Original Article

RESPIRATORY MUSCLE TRAINING PROGRAMS: IMPACT ON THE FUNCTIONAL AUTONOMY OF OLDER ADULTS

Marilia de Andrade Fonseca[1]*, Samaria Ali Cader[2], Estelio Henrique Martin Dantas[3], Silvia Correa Bacelar[4], Elirez Bezerra da Silva[5], Silvania Matheus de Oliveira Leal[6]
Study conducted at Universidade Castelo Branco – UCB, Rio de Janeiro, RJ, Brazil

ABSTRACT

Objective. To compare two respiratory muscle training programs, analyzing the improvement in the functional autonomy of institutionalized older adults.

Methods. Experimental randomized clinical trial conducted at long-stay institution with 42 older adults divided into the following groups: Threshold® group (TG; n=14; age 70.93±8.41), Voldyne® group (VG; n=14; age 70.54±7.73), and control group (CG; n=14; age 73.92±7.28). The groups TG and VG were treated with breathing exercises and muscle training using Threshold and Voldyne, respectively, and the CG only did breathing exercises. The training program lasted for 10 weeks. We used the GDLAM protocol to evaluate functional autonomy.

Results. The comparison between the groups (before vs. after the test) showed significant difference in the TG for all tests (GLDAM index - GI: %Δ = -18.43, p = 0.0001), except for rising from the prone position. In the VG there was significant difference ($p < 0.05$) only for the 10-meter walking test - C10M (%Δ = -17.11, p = 0.004). The comparison between the groups (after vs. after the test) showed statistical significance ($p < 0.05$) for the test of dressing and undressing a T-shirt between TG and VG (%Δ = -3.62%, p = 0.017), with better results for TG. Similarly, there was statistical difference for TG in the C10M test (%Δ = -3.83, p = 0.023), rise from the chair and move around the house - LCLC (Δ% = -34.02, p = 0.012) and GI (Δ% = -13.63, p = 0.004) compared to CG.

Conclusion. The trained groups had levels of functional autonomy above 27.42, which is considered low both for pre- and post-training.

Key Words: Older adult. Muscle strength. Long-term care facilities for older adults. Activities of daily living.

***Correspondence**:
Av. Salvador Allende, 6700 -
Shopping Bandeirantes
Recreio dos Bandeirantes
Rio de Janeiro - RJ, Brazil
CEP: 22780-160

Introduction

Increase in life expectancy, as a result of improvement in the quality of medical care and sanitation, and reduction of fertility are some of the factors responsible for changing the age structure diagram towards a large increase in the number of older adults.[1]

The following aspects are considered risk factors for institutionalization: increasing proportion of weak older people with disabilities in the Brazilian capitals, reduction in the availability of family care and intergenerational transfers in the urban context, lack of social support and health services, high cost of home care, housing with reduced physical space and environments posing risk of falls, and violence against older adults.[2]

1- Mestre em Ciência da Motricidade Humana - Docente da Universidade Estadual do Sudoeste da Bahia – UESB, Jequié, BA
2- Doutora em Medicina do Esporte - Pesquisadora do Laboratório de Biociências da Motricidade Humana da Universidade Castelo Branco - LABIMH-UCB/RJ; Editora-chefe da Fisioterapia da Revista Ciência Online; Editora científica da Fitness & Performance Journal e Fisioterapeuta do CTI do Hospital São Bernardo, Rio de Janeiro, RJ
3- Pós-doutor em Psicofisiologia e Fisiologia - Presidente do Conselho Editorial da Shape Editora e Promoções Ltda; Presidente do Colégio Brasileiro de Atividade Física Saúde e Esporte e da Rede Euroamericana de Motricidade Humana; Docente da Universidade Castelo Branco e Professor colaborador da Universidade Federal do Estado do Rio de Janeiro - UNIRIO; Universidade da Coruna (Espanha); Universidad de Murcia (Espanha); Universidad de Valencia (Espanha e da Universidade de Trás-os-Montes e Alto Douro (Portugal), Rio de Janeiro, RJ
4- Doutora em Radiologia - Fisioterapeuta do Instituto Nacional de Câncer; Diretora da Escola de Ciências da Motricidade da UNIGRANRIO; Docente do Mestrado em Fisioterapia na Universicada Católica de Nuestra Senora de Asuncion, Paraguai e Fisioterapeuta na área oncovascular Clínica Mathilde Bacellar, Rio de Janeiro, RJ
5- Doutor em Educação Física - Professor e coordenador do curso de Fisioterapia da Universidade Gama Filho; Membro do Comitê Científico e Tecnológico; Professor do Mestrado e Doutorado PPGEF, Líder do Grupo de Pesquisa Clínica Escola FIT, Rio de Janeiro, RJ
6- Mestre - Membro acadêmica do Laboratório de Biociências da Motricidade Humana – LABIMH, Rio de Janeiro, RJ

