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Research

The Effect of Different Respiratory Exercise on Spirometer Test Parameters in Stroke Patients: Randomized Controlled Trial

İnme Hastalarında Farklı Solunum Egzersizlerinin Spirometre Test Parametreleri Üzerine Etkisi: Randomize Kontrollü Çalışma

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ABSTRACT

Objective: Respiratory muscle weakness causes increased morbidity and mortality in stroke patients, negatively affects respiratory functions, and even causes the recurrence of previous stroke. This study aims to investigate the effect of respiratory exercise and aerobic exercise programs, which are used in addition to Todd-Davies exercises, which is one of the neurodevelopmental classical treatment techniques on pulmonary function test parameters in stroke patients.

Methods: Thirty-six cases were randomly divided into two groups as breathing exercises group (group-respiratory) and aerobic exercise group (group-aerobics) after doctor's examination. Todd-Davies neurophysiological treatment approach was applied to both groups. Breathing exercises were applied to group-respiratory. An arm ergometer was used in group-aerobics. Follow-up of the cases consisted of a total of thirty sessions of one hour a day, five days a week, over a six-week period. The respiratory system-related parameters of the participants were measured on the first and last day of the forced expiration air volume (FEV1), forced vital capacity (FVC), Tiffeneau index (FEV1/FVC) and chest anthropometric measurements.

Results: When the groups were compared in the post-test evaluation, FEV1/FVC parameter [$t(34)=-2.922$; $p<0.01$] group-respiratory value was found to be higher than group-aerobic value. When the difference in chest circumference measurement was compared [$t(34)=4.049$; $p<0.01$], group-aerobic value was found higher than group-respiratory value.

Conclusion: In cases where aerobic training is added, the increase in chest circumference flexibility facilitates both chest expansion and stroke rehabilitation, and affects spirometry test results more positively than breathing exercises.

Keywords: Aerobic exercise, breathing exercises, neurological rehabilitation, respiratory function tests, stroke

ÖZ

Amaç: İnmeli hastalarda solunum kas zayıflığının artmış morbidite ve mortaliteye neden olduğu ve solunum fonksiyonlarını negatif yönde etkilediği, hatta geçirilen inmenin tekrarlamasına neden olduğu kabul edilmektedir. Bu çalışmanın amacı inmeli hastalarda nörogelişimsel klasik tedavi tekniklerinden biri olan Todd-Davies egzersizlerine ek kullanılan solunum egzersizi ve aerobik egzersiz programının solunum fonksiyon testi parametrelerine etkisini araştırmaktır.

Gereç ve Yöntem: Otuz altı olgu doktor muayenesinden sonra rastlantısal olarak solunum egzersizleri grubu (grup-solunum) ve aerobik egzersiz grubu (grup-aerobik) olmak üzere iki gruba ayrıldı. Her iki gruba da Todd-Davies nörofizyolojik tedavi yaklaşımı uygulandı. Grup-solunuma solunum egzersizleri uygulandı. Grup-aerobiğe ise kol ergometresi çalıştırıldı. Olguların takibi altı haftalık bir süreçte, haftanın beş günü, günde bir saat toplam otuz seanstan oluşturuldu. Katılımcıların solunum sistemi ile ilişkili parametreleri zorlu ekspiryumun 1. saniyesinde çıkarılan hava hacmi (FEV1), zorlu vital kapasite (FVC), Tiffeneau indeksi (FEV1/FVC) ve göğüs antropometrik ölçümü ilk gün ve son gün yapıldı.

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Bulgular: Grup-aerobikte FEV1 (p<0,01), FVC (p<0,01) ve göğüs çevre ölçümündeki farkı (p<0,01) anlamlı bulunup, grup-solunumda yalnızca göğüs çevre ölçüm farkı (p<0,01) anlamlı bulundu. Son test değerlendirmesinde gruplar karşılaştırıldığında FEV1/FVC parametresinde [t(34)=-2,922; p<0,01] grup-solunum değeri, grup-aerobik değerinden yüksek bulundu. Göğüs çevre ölçümü farkı karşılaştırıldığında ise [t(34)=4,049; p<0,01] grup-aerobik değeri, grup-solunum değerinden yüksek bulundu.

