Openventio PUBLISHERS

PULMONARY RESEARCH AND RESPIRATORY MEDICINE

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

Research

*Corresponding author
Alexandre Ricardo Pepe Ambrozin
Master in Human Development and Technologies, Physical Education Department, Biosciences Institute Paulista State University Júlio de Mesquita Filho - UNESP
737, Higyno Muzzi Filho Av
Campus Universitário
CEP 17.525-900 - Marília SP, Brazil
Tel. 55(14)981497071
E-mail: aleambrozin@marilia.unesp.br

Volume 2 : Issue 2
Article Ref. #: 1000PRRMOJ2114

Article History
Received: April 15th, 2015
Accepted: May 29th, 2015
Published: June 2nd, 2015

Citation
Da Silva Raquel DF, Quitério RJ, De Campos MF, Vieira S, Ambrozin ARP. Effects of the resisted exercise in the respiratory function of individuals with hemiparesis after stroke. *Pulm Res Respir Med Open J*. 2015; 2(2): 84-89. doi: 10.17140/PRRMOJ-2-114

Effects of the Resisted Exercise in the Respiratory Function of Individuals With Hemiparesis after Stroke

Doralice Fernanda Da Silva Raquel[1], Robison José Quitério[2,3], Mônica Furquim De Campos[4], Suenimeire Vieira[4] and Alexandre Ricardo Pepe Ambrozin[2,3*]

[1]Physiotherapist, Undergraduate at the Philosophy and Sciences School from Paulista State University Júlio de Mesquita Filho - UNESP, Marília - São Paulo, Brazil

[2]Assistant Professor, Physiotherapy and Occupational Therapy - Philosophy and Sciences School from Paulista State University Júlio de Mesquita Filho - UNESP, Marília - São Paulo, Brazil

[3]Professor, Post Graduation Program in Human Development and Technologies - Biosciences Institute, Paulista State University Júlio de Mesquita Filho - UNESP, Rio Claro - São Paulo, Brazil

[4]Master in Human Development and Technologies, Physical Education Department, Biosciences Institute, Paulista State University Júlio de Mesquita Filho - UNESP, Rio Claro - São Paulo, Brazil

ABSTRACT

Objective: To compare the effects of resisted exercise in lungs volume and capacity and strength of the respiratory muscles on individuals with hemiparesis after a stroke.
Methods: Ten individuals with hemiparesis caused by stroke were evaluated by measuring thoracic cirtometry, spirometry and manovacuometry before and after a muscle strengthening program for upper and lower limb that consisted of three weekly sessions with progressive load increment (30, 40 and 50% of the maximum load). The pre and post intervention data were compared using the t-Student and Wilcoxon tests ($p<0.05$).
Results: The subjects assessed were 52.60±10.50 years old, 70% were men and 70% with right hemisphere damage. These are the pre and post intervention data concerning respectively to axillary thoracic mobility= 4.40±1.20 and 4.20±1.57 cm; xiphoid=4.45±1.34 and 4.90±1.76 cm; basal=4.00±1.68 and 4.25±2.52 cm, spirometry: FVC=3,52±0,57 L e 3,30±0,64 L; FVC%=93,06±9,77 e 86,81±14,06%; FEV_1=2,72±0,49 L e 2.58±0.59 L; FEV_1%=88.27±9.43 e 83.04±15.08%; FEV_1/FVC=83.62±10.62 e 78.70±13.74%; Pimax=-88.50±24.27 e -91.50±21.09 cm H_2O; Pemax = 96.00±23.78 e 95.50±15.71 cm H_2O. After the training period with resisted exercise there was a statistically significant improvement on peripheral muscle strength ($p<0.05$). However, the variables associated with the respiratory function remained similar ($p>0.05$).
Conclusions: Adaptations caused by the resisted exercise training did not promote variation in thoracic expansion and respiratory muscles strength, as well as in lungs volume and capacity on subjects at a stroke chronic phase.

KEYWORDS: Respiratory mechanics; Stroke; Muscle strength; Physical therapy.

