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IMMEDIATE EFFECT OF MANUAL THERAPY ON RESPIRATORY FUNCTIONS AND RESPIRATORY MUSCLE STRENGTH IN STROKE PATIENTS

ORIGINAL ARTICLE

ABSTRACT

Purpose: Although the benefits of manual therapy (MT) are known, studies on its effect on stroke patients are limited. The aim of this study was to evaluate the immediate effects of MT on respiratory function and respiratory muscle strength in stroke patients.

Methods: A total of forty-seven patients, comprising 33 men and 14 women, were enrolled in the study and then randomly assigned to either the MT group (n=31) or the control group (n=16). All participants meet with initial pulmonary function and respiratory muscle testing and then rested supine for 10 minutes before the procedure. The respiratory tests were repeated immediately after the procedure. Tests included: maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC, and peak expiratory flow (PEF).

Results: In intra-group comparisons, a significant improvement was observed in all measured parameters in the MT group ($p<0.05$), while no significant change was observed in the control group except FEV1 and FEV1/FVC values ($p>0.05$). In comparisons between groups, a statistically significant difference was found in FEV1, FEV1/FVC, PEF and MEP values($p<0,05$)

Conclusions: This study demonstrated that manual therapy had a immediate positive effect on lung function and respiratory muscle strength in stroke patients.

Keywords: Manual Therapy, Pulmonary Function Test, Respiratory Muscles, Stroke

İNME HASTALARINDA MANUEL TERAPİNİN SOLUNUM FONKSİYONLARI VE SOLUNUM KAS KUVVETİ ÜZERİNDEKİ ANLIK ETKİSİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Manuel terapinin (MT) faydaları bilinmesine rağmen inme hastalarında etkisi ile ilgili çalışmalar sınırlıdır. Bu çalışmanın amacı, inme hastalarında MT'nin solunum fonksiyonu ve solunum kas kuvveti üzerindeki ani etkilerini araştırmaktır.

Yöntem: Çalışmaya kırk yedi hasta (33 erkek, 14 kadın) dahil edildi ve katılımcılar randomize olarak MT grubuna (n = 31) ve kontrol grubuna (n = 16) ayrıldı. Tüm katılımcıların, başlangıçta solunum fonksiyonu ve solunum kas testi değerlendirildi ve ardından girişim öncesi 10 dakika boyunca sırtüstü dinlendiler. Girişimden hemen sonra solunum testleri tekrarlandı. Testler şunları içeriyordu: maksimum inspiratuar basınç (MIP) ve maksimum ekspiratuar basınç (MEP), zorlu vital kapasite (FVC), 1. saniyedeki zorlu ekspiratuar hacim (FEV1), FEV1/FVC ve tepe ekspiratuar akış (PEF).

Sonuçlar: Grup içi karşılaştırmalarda MT grubunda ölçülen tüm parametrelerde anlamlı iyileşme gözlenirken ($p<0,05$), kontrol grubunda ise FEV1 ve FEV1/FVC değerleri dışında anlamlı değişiklik görülmedi($p>0,05$). Gruplar arası karşılaştırmalarda FEV1, FEV1/FVC, PEF ve MEP değerlerinde istatistiksel olarak anlamlı fark bulundu($p<0,05$).

Tartışma: Bu çalışma, manuel tedavinin inmeli hastalarda solunum fonksiyonu ve solunum kas kuvveti üzerinde anlık olumlu etkisi olduğunu göstermektedir.

Anahtar Kelimeler: Manuel Terapi, Solunum Fonksiyon Testi, Solunum Kasları, İnme

INTRODUCTION

A stroke refers to a persistent neurological impairment that endures beyond 24 hours and stems from either an infarction or hemorrhage affecting a substantial area of the brain (1). The neurological impairment doesn't just impact motor or sensory functions; it also extends to the respiratory system. This leads to alterations in breathing patterns, decreased respiratory volume and airflow, and weakness in the respiratory muscles (2).