Sonuç: Nörofizyolojik egzersizlere solunum veya aerobik egzersiz eğitimini eklemek spirometre test parametrelerini olumlu etkilemektedir. Özellikle aerobik eğitimin eklendiği olgularda göğüs çevre esnekliğindeki artış hem göğüs ekspansiyonunu hem de inme rehabilitasyonunu kolaylaştırmakta ve spirometre test sonuçlarını solunum egzersizlerine oranla daha olumlu etkilemektedir.

Anahtar Kelimeler: Aerobik egzersiz, solunum egzersizleri, nörolojik rehabilitasyon, solunum fonksiyon testi, inme

INTRODUCTION

Stroke is one of the leading causes of morbidity and long-term disability worldwide. The most common complications are fall and pressure sores. Infections occur most frequently in the entire system with 17% and the pulmonary system with 13.6% (1).

Disruption of respiratory rhythm in the hemiplegic patient populations tissue oxygenation and affects the energy distribution (2). Respiratory muscle weakness causes increased morbidity and mortality and negatively affects respiratory functions. Additionally, the central nervous system origin of the lesions in the stroke picture, the involvement of the respiratory muscles and the decrease in muscle strength affect the coordination of the patients with exercise and accordingly prevent stroke rehabilitation (2,3). During respiration after a stroke, the movement of the diaphragm on the hemiplegic side is reduced. The parasternal muscles and particularly the abdominal muscles that help coughing are affected. Additionally, small ischemic lesions in the respiratory control center also affect ventilation (4). The affected side internal and external intercostal muscles, diaphragm and abdominal muscles are partially or totally weak in stroke patients (5). After stroke, respiratory dysfunctions are observed due to decreased vital capacity, total lung capacity, maximum inspiratory pressure, and particularly low expiratory reserve volume (6).

The classical conventional stroke rehabilitation focuses on regaining lost motor control and correct posture. According to Todd Davies, one of a neurodevelopmental classical treatment technique the use of a bilateral rather than unilateral treatment approach for treating hemiplegia in accordance with the Bobath principle gives better results. The aim of bilateral treatment is to first provide symmetry with normal balance reactions and then to facilitate normal movement patterns. For this reason, we focus on the trunk first and then work on normal joint movement in the extremities. Progress in accordance with the development determined during the treatment is added and a holistic approach is followed (7).

In this study, the Todd-Davies neurophysiological approach was applied to stroke patients. While symmetrical improvements are seen in the Todd-Davies method, which is focused on trunk symmetry first, the contribution of respiratory studies is not found in the literature. Therefore, this study was planned to investigate the relationship between respiratory exercise and aerobic exercise programs in addition to the Todd-Davies technique in stroke patients.

METHODS

In this study, in the province of İstanbul, T.C. Ministry of Health forty-six patients included who could understand and follow simple verbal instructions in a medical center affiliated with, who were diagnosed with stroke by specialist physicians and referred to physiotherapy and rehabilitation. After the doctor's examination, the patients were randomly divided into two groups according to their protocol numbers as group-respiratory, those with odd numbers, group-aerobics. Patients with chronic pulmonary and/or cardiac disease (n=3), uncontrolled hypertension (n=2), non-stroke chronic obstructive pulmonary disease and asthma (n=1), mini mental test score of 24 ten stroke patients who were under (n=2) and uncooperative (n=2) were excluded from the study (6,8). The patients were divided into two groups using the block randomization method, 18 in the aerobic exercise group and 18 in the respiratory exercise group. A randomized controlled study was conducted with 36 stroke patients. While the block randomization method eliminates selection bias, it is also a method that provides balancing of the number of individuals between groups (Figure 1).

After recording the sociodemographic and disease characteristics of the participants, respiratory system-related parameters; the volume of air exhaled in the first second of forced expiration (FEV1), forced vital capacity (FVC), FEV1/FVC values were evaluated with computerized spirometry (Schiller Type SP-260; Schiller AG Altgasse 68 CH-6341 Baar Switzerland) device test protocol (9). Brunsstrom upper extremity, chest anthropometric measurements were recorded from the xiphoid region by an independent physiotherapist after evaluating the first test before the exercise and the last test before the thirtieth session.