In Brazil, because of the increasing number of older adults, living in a long-term care facility (LTCF) is something planned and possible for almost two thirds of the older population, if there is no other option.[3] The transfer of an older adult from his/her home to the care facility may cause health problems such as depression, mental confusion, loss of contact with reality, depersonalization, and a sense of isolation and separation from society.[3]

As people grow older, many routine tasks that used to be considered trivial and therefore easy to perform will gradually and often imperceptibly become increasingly difficult to perform, to the point that the individual realizes that he/she depends on another person to perform his/her activities of daily living (ADLs).[4]

Because of the aging process, there is a decrease in skeletal muscles mass mainly after the sixth decade of life. According to some studies, this decrease also affects respiratory muscles.[5,6]

Studies on breathing exercises often investigate chronic respiratory diseases and rarely involve the older population without pathological manifestations. Thus, a low-cost intervention that will improve chest expansion may be of great value, since an efficient respiratory system can prevent or enhance recovery from common respiratory diseases in this population. The inclusion of inspiratory muscle strengthening in the exercise training programs for older adults can be considered an additional alternative in terms of physical therapy.[7,8]

Institutionalized older people seem more prone to these risk factors because of their restricted mobility resulting from the fact that they depend on other people (caregivers) to perform self-care activities, which further increases their loss of functional autonomy.

With regard to functional independence, there are several tests described in the literature for assessment of functional capacity. According to the Latin America Development Group for Maturity (GDLAM), autonomy is related to three aspects: autonomy of action, autonomy of will, and autonomy of thought. Therefore, autonomy should not be defined based only on a single aspect, standpoint, or perspective, but according to a holistic context. Thus, lack of autonomy is associated with decline in the ability to perform activities of daily living (ADLs) and gradual reduction in muscle functions, which is one of the major losses caused by aging.[9]

With that in mind, the objective of the present study is to compare two respiratory muscle training programs, analyzing the improvement in the functional autonomy of institutionalized older adults. We decided to compare different training programs because of their difference in terms of costs.

Methods

Sample

This is an experimental randomized clinical trial conducted at long-term care facilities. In order to be included in the sample, older adults should be physically and cognitively able to take the tests proposed by this study. Initially, 54 older individuals met the inclusion criteria and participated in the study. Of these, 12 were excluded. One for cognitive impairment, one because of death from stroke, one due to visual deficit (glaucoma), and nine for lack of adherence to training. Exclusion criteria were: older adults who were in the acute phase of cardiopulmonary disorders, those who did not have cognitive level suitable for understanding and taking the tests, both assessment tests and the exercises included in the training programs, patients with musculoskeletal and neurological sequelae, uncontrolled or untreated metabolic syndromes. In addition, nonadherence to the training programs for longer than one week was also an exclusion criterion to avoid interference in the results.

Thus, after the screening for the inclusion and exclusion criteria, the sample included 42 volunteer individuals who were randomly divided (raffle) in three groups: Threshold® group (TG), Voldyne® group (VG), and Control group (CG) distributed according to mean age and body mass index (BMI) as shown in Table 1.

TG, VG, and CG were treated with the same protocol of respiratory exercises. TG received the muscle training protocol using Threshold equipment, VG was treated with the protocol that used Voldyne equipment, and CG only performed a protocol of respiratory exercises.

After receiving information about the respiratory muscle training and the tests included in the GDLAM protocol, the participants and those responsible for the care facilities signed a consent form. The present study was approved by the Research Ethics Committee of Universidade Castelo Branco (UCB-RJ) (report no. 0043/2008), being in agreement with the ethical principles set by the 2000 Helsinki Declaration.