In hemiplegia, which is one of the classic symptoms of stroke, patients' pulmonary functions decrease due to the decreased expansion of the chest on the hemiplegic side and the insufficiency of the respiratory muscles. In addition, the ankylosis and limited use of muscles cause oxygen deficiency, and the increased oxygen demand is not met (3). In addition, paralysis of the diaphragm and respiratory muscles after stroke results in decreased thoracic expansion and a restrictive breathing pattern. If this condition persists, it can lead to muscle fibrosis. As a result, chest expansion decreases during breathing (4). The limited movement in the thoracic spine shows a connection to reduced forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). When the chest wall becomes stiffer, it hampers the mechanics of ventilation. To enhance pulmonary function, it's suggested to alleviate stiffness by enhancing chest wall mobility (5).

Traditional stroke rehabilitation primarily targets the motor control deficits in patients(6). Yet, it's crucial to acknowledge that neurological issues often underlie various respiratory problems, and respiratory failure might arise as a consequence of neurological conditions or symptoms (7). Hence, apart from standard treatments, specific approaches are necessary to enhance respiratory function and bolster respiratory muscle strength in stroke patients (8).

Manual therapy (MT) encompass evidence-supported hand movements and maneuvers utilized to alleviate pain, enhance tissue flexibility, widen range of motion, and induce relaxation, commonly applied in clinical settings (9). These techniques are believed to positively impact chest wall mobility and respiratory functions by expanding joint motion (10). While most studies investigating chest manipulation techniques focused on individuals with respiratory conditions (11), Noll et al. observed that a single session of osteopathic manual therapy effectively enhanced both static and dynamic pulmonary function in elderly chronic obstructive pulmonary disease (COPD) patients (12). Similarly, another study involving COPD patients reported improvements in dynamic lung function parameters (13).

Although there is a preliminary study in the literature in which a single spinal manipulation was performed in hemiplegic patients (14), no study has been found in which an MT protocol including various manual therapy techniques such as myofascial release and mobilizations was applied in hemiplegic patients and its effects on respiration were investigated. Therefore, the aim of this study is to examine the immediate effects of thoracic manual therapy in hemiplegics on respiratory function.

METHODS

Study Design

A prospective, single blind randomized controlled trial was conducted, registered under clinicaltrials.gov number: NCT04503499. Ethical clearance was granted by the Research Ethics Committee for Science, Social, and Non-Interventional Health Sciences of Istanbul Okan University (Meeting date: 04.07.2018 and Decision Number: 96), aligning with the principles outlined in the Declaration of Helsinki and Good Clinical Practice Guidelines. The study spanned from September 2019 to August 2020, during which participants provided informed consent before random allocation into two groups.

Participants

Eighty patients with chronic stroke were invited from the Rehabilitation and Disability Center of Bayrampasa Municipality. Sixty eight patients who met the inclusion criteria were included in the study. The inclusion criteria were: Stroke at least 6 months ago, age between 18 and 60 years, a score of > 24 in the Mini-Mental Test, lower extremity score of 4-6 in the Brunnstrom stage, no cognitive impairment, willingness and voluntariness to work. Exclusion criteria were various vestibular and orthopedic problems, visual or hearing impairment, known cardiopulmonary disease, transient ischemic