Follow-up of the cases consisted of 30 exercise sessions applied for 1 h a day, 5 days a week, over a 6-week period

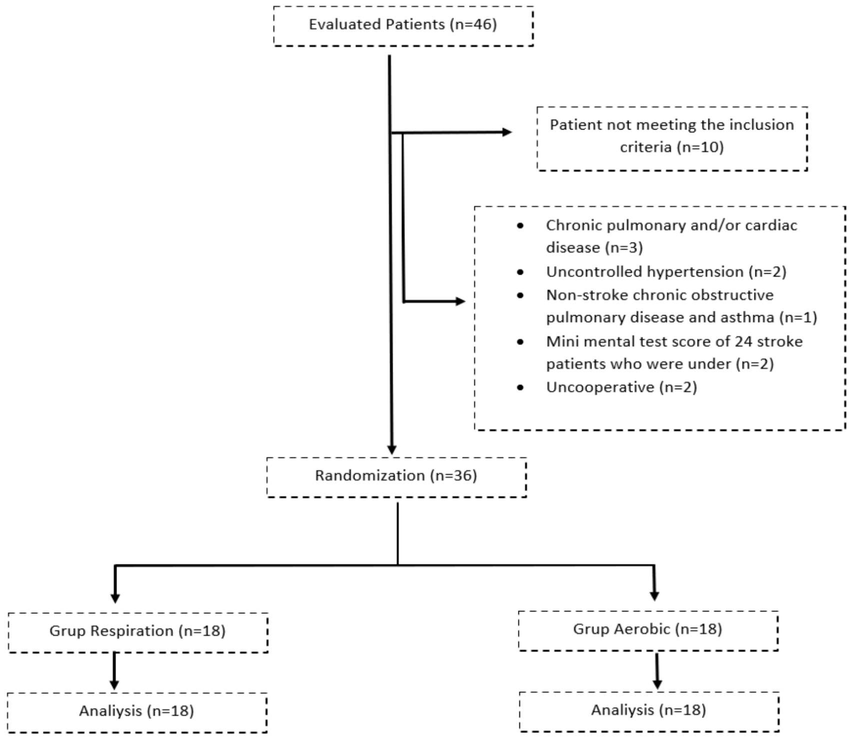

Figure 1. Flow chart

(10). In each session, the physiotherapist applied the 40-minute Todd-Davies approach to the participants. The patient was then directed to a quiet environment to perform the exercises for the respiratory group in which he was involved.

In addition to the Todd-Davies approach, diaphragmatic breathing and pursed lip breathing exercises were applied to group-respiratory cases at the end of the session. The patients were positioned in the supine position, with the knees semiflexed and head-shoulder supported by a pillow, with the hemiplegic hand at chest level and the intact hand in the abdominal region, and support was provided with a pillow for positioning when necessary (11). Breathing exercises consisted of diaphragmatic breathing for inspiration, pursed lip breathing for expiration, and spontaneous breathing, which we described as a silent breathing pattern. This cycle was applied to the patients for 3 sets of 6 min each, for 18 minutes (12). A maximum rest period of 5 min was allowed between each set (10). After the breathing exercise training, the patients showed the physiotherapist how to perform diaphragmatic and pursed lip breathing. The participant was questioned if he needed any question or repeated exercise demonstrations. Additional instructions were required during the exercise and he was asked to repeat the exercise (13).

In addition to the Todd-Davies approach to group-aerobic cases, arm ergometry was started at the end of the session. Aerobic training was performed on a motorized arm ergometer (Voit Dynamic® R-10 Exercise Bike). For exercise, the patients were seated in their own chair with the brakes off or on a fixed chair in such a way that the armrests did not hinder the patient. All participants started the exercise by turning the pedal forward. Each training session was created as a 15-minute forward and 15-minute reverse cycle. During the rest break, which lasted for a maximum of 5 min, between the two directions, the patient was asked to start turning in the opposite direction when he felt ready. Only verbal stimuli were given by the physiotherapist during the exercise (14). When necessary, the hemiplegic hand of the patient was properly fixed with a soft bandage.

