões RP, Castello V, Auad MA, Dionísio J, Mazzonetto M. Força muscular respiratória e sua relação com a idade em idosos de sessenta a noventa anos. RBCEH. 2010;7(1):52-61.
19. Oyarzún M. Función respiratoria en la senectud. Rev Méd Chile. 2009;137:411-8.
20. Simões RP, Castello V, Auad MA, Dionísio J, Mazzonetto M. Prevalence of reduced respiratory muscle strengh in institucionalized elderly people. São Paulo Med J. 2009;127(2):78-83.
21. Freitas FS, Ibiapina CC, Alvim CG, Britto RR, Parreira VF. Relação entre força de tosse e nível funcional em um grupo de idosos. Rev Bras Fisioter. 2010;4(6):470-6.
22. Fonseca MA, Cader SA, Dantas EHM, Bacelar SC, Silva EB, Leal SMO. Programas de treinamento muscular respiratório: impacto na autonomia funcional de idosos. AMB Rev Assoc Med Bras. 2010;56(6):642-8.
23. Kotz JC. Estudo comparativo do efeito dos incentivadores respiratórios voldyne e respiron sobre a força dos músculos inspiratórios em indivíduos saudáveis. [graduação]. Paraná (PR): Universidade Estadual do Oeste do Paraná; 2005.
24. Weindler J, Kiefer RT. The efficacy of postoperative incentive spirometry is influenced by the device: specific imposed work of breathing. Chest. 2001;119:1858-64.
25. Lunardi AC, Porras DC, Barbosa RC, Paisani DM, Marques da Silva CC, Tanaka C, Carvalho CR. Comparison of distinct incentive spirometers on chest wall volumes, inspiratory muscular activity and thoracoabdominal synchrony in the elderly. Respir Care. 2013 Aug 27. [Epub ahead of print].
26. Guimarães ACA, Pedrini A, Matte DL, Monte FG, Parcias SR. Ansiedade e parâmetros funcionais respiratórios de idosos praticantes de dança. Fisioter Mov. 2011;24(4):683-8.
27. Ho SC, Chiang LL, Cheng HF, Lin HC, Sheng DF, Kuo HP, Lin HC. The Effect of incentive spirometry on chest expansion and breathing work in patients withchronic obstructive airway disease: comparison of two methods. Chang Gung Med J. 2000;23(2):73-9.
28. Parreira VF, Tomich GM, Britto RR, Sampaio RF. Assessment of tidal volume and thoracoabdominal motion using volume and flow-oriented incentive spirometers in healthy subjects. Braz J Med Biol Res. 2005;38(7):1105-12.
29. Tomich GM, França DC, Diório ACM, Britto RR, Sampaio RF, Parreira VF. Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises. Braz J Med Biol Res. 2007;40(10):1409-17.