ABBREVIATIONS: FVC: Forced Vital Capacity; COPD: Chronic Obstructive Pulmonary Disease; BMI: Body Mass Index; ATS: American Thoracic Society; 6MWT: Six Minute Walk Test.

INTRODUCTION

Cerebrovascular diseases or stroke, main cause of permanent morbidity,[1] were respon-

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

sible for close to 17 million deaths around the world in 2008.[2] Damages caused by this disease include the plegias or paresis (uni or bilaterals), sensorial alterations and muscle tonus alterations.[3] These changes are responsible for motor and functional deficits,[4,5] that can compromise the respiratory biomechanics.[3]

The respiratory damage shown by subjects after a stroke can result from motor and functional deficits, from the inadequate movement of the diaphragm and intercostal muscles of the affected hemibody, leading to a reduction of the maximum respiratory pressures,[4,5] which indicates the reduction of the respiratory muscles strength.[4-6]

Besides that, subjects who suffered a stroke can present reduction on the thoracic and pulmonary complacency, which leads to a reduction of the total lung capacity and vital capacity, pointing to a restrictive ventilatory disturb.[7]

Rehabilitation programs after a stroke count on a great number of techniques which aim to improve the overall physical capacity.[8] Besides that, it is well known that subjects with stroke effects must join muscle strength and aerobics conditioning training programs to achieve functional improvements and also improvements on life quality, strength and physical conditioning.[9]

On the other hand, the resisted exercises were, not long ago, contraindicated as a rehabilitation technique for subjects who suffered a stroke, due to the concern of exacerbating the spasticity.[8] Recent studies has shown that resisted exercises do not change the spasticity, so it is getting more attention as a therapeutic resource for the neuromotor function.[10,11] The main benefits of the resisted exercise are the improvements on muscle strength and resistance and the improvement on functional development without tonus alteration.[12,13] According to Shepherd,[14] muscle strengthening exercises act on increasing motor unities recruitment, which improves body balance and both capacity and time of motor answer on generating strength. It also reduces the muscle stiffness and the reflexive hyperactivation while preserves the muscles functional extensibility.

We haven't found in the literature, studies about the chronic effects of this kind of exercise over pulmonary functions on hemiparetic. On subjects with Chronic Obstructive Pulmonary Disease (COPD), the resisted physical exercise was effective in the improvement of the peripheral muscles strength and it can provide improvement of the Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV_1) and on the relation between both variables (FEV_1/FVC).[15]

That said, the objective of this study was to investigate the effects of the training with resisted physical exercise over lungs volume and capacity and the respiratory muscles strength on subjects with hemiparesis after a stroke.

MATERIALS AND METHODS

Design of Experiment

After the approval of the Research Ethics Committee from the institution (document 0093/2011) a prospective and interventionist study was performed, where seventy volunteers were sorted after a previous diffusion of the research in health units, places with wide movement of people and local means of communication. Seventeen fulfilled the inclusion criterion and, among them, ten concluded the research protocol. The inclusion criterion were: (1) subjects over 18 years old, (2) unilateral cerebrovascular lesion, for at least six months, associated with hemiparesis, (3) ability to understand verbal instructions, (4) ability to stay in orthostatic position without auxiliary means, (5) no significant orthopedic and neurological alterations prior to the stroke. Subjects who were incapable of understanding or performing the required activities were not included. All the subjects who passed the inclusion criterion signed the Informed and Consent Form.

Assessment

The selected subjects undertook an assessment performed in three days. On the first day, anamnesis, body weight and height, cirtometry, spirometry and manovacuometry were performed. On the second and third assessment days, a one maximum repetition test (1RM) was performed and, after 72 hours, the muscle strengthening program for upper and lower limb started.

The body weight was performed on a digital weighing machine (Filizola® brand) and height was taken on a stadiometer device, attached to the weighing machine. The Body Mass Index (BMI) was calculated with these data by dividing the body weight (kg) by the squared height (m^2).