Table 1 - Mean age and BMI of the groups

	TG (Threshold Group) n=14	VG (Voldyne Group) n=14	CG (Control Group) n=14
Age	70.93±8.41	70.54±7.73	73.92±7.28
BMI	24.06±3.69	27.17±5.66	24.80±5.42

Age in years: mean and standard deviation and BMI Kg/m2: mean and standard deviation

Procedures

The procedures for this study consisted of a preliminary phase (pre-training), comprising full assessment of the older adults, which included personal data, medical history, and physical examination. In addition, functional tests based on the GDLAM protocol were carried out soon after measurement of maximal respiratory pressures. The instrument used to measure maximal respiratory pressures was the aneroid manometer critical med® - USA, ±120cmH²O, with operating range from 4 to 4 cmH_2O. We measured the maximal inspiratory pressure (MIP) based on residual volume - RV, and the maximal expiratory pressure (MEP) based on total lung capacity (TLC). These tests were repeated after ten weeks of training in order to obtain the results.

Respiratory Muscle Training for the Threshold Group (TG)

As part of the respiratory muscle training, the older adults underwent a program of breathing exercises based on the study conducted by Ide et al.,[7] which evaluated the improvement in chest expansion in healthy older adults. The program consisted of the following exercises: resisted active exercise of horizontal adduction-abduction of the shoulder joint, resisted active exercise of flexion-extension of the shoulder joint, resisted active exercise of forward flexion associated with trunk rotation, resisted active exercise of lateral flexion of the trunk, resisted active exercise of lateral rotation of the trunk, active exercise of upper limbs raising above the head, final relaxation - deep inhaling and exhaling without other movements.

The Threshold group performed these exercises and soon after the device Threshold® IMT (Respironics USA - 2004) was used. This equipment is available in the market as a transparent plastic cylinder containing, at one end, a valve that is kept closed by the positive pressure from a spring and, at the other end, a nozzle. The valve blocks air flow in the airways until the patient produces sufficient inspiratory pressure to overcome the burden imposed by the spring. The use of the Threshold device in the present study began with a workload gradually installed, starting with 50% of each individual's MIP and adding 10% a week until the fourth week. Starting at the fifth week, 5% was added until reaching 100% in the eighth week or the maximum pressure value of Threshold IMT (41cmH²O). Thereafter, this value was maintained in the last two weeks. The sessions lasted for 20 minutes, with seven series of muscle strengthening (two minutes each) and a one-minute interval between the series during 10 weeks, three times a week.[10]

Respiratory Muscle Training for the Voldyne Group (VG)

The same exercises proposed by Ide et al.[7] were used for the VG, but the participants used Voldyne as a respiratory stimulator. Such equipment has nonlinear pressure load. The technique of sustained maximum inspiration (SMI) using Voldyne is performed with the mobilization of large lung volumes, which are responsible for increased intra-alveolar pressure at the end of sustained inspiration. Increased intra-alveolar pressure is directly proportional to the contractile force of respiratory muscles, diaphragm, and accessories, thus explaining the fact that, in order to achieve TLC and sustain inspiration at this level, there is an intense muscle activity.[11]

Incentive spirometry (IS) was used with Voldyne® and some guidelines suggested by Machadoo[12] were recommended. The patient was positioned with a horizontal inclination of the trunk at 30º, providing greater diaphragmatic recruitment. The device was arranged vertically. The record related to volume was visible for the older patients, occurring effect of visual biofeedback, as the patients achieved the recommended volume, it was gradually increased until they could reach the new goal. The participants were instructed to perform one slow and deep inspiration until TLC from the functional residual capacity (FRC). Slow inspiration promotes laminar flow. Sustained maximum inspiration was set at approximately three seconds. Expiration was physiologically performed until reaching FRC. Patients were not allowed to hyperventilate while using Voldyne. Intervals of 60 seconds between sustained maximal inspirations were recommended.[12] The elderly were given a verbal command every time they should begin a new inspiration. In the present study, the use of Voldyne was performed for 20 minutes, that is, 40 repetitions, totaling two repeats every minute. This respiratory muscle training program lasted for 10 weeks with sessions three times a week. The group of elderly was continuously supervised during 20 minutes with the purpose of preventing hyperventilation.