Statistical Analysis

Sample size and power analysis were calculated with the program G*Power 3.1 (Franz Foul, Universitat Kiel, Germany). As in a similar study in the related literature, Joo et al. (9), the effect size was calculated as 0.848. To exceed the value of 95% in determining the power of the study; a total of 36 stroke patients in two groups, 18 in the aerobic exercise group and 18 in the respiratory exercise group, at a 5% significance level and an effect size of 0.848 were included in the study.

The data obtained in the study were analyzed using SPSS (Statistical Package for Social Sciences Inc, Chicago, IL, USA) for Windows 22.0 program. Number, percentage, mean and standard deviation were used as descriptive statistical methods in the evaluating of the data. The relationship between grouped variables was tested by chi-square analysis. The t-test was used to compare quantitative continuous data between two independent groups. Repeated measurements within the group were analyzed with the paired group t-test.

Ethics

Ethics committee approval: This study was approved by the İstanbul Medipol University, Non-Invasive Clinical Research Ethics Committee (decision no: 653, date: 14.11.2018). Written informed consent was obtained from the patient.

RESULTS

There was no statistically significant difference between the groups in the patients' age, height, weight, body mass index, mini mental test scores, and the groups showed a homogeneous distribution in terms of these parameters ($p>0.01$) (Table 1).

There was no difference between the groups in the upper extremity Brunsstrom Staging in the first test ($X2=6.804$; $p>0.01$) and in the post-test Brunsstrom Staging ($X2=5.222$; $p>0.01$).

In group-aerobics; the increase in the FEV1 post-test value compared to the FEV1 first test value was significant ($p<0.01$). In group-respiration; the increase in the FEV1 post-test value compared to the FEV1 first test value was not significant ($p>0.01$) (Table 2). FEV1 first test and FEV1 post-test values of the patients did not differ significantly according to the group variable ($p>0.01$) (Figure 2).

Intra-group evaluations of both groups showed significant increases in FVC post-test value compared to FVC first test value ($p<0.01$) (Table 3). According to the group variable, the FVC first and posttest values of the patients did not differ significantly ($p>0.01$) (Figure 2).

Group-aerobics; The decrease in the FEV1/FVC post-test value compared to the FEV1/FVC first test value was not significant ($p>0.01$). Group-respiratory; the increase in the FEV1/FVC post-test value compared to the FEV1/FVC initial test value was not significant ($p>0.01$) (Table 4). When the FEV1/FVC post-test scores of the patients were examined, the group-respiratory FEV1/FVC post-test value was found to be higher than the group-aerobic FEV1/FVC post-test value [$t(34)=-2.922$; $p<0.01$] (Figure 2).

Group-aerobics; compared to the first test value of chest circumference difference ($\bar{x}=0.639$), the increase in the post-test value of the chest circumference difference ($\bar{x}=1.417$) was found to be significant ($p<0.01$). Group-respiratory; compared to the first test value of chest circumference difference ($\bar{x}=0.528$), the increase in the chest circumference difference post-test value ($\bar{x}=0.822$) was significant ($p<0.01$)

Table 1. Differences in age, height, weight, BMI, mini mental test scores by groups

	Aerobic (n=18)		Respiratory (n=18)		t	SD	p
	Mean	SD	Mean	SD			
Age	1965.944	10.315	1969.444	15.050	-0.814	34	0.422
Height	1.682	0.071	1.682	0.063	0.025	34	0.980
Weight	79.667	10.992	78.111	9.055	0.463	34	0.646
BMI	28.230	4.238	27.625	2.852	0.503	34	0.618
MMT	25.500	1.098	25.222	1.478	0.640	34	0.526

Independent groups t-test, BMI: Body mass index, MMT: Mini mental test, SD: Standard deviation