For the thoracic cirtometry, the subject stood up straight with the upper limbs extended along the body. A measuring tape was used to measure the axillary, xiphoid and basal regions. Each measurement was taken after a maximum expiration, followed by a maximum inspiration and another maximum expiration. The difference between the maximum inspiration and expiration was taken as the thoracic expansibility. Measurements were repeated twice in each region, and only the highest values were considered.[16]

The spirometry was performed according to the criteria of the *American Thoracic Society (ATS),* on a spirometer (Digital One Flow FVC Kit Function System 1070) and three forced vital capacity tests were performed, reproductive and acceptable. The FVC and FEV_1 in liters and the predicted percentage were obtained as well as the relation FVC/FEV_1 in percentage.[17]

The assessment of the respiratory muscles strength was carried out using the maximum inspiratory and expiratory pres-

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

sure measures, MIP and MEP. The patient remained seated, with hips on 90º and straight stem. Nares were occluded by a nasal clip and the same was done with the mouth between teeth and lips, in order to avoid air escape. A forced inspiration from the residual volume was requested to obtain MIP and a forced expiration from the total lungs capacity was requested to obtain MEP. The procedures were repeated three times and the highest value was considered for the analysis.[18]

In order to perform the training program, a one maximum repetition test (1RM) was performed with progressive load increment until obtaining the highest dislocated load on the total articular range in the eccentric and concentric phases, without support in all the exercises.[19] The following muscle groups were tested: elbow flexors and extensors, shoulder horizontal adductors and abductors, shoulder abductors, knee flexors and extensors, hip flexors and extensors. The maximum strength tests were performed in two days; five exercises a day, randomly chosen, starting on the paretic and non paretic sides. Upper limb exercises were interspersed with lower limb exercises.

Muscle Strengthening Program

The training program was conducted in three weekly sessions for twelve weeks. The program consisted of exercises performed on an opened kinetic chain using mechano-therapy equipments: elbow flexion (biceps curl bench and dumbbells); elbow extension (dumbbells); shoulder horizontal adduction (pec deck); shoulder horizontal abduction (reverse pec deck); shoulder abduction (dumb bells); knee flexion (leg extension machine); knee extension (leg extension machine); hip adduction (adduction/abduction machine) and hip abduction (adduction/abduction machine), performed unilaterally (paretic side). In the first week, the training was performed with 30% of 1RM, in the second week 40% and in the following weeks 50% of 1RM. In the end of each month, the volunteers took the 1RM test again and the training loads were adjusted. A five-minute warm up was performed before every resisted training. After the trainings, also in every session, there was a 5 minute relaxation.

Blood pressure and heart rate were monitored in the beginning and in the end of the sessions. After performing the training protocol, patients were reassessed.

Statistical Analysis

The descriptive statistics was used for the characterization of the sample and data presented in mean and standard deviation. The variables went through a *Shapiro-Wilk normality test*. The ones which presented normal distribution were compared with a *t-student test* and those which didn't present normal distribution were compared with a *Wilcoxon test*, with a 5% level of significance. The statistical software BioEstat 5.0 was used for all the analysis.

RESULTS

Ten subjects were assessed, 70% of them were men. They were 52.60±10.50 years old, they had 82.10±18.05 kg of body weight, 1.69±7.31 m of height and they also had 28.70±5.99 kg/m^2 of BMI. The cerebrovascular lesion time was 40.60±29.56 months, and 70% of them presented right hemiparesis.

The thoracic mobility, as well as the spirometric variables and maximum respiratory pressures didn't show significant differences in the sample when compared to the assessments before and after the muscle strengthening program (Table 1).