Training of Control Group

The control group performed only breathing exercises, according to a study by Ide et al.[7]

Before participating in the training programs, all older adults were evaluated individually, but trained in a group with special attention to each of the study participants. The older adults included in the TG received loads of pressure for the Threshold, and those included in the VG received the maximum inspiratory capacity, according to values obtained in the evaluation of each individual. We used group training with the intention of providing greater social integration among the older participants.

The GDLAM functional autonomy protocol was used to serve the purpose this study. It is composed of five tests: C10M (10-meter walking test)[;13] LPS (rising from the sitting position);[14] LPDV (rising from the prone position);[15] LCLC (rising, walking, and moving around the house);[16] VTC (dressing and undressing a T-shirt).[17] After this phase, the data collected were inserted into a formula to calculate the general index of autonomy - GDLAM index (GI).

Each patient made two attempts for each test and the fastest attempt was recorded, i.e., the shortest time in seconds

Table 2 - Standard assessment of functional autonomy according to the GDLAM protocol

TESTS CATEGORY	C10M (SEC)	LPS (SEC)	LPDV (SEC)	VTC (SEC)	LCLC (SEC)	GI (SCORES)
Weak	7.09	11.19	4.40	13.14	43.00	27.42
Moderate	7.09-6.34	11.19-9.55	4.40-3.30	13.14-11.62	43.00-38.69	27.42-24.98
Good	6.33-5.71	9.54-7.89	3.29-2.63	11.61-10.14	38.68-34.78	24.97-22.66
Very Good	-5.71	-7.89	-2.63	-10.14	-34.78	-22.66

C10M = 10-meter walking test; LPS = rising from the sitting position, LPDV = rising from the prone position, LCLC = rising, walking, and moving around the house, VTC = dressing and undressing a T-shirt; scores in seconds. GI = GDLAM index, values in scores (VALE, 2005).

before and after 10 weeks of respiratory muscle training.

After this phase, the time results obtained on the tests and scores of GI were classified according to standard evaluation of the functional autonomy of the GDLAM protocol shown in Table 2.

Statistical treatment

We used descriptive statistics with mean and standard deviation for age, body mass index, and functional autonomy. The normality of the sample was evaluated by the Shapiro-Wilk test and the homogeneity of variance was assessed by the Levene's test. For the intragroup analysis of the response variables, the paired Student's t test or Wilcoxon's test were used, when appropriate (homogeneous or heterogeneous distribution of data, respectively). For the intergroup evaluation, we used the nonparametric Kruskal Wallis test followed by multiple comparisons using the Mann-Whitney test. The significance level was set at 0.05. To analyze the results we used the software Excel and the statistical package SPSS 14.0.

Results

To assess the normality of the sample, we used the Shapiro Wilk (SW) test ($p < 0.05$). We found a heterogeneous distribution of data: (a) VG: LPS ($p=0.013$); LPDV ($p=0.017$); (b):CG: C10M ($p=0.043$); LPDV (0.036); LCLC ($p=0.018$).

Table 3 shows data obtained for the mean and standard deviation of functional autonomy of the Threshold group (TG), Voldyne group (VG), and Control group (CG), both for comparison within the groups (pre vs. post) and intergroups (post vs. post).

We also calculated the Δ% (delta percentage) for all groups that received different respiratory muscle training programs.

For the Threshold group, when pre- and post-intervention were compared, there was no significant difference ($p<0.05$) for all tests, and the negative Δ% shows that after the intervention this group the older adults had a shorter time (in seconds)

Table 3 - Comparison of intra- and intergroup functional autonomy

	Threshold Group (TG)		Voldyne Group (VG)		Control Group (CG)	
	Mean ± s (pre)	**Mean ± s (post)**	**Mean ± s (pre)**	**Mean ± s (post)**	**Mean ± s (pre)**	**Mean ± s (post)**
C10M	9.58±2.53	7.61 ± 1.83 * #	9.36±2.60	7.76±2.07*	9.99±4.20	11.44±6.60
LPS	12.45±2.80	10.77±1.89*	12.49±2.70	11.44±2.45	10.04±2.16	12.99±4.60
I LPDV	7.28±3.26	7.45±3.20	6.32±3.32	6.91±2.79	7.11±3.26	8.48±3.56
VTC	19.17±6.28	13.81 ± 3.19 * **	19.44±5.95	17.43±4.89	14.62±3.69	16.97±5.26
LCLC	64.59±14.73	52.51 ± 8.02 * #	62.87±16.66	60.32±14.37	69.54±25.31	86.53±47.80
GI	40.39±8.01	32.94 ± 5.37 * #	39.52±9.36	36.86±8.31	38.26±10.23	46.57±19.09