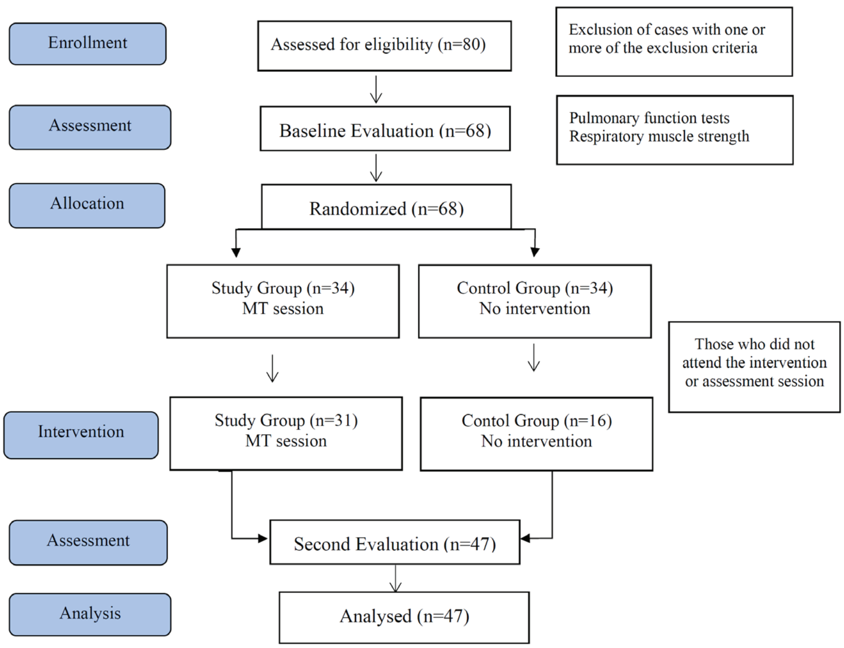

Figure 1. CONSORT Flow Diagram of Study

attack or multiple strokes, no independent balance in sitting and standing, and chronic disease.

Sixty eight participants were randomly divided via the e-picos website (1:1 allocation) into 2 groups, a MT group (n=34) and a control group (n=34). (Fig. 1). 3 participants included in the MT group and 18 participants included in the control group did not come on the day of the study. For this reason, the MT group was completed with 31 patients and the control group with 16 patients.

Outcome measures

All measurements were taken before and after a single session of the MT application. All patients were rested before the start of the study to avoid fatigue. After the MT application, a 2-minute rest was taken before the measurement was performed again. Measurements and MT application were made by two different researchers who were blind to each other.

Pulmonary Function Tests

Spirometry tests were conducted using a portable spirometry device (Spirobank MIR, Italy) in adherence to the criteria outlined by the American Thoracic Society and European Respiratory Society. All patients were seated and wore nose clips during the procedures. The test was repeated three times, a recognized and reliable method for ensuring consistent effort. Baseline measurements for forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, and peak expiratory flow (PEF) were recorded for the study (15,16).

Respiratory muscle strength

Respiratory muscle strength was assessed using a portable electronic oral pressure monitor (Micro Medical MicroMPM, UK). This device measures two key indicators, maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP), which evaluate overall strength in inhaling and exhaling muscles by recording the highest mouth pressures (17). For MIP measurement, the airway is sealed after maximal exhalation, and the individual is instructed to execute and sustain a maximal inhalation. Conversely, MEP is measured with the airway sealed after maximal inhalation, prompting the subject to exhale maximally against the closed airway. To ensure accuracy, three trials were conducted, and the best result was selected. Patients were directed to take deep breaths, use a nose clip, and seal their lips firmly around the mouthpiece. Throughout the test, they were prompted to inhale maximally for MIP and exhale maximally for MEP, with a one-minute rest interval between each trial (17).

MT protocol

The MT group received a consistent 45-minute MT session conducted by the same physical therapist. The protocol encompassed various sequential techniques, including suboccipital decompression, cervical joint sliding (anterior/posterior), relaxation of sternocleidomastoid and trapezius myofascial, sternoclavicular joint sliding (anterior/posterior), intercostal and paravertebral myofascial relaxation, diaphragmatic relaxation, ribs lifting, scapulothoracic joint mobilization, and thoracic vertebral joint sliding (anterior/posterior) (12,13). Each myofascial release technique was applied for approximately 3-5 minutes. The gliding approach was repeated five times for each joint, with each repetition lasting 30 seconds (Appendix 1).

Participants in the control group were positioned in the same position as the MT group and rested for 45 minutes without any intervention.

Statistical analysis

Statistical analyses were conducted using SPSS 22.0 (SPSS Inc, USA). The Kolmogorov-Smirnov/Shapiro-Wilk test confirmed the normal distribution of continuous variables. Descriptive statistics utilized mean ± standard deviation for continuous variables and patient count with percentage (%) for categorical variables. The chi-square test compared nominal variables between the MT and control groups, while Student's T-test assessed differences between groups. Within-group comparisons were performed using paired-sample T-tests. Statistical significance was set at $P<0.05$. Repeated-measures analysis of covariance (ANCOVA), with baseline as a covariate, evaluated the interaction effect between group and time. Cohen's d test determined effect sizes between groups: ≤0.50 indicated a low effect, 0.51–0.8 a medium effect, and ≥0.81 a large effect, characterizing differences in treatments (18).