Variables	Before	After	p-value
Caxillary (cm)	4.40±1.20	4.20±1.57	0.34
Cxiphoid (cm)	4.45±1.34	4.90±1.76	0.09
Cbasal (cm)	4.00±1.68	4.25±2,52	0.33
FVC (L)	3.52±0.57	3.30±0.64	0.06
FVC (%)	93.06±9.77	86.81±14.06	0.06
FEV_1 (L)	2.72±0.49	2.58±0,59	0.08
FEV_1 (%)	88.27±9.43	83.04±15,08	0.07
FEV_1/FVC (%)	83.62±10.62	78.70±13,74	0.09
MIP (cmH_2O)	-88.50±24.27	-91.50±21.09	0.24
MEP (cmH_2O)	96.00±23.78	95.50±15.71	0.47

Caxillary: axillary cirtometry; C xiphoid: xiphoid cirtometry; C basal: basal cirtometry; FVC: Forced Vital Capacity; FEV_1: Forced Expiratory Volume in the first second); FEV_1/FVC: relation between forced expiratory volume in the first second and forced vital capacity; MIP: Maximum Inspiratory Pressure; MEP: Maximum Expiratory Pressure; L: Liters); cm: Centimeters); %: Percentage over the predict; cm H_2O: water centimeters)

Table 1: Comparison of the variables before and after the muscle strengthening program.

On the 1RM test in the paretic side, there was improvement in every muscle group assessed, except on elbow and knee flexors and knee extensors (Table 2).

Muscle Groups	Before	After	p-value
Elbow flexors	5.50±3.72	7.22±4.68	0.09
Elbow extensors	3.20±2.86	4.44±2.13	0.03
Shoulder abductors	2.40±2.88	3.70±2.00	0.02
Horizontal abductors	12.50±10.61	17.50±13.59	0.02
Horizontal adductors	16.50±14.54	26.50±15.99	<0.01
Knee flexors	16.22±13.45	18.78±13.31	0.10
Knee extensors	7.00±4.38	8.13±4.58	0.20
Hip abductors	34.00±19.26	44.50±18.33	<0.01
Hip adductors	47.00±24.97	58.00±21.37	0.02

Table 2: Comparison of the 1 RM test in kilograms on the paretic side, before and after the muscle strengthening program.

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

In the non paretic side there was improvement on elbow flexors and extensors and hip abductors (Table 3).

Muscle Groups	Before	After	p-value
Elbow flexors	10.50±4.45	12.11±5.11	0.02
Elbow extensors	8.70±2.75	7.56±2.83	0.01
Shoulder abductors	5.20±2.15	5.20±1.87	0.50
Horizontal abductors	25.50±7.62	29.50±11.41	0.07
Horizontal adductors	29.00±9.66	28.00±12.29	0.38
Knee flexors	19.50±13.01	20.50±11.65	0.17
Knee extensors	12.50±6.77	13.00±6.32	0.29
Hip abductors	39.00±20.39	44.50±18.17	0.02
Hip adductors	57.00±20.84	56.50±19.30	0.36

Table 3: Comparison of the 1RM test in kilograms on the non paretic side, before and after the muscle strengthening program.

DISCUSSION

Analyzing the effects of the resisted exercise in the studied variables, no significant differences were found in thoracic mobility as well as in lungs volume and capacity and strength of the respiratory muscles, even though there was improvement in the muscle groups trained.

The studied sample was composed, in its majority, by male subjects, which confirms studies that point to a greater stroke incidence on men.[20,21] Concerning age, the mean was 52.60±10.50 years old, indicating that the studied sample can suffer the aging harmful effects[22,23] besides the hemiparesis that can interfere in a negative way in the variables after the muscle strengthening. It's known that aging leads to a reduction on innervation, capilar density, number and size of muscle fibers and therefore substitution of the muscle tissue for non contractile tissue, bringing reduction on peripheral muscle strength and less fatigue resistance.[22] These factors may have interfered on muscle strength gain in lower limbs in this sample.

Concerning the respiratory system, studies show that aging leads to a reduction in the number of alveolus and pulmonary compliance, raise in thoracic anteroposterior diameter and thoracic kiphosis in a way that there is a reduction in the pulmonary function.[23] The majority of the subjects were over 50 years old, besides that, we believe that age hasn't influenced the results of pulmonary function since all of them were according to the normality parameters.