* $p<0.05$, pretest x post-test
** $p<0.05$, post-test Threshold x post-test Voldyne
# $p<0.05$, post-test Threshold x post-test Control
S: standard deviation; pre: pre-test; post: post-test; C10M: 10-meter walk; LPS: rising from a sitting position; LPDV: rising from a prone position.
VTC: dressing and undressing a T-shirt; LCLC: rising, walking and moving around the house; GI: GDLAM index. The unit of measure of the tests is second(s).

to perform the tests of functional autonomy according to the GDLAM protocol (C10M: Δ%= -20.57, p=0.0001; LPS: Δ%= -13.53, p=0.020; VTC: Δ%= -27.96, p=0.0001; LCLC: Δ%= -18.71, p=0.0001 and GI: Δ%= -18.43, p=0.0001), except in the LPDV.

However, in the VG, there was significant difference ($p < 0.05$) only for the C10M test with a significantly shorter time (%Δ = -17.11, p = 0.004).

The control group did not achieve significant improvement in any of the tests after the intervention.

However, when the groups were compared (post vs. post), there was statistical significance ($p < 0.05$) only for the VTC test between TG and VG (%Δ = -3.62%, p = 0.017), with better results for TG. Similarly, there was statistical difference ($p < 0.05$) for the TG on the C10M (Δ% = -3.83, p = 0.023), LCLC (Δ% = -34.02%, p = 0.012), and GI (Δ% = - 13.63, p = 0.004) compared to CG satisfactorily.

According to reference data provided by Vale,[18] it is clear that the sample had levels of functional autonomy (GI) higher than 27.42; considered weak, both during pre- and post-training for all groups. With regard to the GI score no group had statistically significant improvements in the levels of functional autonomy recommended by Vale.[18] (Table 3)

Discussion

The respiratory muscle training programs used in the present study in order to promote improvements in the functional autonomy scores do not seem to be broadly satisfactory considering our results.

Respiratory muscle training (RMT) was best for the functional autonomy of the older participants allocated to the Threshold group (TG). However, there were no significant changes capable of improving the scores according to reference values recommended by Vale[18]. These results agree with the systematic literature review conducted in patients with cystic fibrosis with improvement in functional capacity using respiratory muscle training, which led to the conclusion that the benefit of training in adolescents and adults with cystic fibrosis to improve inspiratory muscle function is supported by weak evidence. Its impact on exercise capacity, dyspnea, and quality of life is still unclear.[19]

For the 10-meter walking test (C10M), the training programs used by the Threshold and Voldyne groups compared within the groups (pre- vs. post-training) had significant means and standard deviation for distance, 9.58±2.53 vs. 7.61±1.83, and 9.36±2.60 vs. 7.76 ± 2.07, respectively. Supporting part of the present study, Vasconcelos et al.,[8] conducted a correlation study between respiratory muscle strength through maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) and functional capacity using the six-minute walking test and found that coefficients of Pearson correlation between distance traveled and MIP and MEP were, respectively: r = 0.44 (p = 0.005) and r = 0.27 (p = 0.11), positively correlated only for MIP, recommending RMT for the physical rehabilitation programs to improve the functional capacity of older adults. However, in this study, C10M was significant in an isolated manner, without causing significant differences in the general index (GI) of the protocol used.

Another study correlated respiratory and peripheral muscle strength with the functional capacity of 65 older adults. Moderate and significant correlations were found between peripheral and respiratory muscles, as well as those with functional capacity of older people. The results showed an association between increased muscle strength and longer distance in the six-minute walk.[20] A randomized controlled clinical trial[21] conducted in 33 patients with respiratory muscle weakness and heart failure who performed inspiratory muscle training. One group used the Threshold equipment with incremental load and the other group did not receive resistive load. The group trained with incremental load had a significant increase in MIP and functional capacity measured by a six-minute walking test. The group without additional load did not show such results. These results support our findings because if we analyze the 10-meter walking test (C10M) alone, the TG and VG had significant improvements ($p < 0.05$) before and after the test for this variable. The groups trained with the addition of equipment to the pressure and volume had significant improvements on some tests, but their GI score remained unchanged. Therefore, the GI was not significant for the gain achieved by RMT.