Table 2. Differentiation of FEV1 measurement scores by groups

	Aerobic (n=18)		Respiratory (n=18)		t	SD	p
	Mean	SD	Mean	SD			
FEV1 first test	2.923*	0.809	3.342	1.046	-1.344	34	0.188
FEV1 final test	3.590*	0.853	3.548	0.863	0.148	34	0.883
t	-4.177		-1.463				
p	0.001		0.162				

*Dependent groups t-test, FEV1: 1 second of forced expiratory volume, SD: Standard deviation

Table 3. Differentiation of FVC measurement scores by groups

	Aerobic (n=18)	Respirotary (n=18)	t	SD	p
	Mean SD	Mean SD			
FVC first test	3.431*	0.909	4.015	1.309	-1.554
FVC final test	4.438*	1.116	4.043	1.191	1.025
t	-3.928	-0.123			
p	0.001	0.903			

*Dependent groups t-test, FVC: Challenging vital capacity, SD: Standard deviation

(Table 5). When the chest circumference difference between the groups was examined, there was no significant difference between them in the first measurement (p>0.01), but the group-aerobic measurement difference in the last measurement and the chest circumference difference of the group-respiratory measurement were higher than the last measurement [t(34)=4.049; p<0.01] (Figure 2).

DISCUSSION

In our study, which was conducted to examine the effects of breathing exercises and aerobic exercise applied for 6 weeks on spirometry test parameters and chest expansion, group respiration was found to be significant in FEV1/FVC value, while group aerobic results were found to be significant in chest circumference measurement.

Pulmonary function tests are one of the most common measurement methods used in clinics. It is used to evaluate how efficiently the patient's pulmonary functions function (15). We preferred spirometric evaluation over pulmonary function tests in our study because it is cheap, portable and home-type. FEV1 and FVC values are used to determine the decrease in ventilation capacity in people with cardiopulmonary ventilation disorders. These findings are generally preferred to assess prognosis and monitor progress, as they show less variability than other indices (16). In our study, main respiratory indices such as FEV1, FVC, and FEV1/FVC were examined to evaluate pulmonary function.

There are quantitative results regarding the effect of repetitive aerobic training with arm ergometry on spasticity (17).