The majority of subjects showed right-sided hemiparesis indicating left-sided cerebral lesion. There is no consensus in the literature about the most affected hemisphere. What is known is that the left hemisphere is dominant for the motor control, that is, motor activities are more damaged in subjects with left-sided lesion, suggesting that these subjects present a lower functional recovery when comparing to subjects with right-sided lesion.[24] As the sample was mostly composed by subjects with left-sided cerebral lesion, we believe that the damaged hemisphere may have been one of the factors that contributed to our results, as well as the training applied, which didn't aim the respiratory muscles specifically.

Thoracic expansibility alteration allows us to infer that there is also change in the volume of mobilized air during respiration.[25] Thus, the asymmetry in the respiratory dynamics, as it happens in the hemiparesis, is going to lead to a reduction in the thoracic mobility because of the movement restriction of the paretic hemithorax, being the lower thoracic region the most restricted.[26] The reference values for the thoracic cirtometry vary between 4 to 11 centimeters.[16,27] In this study, subjects presented less than 4 centimeters of mean in the thoracic basal region. Other assessed regions showed thoracic expansibility close to 4 centimeters. The thoracic expansibility didn't show significant difference after the training program, which is attributed to the non significant alteration of the respiratory muscles strength, which would lead to a lung volume increment. In the sample, as there was no significant increment in the strength of the respiratory muscles, the thoracic expansibility also didn't show significant alteration after the muscle strengthening program.

The analysis of the spirometric variables before the program indicates that the sample presents normal values, which goes against the literature information that shows that hemiparetic individuals present pulmonary ventilatory restrictive defect, characterized by a reduction of FVC and FEV_1, with FEV_1/FVC values close to the normality.[6] After the muscle strengthening, there was no significant alteration of lungs volume and capacity, besides the reduction in the thoracic expansibility when compared to the normality.[16,27] The strength of the respiratory muscles can also have interfered on lungs capacity and volume during the FVC test.

Concerning strength of the respiratory muscles, the obtained values were according to the normality, which can be justified by the compensation strategies to maintain pulmonary function that are developed by individuals with chronic hemiparesis, such as higher muscle recruitment on the non paretic side and use of accessory muscles.[28] In the present study, the maximum respiratory pressures showed a slight increment after the muscle strengthening program, but this value was not statistically relevant. The muscle training program performed didn't aim specifically the increment of the respiratory muscles strength and, even though it involved the scapular waist muscle, it was not able to change the strength of the respiratory muscles in a significant way. It's important to highlight that the resisted exercise didn't influence, in a positive or negative way, the studied variable. Thus, there's no risk of exacerbating the chronic respiratory damages of individuals with hemiparesis.

While analyzing the peripheral muscle strength before and after the muscle strengthening training, it was possible to

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

find a strength gain in all muscle groups involved, even though it was slight and not significant in some muscle groups, suggesting that the work load used in the protocol may have been underestimated. According to Hill, et al.[29] the strengthening training with load between 85% and 95% of the 1RM increases significantly the muscle strength and the performance of hemiparetic individuals on the Six Minute Walk Test (6MWT). In our study, the loads used were 30%, 40% and 50% of the 1RM, which is relatively low when compared to the study quoted above. Besides that, we used static tests to assess pulmonary function. The use of the 6MWT would allow us to check if the used loads were capable of providing improvements in the cardiopulmonary capacity, even though the pulmonary function, individually, was not significantly changed.

Though we have observed an increment on strength in muscles related to the scapular waist, which could influence the respiratory mechanics, this improvement was not enough to change the respiratory parameters. Protocols focused on the strengthening of the stem muscles and respiratory muscles are necessary in order to obtain significant results when it comes to respiratory muscles strength.