Our results suggested that the group trained with incremental load had a significant increase in MIP and functional capacity measured by a six-minute walking test. The group without additional load did not show such results. These results support our findings because if we analyze the 10-meter walking test (C10M) alone, the TG and VG had significant improvements ($p < 0.05$) before and after the test for this variable. However, the GI was not significant for the gain achieved by RMT because the groups trained with the addition of equipment to the pressure and volume had significant improvements on some tests, but their GI score remained unchanged.

Studies assessing the functional capacity of individuals, either older people or those suffering from diseases, often use of the six-minute walking test, failing to investigate other physical abilities. On the other hand, institutionalized older people are more susceptible to impairment caused by low mobility and consequent decrease of functional autonomy. A study conducted by Creutzberg[2] in long-term care facilities (LTCF), focusing on the current health care system provided to older people, reported that social isolation shows that the practice of professionals in LTCFs have a performance largely based on a care model resulting in protective care, without considering the possibilities of promoting older individuals' potential abilities, freedom of choice, and increasing the condition of dependence, lack of opportunities and social isolation.

The social isolation experienced by older people in the present study encourages further loss of functional autonomy, suggesting the need for an interdisciplinary work, including physical exercises and other activities that promote health and wellness. Respiratory muscle training emerges as a therapeutic option in this population for the reduction of respiratory risks, which was confirmed by a study by Villas Boas & Ferreira,[22] who observed the prevalence of infections in older people living in long-term care facilities, with respiratory infection being present in 50% of the participants.

Since our study investigated the impact of respiratory muscle training programs on the increase in the level of functional autonomy of older adults and, as shown by the delta percentages, although the TG had better results for the tests proposed by the GDLAM protocol, there were not significant differences in all tests analyzed. However, these results can be explained by the low mobility faced by the older adults living in long-term care facilities. Because they always depend on caregivers, older people move little, even for self-care activities, restricting their daily activities to handcrafting like sewing, embroidery, and crafts, or TV watching. Based on these findings, it is important to think about possible alternatives to overcome the low mobility of this population.

Thus, the present study should be regarded as an initial step for future research, suggesting the need for prospective studies applied with the purpose of evaluating the effects of training and its continuity in order to promote improvements in physical and functional abilities and delay the onset of complications associated with aging, which are predictable and most of the time preventable.

However, multicenter studies would be a relevant factor for further future discussions because there is evidence that regional and cultural differences in this population may cause different results. Decline of cognitive and motor skills in the older population if evident, including functional dependence typical of the aging process, especially in the case of residents of long-term care facilities. On the other hand, it is known that many of these deficits can and should be minimized or controlled by direct observation of health professionals involved in promoting healthy aging. Simple but careful measures could be taken so that older adults go through an aging process mainly based on the careful attention to primary health care, since the cardiovascular system diseases are a major cause of hospitalization as individuals get older.

It is necessary to pay special attention to older adults living in long-term care facilities, where moral and social apathy is often present, leading to lack of interest in performing the activities of the daily living, leisure activities, physical exercise, among other skills that promote a more active life.

Conclusion

After analyzing our results, we found that the RMT performed by the TG had partially satisfactory functional autonomy. However, given the broad definition of functional autonomy for older people, although the Threshold group showed improvement compared to the other groups, there was no improvement in the levels of autonomy in all tests proposed by the GDLAM protocol, i.e., the GI remained weak.

However, it is well known that RMT performed by institutionalized older people is important to compose a pulmonary rehabilitation program, as the muscle weakness typical of aging, associated with low mobility, promotes the development of respiratory diseases and chronic degenerative diseases and, consequently, loss of functional autonomy.

Other protocols reproducing the daily activities of the individuals, as well as further studies using the GDLAM protocol in other populations should be investigated to promote a more accurate comparison on functional capacity. It seems imperative that institutionalized older people have a closer monitoring of physical and functional abilities for the early detection of difficulties to perform ADLs using easily administered tests for the assessment of functional autonomy, such as the GDLAM protocol, as markers of functional loss.

No conflicts of interest declared concerning the publication of this article.

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Artigo recebido: 14/10/09
Aceito para publicação: 31/08/10