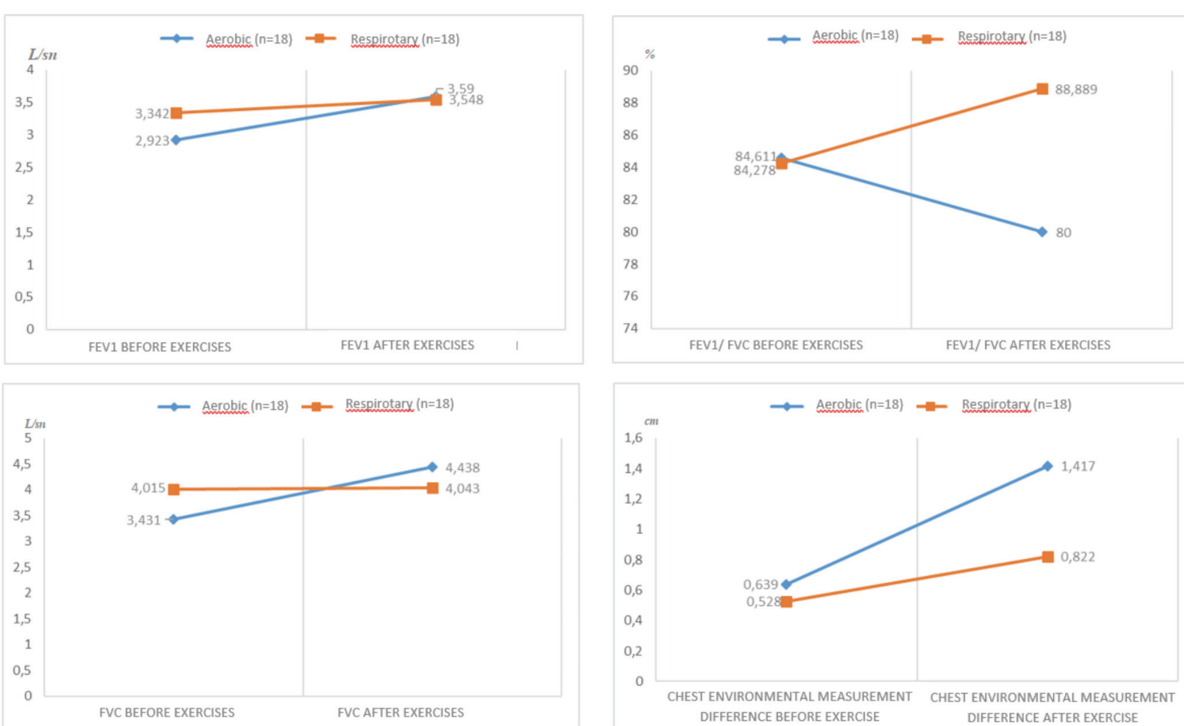

Figure 2. Differences in FEV1, FVC, FEV1/FVC, chest environmental measurement scores according to groups
FEV1: 1 second of forced expiratory volume, FVC: Challenging vital capacity, FEV1/FVC: Tiffeneau index

Table 4. Differentiation status of Tiffeneau index by groups

	Aerobic (n=18)		Respiratory (n=18)		t	SD	p
	Mean	SD	Mean	SD			
FEV1/FVC first test	84.611	10.308	84.278	13.190	0.084	34	0.933
FEV1/FVC final test	80.000*	10.053	88.889*	8.094	-2.922	34	0.006
t	1.766		-1.635				
p	0.095		0.120				

*Independent group t-test, FEV1: 1 second of forced expiratory volume, FVC: Forced vital capacity, FEV1/FVC: Tiffeneau index, SD: Standard deviation

Table 5. Differences in chest circumference measurements by groups

	Aerobic (n=18)		Respiratory (n=18)		t	SD	p
	Mean	SD	Mean	SD			
Chest circumference difference first test	0.639*	0.230	0.528*	0.118	1.821	34	0.080
Chest circumference difference final test	1.417*	0.493	0.822*	0.381	4.049	34	0.000
t	-7.714		-4.165				
p	0.000		0.001				

*Dependent and independent groups t-test, SD: Standard deviation

Aerobic exercise added to the neurodevelopmental approach increase the motivation of the patients to exercise, and the use of a bicycle ergometer as a repetitive activity may contribute to motor recovery. Bashir et al. (18) in their pilot study, they tested whether arm ergometry improves motor performance in stroke patients. Three patients received one-way cycling training on the arm ergometer for 20 min a day, 5 days a week, for 3 weeks. They stated that the grip strength of the lesioned hand increased after three weeks and that the arm ergometer was a useful device for motor training (18). In the data of our study, the difference between the first and last evaluations of aerobic exercise Brunnstrom upper extremity motor staging was not found significant. We think that the decrease in spasticity and the improvement of motor evaluation in aerobic exercise in a short period of 3 weeks may be due to the use of the arm ergometer in one direction throughout the exercise and the more repetition of the movement. In our study, the bicycle ergometer was applied forward for 15 min and backward for 15 min. Changing the direction of rotation during exercise may affect motor staging as it reduces the number of repetitions in the relevant muscle group. Longer unidirectional application of aerobic exercise may reduce spasticity in a shorter time and benefit motor evaluation. Further studies with more participants are needed to examine the effect of arm ergometer use on motor function in stroke patients.

In rehabilitation, verbal notification tone, use of imperative mood, emphasis and words used, or visual feedback may affect the measurement results. Kim et al. (19) divided 37 patients diagnosed with post-stroke hemiplegia into three groups. Among them, diaphragmatic training was given to the group, for 6 weeks, 5 days a week, 15 min, stimulating respiratory spirometry was applied with audible and visual back stimuli, and the changes in FEV1 were examined. Changes before and after exercise were found to be significant (19). In our study, the increase in the FEV1 post-test value was not found to be significant compared to the FEV1 first test value in group-respiratory cases. In our study, visual feedback was not given to the subjects in both groups during the exercises, only verbal feedback was used as an incentive. Visual feedback may be important for the FEV1 value in hemiplegic patients, and this notification may affect spirometry test results. It will be important to supplement exercise with visual feedback to improve respiratory test parameters. Feedback methods continue to be enriched with the development of technology, therefore, it is necessary to evaluate new methods and compare them with proven techniques and to increase the number of studies examining spirometry values, especially by using visual biofeedback in addition to audio feedback.