The significant increment of the peripheral muscle strength in the majority of the muscle groups assessed in the paretic side, and in some groups of the non paretic side, can indicate benefits of the resisted exercise by suggesting adaptations in the neuromuscular system, higher recruitment of motor units and discharge synchronization, sparking bilateral stimulus.[30]

In our study, in the lower limbs groups of muscles, there was no significant strength increment on both paretic and non paretic sides, which explains the non significant change in the pulmonary function of the subjects since the study showed that the positioning adopted during the strengthening exercise of the lower limbs, that demands activity from the abdominal muscles, can influence the forced expiration.[15]

New studies must be done with higher work load, exercises focused on the respiratory muscles and using other tests that assess the cardiorespiratory function, which will allow the assessment of whether the muscle strengthening provides functional capacity improvement. Even though the sample studied in this work presents diversity when it comes to lesion time, we believe that this variable didn't influence the results, as all participants had unilateral cerebrovascular lesion for, at least, six months, which is the period of time to consider the hemiparesis chronicity. It is important to highlight that overall, seventy volunteers were sorted. However, only seventeen did not present plegia in any body segment and could perform the movements required during the performance of the training program. Thus, the sample was considered homogeneous for the level of musculoskeletal compromising. From the seventeen participants, seven were not included for not taking the twelve week training.

The results of the present study indicate that the adaptations caused by the training with resisted exercise did not promote alterations in the thoracic expansibility and strength of the respiratory muscles, as well as in the lungs volume and capacity of individuals at a stroke chronic phase.

CONFLICTS OF INTEREST: None.

REFERENCES

1. Ministry of Health. Datasus. Morbidity indicators. Brazil; 2010.

2. World Health Organization (WHO). World health statistics annual: 2008. Geneva; 2008.

3. Meneghetti CHZ, Figueiredo VE, Guedes CAV, Batistela ACT. Respiratory Muscle Strength Assessment Individuals affected by Stroke. *Rev Neurocienc*. 2011; 1(19): 56-60.

4. Pizzol R, Yu F, Bott G, Tarumoto M. Spirometry and respiratory muscle strength in patients with hemiplegia assessment. *Rev Bras Fisioter.* 2004; S85

5. Marcucci FCI, Cardoso NS, Berteli KS, Garanhami MR, Cardoso JR. Electromyographic changes of the trunk muscles of patients with hemiparesis after stroke. *Arq Neuropsiquiatr*. 2007; 65: 900-905.

6. Fernandes MA, Freitas BHPF, Negrini F, Sampaio LMM, Medalha CC. Contributions of the Cardiopulmonary Evaluation in Patients Hemiplegics. *Arq Sanny Pesq Saúde*. 2008; 1(2): 90-97

7. Ovando AC, Michaelsen SM, Dias JA, Herber V. Gait training, Cardiorespiratory and Muscular after Stroke: strategies, strengths and outcomes. *Fisioter Mov*. 2010; 23(2): 253-269. doi: 10.1590/S0103-51502010000200009

8. Teixeira-Salmela LF, Oliveira ESG, Santana EGS, Resende GP. Muscle strengthening and physical conditioning in chronic stroke subjects. Acta Fisiátr. 2000; 7(3): 108-118.

9. Morris SL, Dodd KJ, Morris ME. Outcomes of progressive resistance strength training following stroke: a systematic review. *Clin Rehabil*. 2004; 18: 27-39.

10. Teixeira-Salmela LF, Olney SJ, Nadeau S. Muscle strengthening and physical conditioning to reduce impairment and disability in chronic stroke survivors. *Arch Phys Med Rehabil*. 1999; 80: 1211-1218. doi: 10.1016/S0003-9993(99)90018-7

11. Junqueira RT, Ribeiro AMB, Scianni AA. Effects of muscle strengthening and its relationship with functional activity and spasticity in hemiparetic individuals. *Rev Bras Fisioter.* 2004; 8(3): 247-252.

ISSN 2377-1658 Open Journal http://dx.doi.org/10.17140/PRRMOJ-2-114

12. Teixeira-Salmela LF, Nadeu S, McBride I, Olney SJ. Effects of muscle strengthening and physical conditioning training on temporal, kinematic and kinetic variables during gait in chronic stroke survivors. *J Rehab Med*. 2001; 33: 53-60.