Sample size

A two-way hypothesis was established and it was found that a total of 62 cases, 31 participants in each group, should be included in order to obtain an effect size of 0.7 (medium-large effect size) with $\alpha=0.05$ and 80% power. Considering drop out, 80 stroke patients were invited to the study. Of the invited participants, 68 met the inclusion criteria. 68 patients were divided into 2 groups as control (n=34) and study (n=34) and appointments were made for measurement and MT application sessions. 18 participants in the control group and 3 participants in the MT group did not show up for the measurement and MT application session on the day they were invited. Necessary measurement and MT application of the patients who attended the sessions were completed. Before the completion of the drop outs, a power check of the study was made. When the power calculation of the post-hypothesis study was made based on the MIP value, the mean difference before and after the participants in the control group was -1.31±8.83, and the mean difference before and after the participants in the MT group was 8.39±9.1, and when

Table 1. The Demographic and Clinical Features of the Participants

Characteristics	MT Group (n=31)	Control Group (n=16)	p
Age (years)	59.10±7.54a	59.87±11.07	0.777
Body Mass Index (kg/m^2)	28.67±2.87	26.52±2.63	**0.016***
Time since stroke (months)	53.00±44.69	65.62±49.59	0.381
Gender			
Male	23 (75.2%) [b]	10 (62.5%)	0.406
Female	8 (25.8%)	6 (37.5%)	
Stroke type			
Hemorrhagic	2 (6.5%)	1 (6.2%)	0.979
Ischemic	29 (93.5%)	15 (93.8%)	
Side affected			
Right	13 (42%)	12 (75%)	**0.031***
Left	18 (58%)	4 (25%)	

Chi-square test. Student T test. *. $p<0.05$; Data are mean ± standard deviation[a] and n (%)[b]; Statistically significant values are given in bold.

α=0.05, the power was calculated as 94.2%. For this reason, although the drop out rate was high, participant recruitment was not continued.

RESULTS

The study comprised 47 participants, with 31 in the MT group and 16 in the control group, all stroke patients. In the MT group, participants had a mean age of 59.10±7.54, while in the control group, it was 59.87±11.07. The disease duration for MT group participants was 53.00±44.69 months and 65.62±49.59 months for those in the control group. Both study and control groups exhibited similarities in age, sex, disease duration, and stroke type (p>0.05). However, differences were noted in BMI and affected side between the groups (p<0.05, Table 1). Before to the measurement and MT application, there were no significant differences in measured values between the study and control groups (p > 0.05, Table 2). In intra-group comparisons, a significant improvement was observed in all measured parameters in the MT group (p<0.05), while no significant change was observed in the control group except FEV1, FEV1% pred, FEV1/FVC

Table 2. Comparison of All Measurements Taken Before Treatment Between the Groups

Variables	MT Group (n=31) Mean ± SD	Control Group (n=16) Mean ± SD	p
FEV_1	2.08±0.64	2.12±0.88	0.632
FEV_1, % pred	70.64±18.95	77.81±26.33	0.289
FVC	2.81±0.84	2.68±1.005	0.62
FVC, % pred	79.35±16.82	79.00±23.05	0.952
FEV_1/FVC	71.58±15.006	78.87±12.39	0.102
FEV_1/FVC, % pred	92.90±18.95	102.75±16.30	0.084
PEF	2.87±1.37	3.28±1.68	0.382
PEF, % pred	38.54±17.63	45.00±20.69	0.269
MIP, cmH_2O	61.61±23.28	60.18±38.47	0.257
MEP, cmH_2O	76.03±30.91	80.12±23.83	0.646

Abbreviations: FEV1. forced expiratory volume in 1 s; FVC. forced vital capacity; PEF. forced expiratory flow; % pred. % predicted; MIP. Maximal Inspiratory Pressure; MEP. Maximal Exspiratory Pressure; *. p<0.05; **. p<0.001. Statistically significant values are given in bold.