Also, Bang and Son (20) In another pilot study conducted, 12 stroke patients were included in aerobic exercise and traditional physical therapy training for 30 min a day, 5 days a week, for 4 weeks. At the end of four weeks, it was found that FEV1 and FVC parameters were positively affected (20). In our study, the increase in the post-test values compared to the first test values of FEV1 and FVC was found to be significant in group-aerobic cases. This significant increase indicates that aerobic exercise positively affects respiratory parameters.

To obtain effective results in rehabilitation, the continuity of treatment is as important as patient motivation. The literature recommends at least 6 weeks of application for continuity. Seo et al. (21) In their study, 30 stroke patients were randomly and equally included in the study as the experimental group and the control group. The combined diaphragmatic breathing and pursed lip exercise was applied to the experimental group 5 times a week for 4 weeks. Significant differences were observed in the measurement of FEV1/FVC. No significant differences were found in the FEV1 and FVC values (21). In our study, the increase in FEV1 and FEV1/FVC post-test values was not found significant compared to the first test value in group-respiratory cases. Additionally, the increase in FVC post-test values was found to be statistically significant. We think that 4-6 weeks of respiratory training is not enough time for FEV1 value, and at least 6 weeks of combined breathing exercises should be performed for FVC.

There is a consensus in the literature that respiratory exercise programs shorter than 6-8 weeks have little effect.

Epigastric measurements are important to evaluate the chest expansion in breathing exercises. Aygün Keşim (22) performed, in a study in which 30 stroke patients participated, there was no significant difference between the two groups in axillary and subcostal measurements, while the difference in epigastric measurement was found to be significant (22). In our study, the difference in chest circumference measurement was made epigastric, and the increase observed in the post-test value was found to be significant both within and between groups and supports the literature. Thanks to the increased chest expansion, patients can adapt to exercise more easily and for a longer period.

One of our study limitations is that we did not create a control group to apply the optimum treatment in the clinic. As expected, the results in the respiratory or aerobic exercise studies conducted with the control group in the literature are in favor of the intervention group. The strength of our study is that we report which of the respiratory and aerobic exercises are more effective. Additionally, although we could not perform it because our laboratory conditions were not suitable, the relationship between aerobic exercise and blood pressure values was investigated in the literature and it was reported that systolic blood pressure increased during exercise, while diastolic blood pressure remained constant. Furthermore, in chronotropic incompetence is an issue that needs to be investigated in the relationship between exercise and blood pressure.

CONCLUSION

In conclusion, the addition of additional breathing exercises to conventional stroke rehabilitation had a positive effect on FEV1 and chest circumference measurement in the short term. Additionally, the effect of breathing exercises on the mental fitness and coordination of the patients can be investigated. Such exercises can be preferred in clinics because they do not require equipment. Including aerobic exercises in the rehabilitation program has significantly benefited the measurement of FEV1, FVC, and chest circumference. For this reason, adding aerobic training to exercise facilitates treatment, increases compliance with exercise, and facilitates fatigue management.

*This study entitled "İnme Hastalarında Farklı Egzersiz Yaklaşımlarının Solunum Fonksiyon Testi Parametrelerine Etkisi" is being produced by one of the authors Cansu Keskin's master of thesis.

ETHICS

Ethics Committee Approval: This study was approved by the İstanbul Medipol University, Non-Invasive Clinical Research Ethics Committee (decision no: 653, date: 14.11.2018).

Informed Consent: Written informed consent was obtained from the patient.

Authorship Contributions

Surgical and Medical Practices: C.K., Concept: C.K., S.Ç., Design: C.K., S.Ç., Data Collection or Processing: C.K., Analysis or Interpretation: C.K., S.Ç., Literature Search: C.K., S.Ç., Writing: C.K., S.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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