13. Yang YR, Wang RY, Lin KH, Chu MY, Chan RC. Task-oriented progressive resistance strength training improves muscle strength and functional performance in individuals with stroke. *Clin Rehab*. 2006; 20: 860-870. doi: 10.1177/0269215506070701

14. Shepherd RB. Exercise and training to optimize functional motor performance in stroke in stroke: driving Neural Reorganization? *Neural Plast*. 2001; 8(1-2): 121-129. doi: 10.1155/NP.2001.121

15. Hoff J, Tijonna AE, Steinshamn S, Hoydal M, Richardson RS, Helgerud J. Maximal strength training of the legs in CODP: a therapy for mechanical inefficiency. *Med Sci Sports Exerc*. 2007; 39: 220-226.

16. Kakizaki F, Shibuya M, Yamazaki T, Yamada M, Suzuki H, Homma I. Preliminary report of the effects of respiratory muscle stretch gymnastics on chest wall mobility in patients with chronic obstructive pulmonary disease. *Respir Care. J Cardpulm Rehabil*. 1999; 44(4): 409-414.

17. American Thoracic Society. Standardization of Spirometry, 1994 Update. *AM J Respir Crit Care Med*. 1995; 152(3): 1107-1136.

18. Black L; Hyatt R. Maximal respiratory pressures: normal values and relationship to age and sex. *Am Ver Respir Dis*. 1966; 99: 696-702.

19. Robertson RJ, Goss FL, Rutkowsi J, et al. Concurrent Validation of the OMNI Perceived Exertion Scale for Resistence Exercise. *Med Sci Sports Exerc*. 2003; 35(2): 333-341

20. Nedeltchev K, Maur T, der A, et al. Ischaemic stroke in young adults: predictors of outcome and recurrence. *J Neurol Neurosurg Psychiatry*. 2005; 76: 191-195. doi: 10.1136/jnnp.2004.040543

21. Pires SL, Gagliard RJ, Gorzoni ML. Study of the frequency of the major risk factors for ischemic stroke in elderly. *Arq Neuro Psiquiatr*. 2004; 62(3): 844-851.

22. Doherty TJ. Physiology of Aging. Invited Review: Aging and sarcopenia. *J Appl Physiol*. 2003; 95: 1717-1727.

23. Pride NB. Ageing and changes in lung mechanics. *Eur Respir J*. 2005; 26: 563-565. doi: 10.1183/09031936.05.00079805

24. Voos MC, Ribeiro do Valle LE. Comparative study of the hemispheric relationship affected in stroke and functional evolution in right-handed individuals. *Rev Bras Fisioter*. 2008; 12(2): 113-120. doi: 10.1590/S1413-35552008000200007

25. Brazilian Society of Thoracic. Guidelines for pulmonary function tests. *J Bras Pneumol.* 2002; 28(3): 1-238.

26. Ogiwara S, Ogura K. Ântero-Posterior Excursion of the Hemithorax in Hemiplegia. *J Phys Ther Sci*. 2001; 13(1): 11-15. doi: 10.1589/jpts.13.11

27. Caldeira, VS, Starling CCD, Britto RR, Martins JA, Sampaio RF, Parreira VF. Reliability and accuracy of cirtometry in healthy adults. *J Bras Pneumol*. 2007; 33(5): 519-526. doi: 10.1590/S1806-37132007000500006

28. Pompeu SMAA, Pompeu JE, Rosa M, Silva MR. Correlation between Motor and Respiratory Disorders in stroke. *Rev Neurocienc*. 2011; 19(4): 614-620.

29. Hill TR, Gjellesvik TI, Moen PM, et al. Maximal Strength Training Enhances Strength and Functional Performance in Chronic Stroke Survivors. *Am J Phys Med Rehabil*. 2012; 91(5): 393-400. doi: 10.1097/PHM.0b013e31824ad5b8

30. Moritani T, De Vries HA. Neural factors versus hypertrophy in the time course of muscle strength gain. *Am J Phys Med.* 1979; 58: 115-130.