Table 3. Comparison of Pulmonary function and Respiratory Muscle Strenght Between the Groups

	MT Group (n=31)		Within Group p	Control Group (n=16)		Within Group p	Treatment affect p	Cohen's d
	Pre Mean ± SD	Post Mean ± SD		Pre Mean ± SD	Post Mean ± SD			
FEV_1	2.01±0.64	2.27± 0.69	**<0.001****	2.12±0.88	1.91± 0.83	**0.004****	**<0.001****	0.353
FEV_1, % pred	70.64±18.95	79.64± 17.66	**<0.001****	77.81±26.33	70.25± 21.73	**0.003****	**<0.001****	0.371
FVC	2.81±0.84	2.96± 0.85	**0.010***	2.68±1.005	2.73± 1.14	0.491	0.379	0.017
FVC, % pred	79.35±16.82	83.38± 16.78	**0.008***	79.00±23.05	80.43± 25.59	0.535	0.317	0.022
FEV_1/FVC	71.58±15.006	76.64 ±10.16	**0.007***	78.87±12.39	71.18± 14.76	**0.014***	**<0.001****	0.269
FEV_1/FVC, % pred	92.90±18.95	99.48±12.74	**0.006***	102.75±16.30	92.68±19.06	**0.013***	**<0.001****	0.274
PEF	2.87±1.37	3.71±1.66	**0.001****	3.28±1.68	3.04±1.84	0.329	**0.004***	0.168
PEF, % pred	38.54±17.63	49.19±19.40	**0.001****	45.00±20.69	41.50±21.8	0.253	**0.002***	0.19
MIP, cmH_2O	61.61±23.28	70.00± 24.84	**<0.001****	60.18±38.47	58.87±39.03	0.534	0.716	0.003
MEP, cmH_2O	76.03±30.91	84.48±29.29	**<0.001****	80.12±23.83	79.68±27.50	0.874	**0.012***	0.132

Abbreviations: FEV1. forced expiratory volume in 1 s; FVC. forced vital capacity; PEF. peak expiratory flow; % pred. % predicted; MIP. Maximal Inspiratory Pressure; MEP. Maximal Expiratory Pressure. *. p<0.05; **. p<0.001. Statistically significant values are given in bold.

and FEV1/FVC, % pred values ($p>0.05$). Following the measurement and MT application, changes in FEV1, FEV1% pred, FEV1/FVC, FEV1/FVC% pred, PEF, PEF%, and MEP (cmH2O) values significantly varied between the MT and control groups ($p<0.05$, Table 3). Nonetheless, there were no significant differences observed in FVC, FVC% pred, and MIP (cmH2O) values between the groups ($p>0.05$, Table 3).

DISCUSSION

This study highlighted the immediate effects of lung function and respiratory muscle strength in chronic stroke patients following a single MT session.

A prior study investigating the immediate impact of MT on lung function in stroke patients noted increased lung function scores among those using MT, but without significant improvement. Notably, patients utilizing the MT technique showed significant differences favoring FVC and FEV1 compared to the control group (14). Yelvar et al. similarly observed immediate improvements in lung function and inspiratory muscle strength among COPD patients after a single MT session (13). However, in another study focusing on short-term effects, the application of a soft-tissue-based MT form did not lead to immediate improvements in respiratory function (19).

Noll et al. showcased the effectiveness of single-session osteopathic MT in enhancing lung function among elderly COPD patients (12). Similarly, in our study, there was a statistically significant difference in lung function parameters between baseline and post-treatment. MT techniques are known to positively impact the autonomic nervous system, with diaphragm relaxation activating the parasympathetic system and sympathetic mobilization inhibiting its activation. This regulation leads to improved lung function, increased oxygen saturation, and lowered heart and respiratory rates (20,21). As a result of our study, the reason for the significant improvement in values such as FEV1, FEV1/FVC, PEF and MEP in the study group compared to the control group is due to the relationship between this parasympathetic activity and MT. Because increased parasympathetic activity may have increased expiratory flows by reducing obstruction. A low FVC value indicates a restrictive type pattern and it is known that stroke patients have a restrictive type pattern (22,23). Since a single MT application may not have changed the breathing pattern resulting from the nature of the disease, there may have been no change in FVC and MIP values between the study and control groups as a result of the study. Our results emphasize MT's immediate impact on respiratory muscle strength in chronic stroke patients. Post-stroke complications can affect breathing by impacting the diaphragm and causing trunk postural deviations. Moreover, biomechanical changes within the respiratory system involving various muscles, chest, and abdomen may contribute to declining lung function (24).

This study's strengths lie in its randomized controlled design, ensuring similarity and homogeneity between the study and control groups. Data collectors remained blinded throughout, enhancing objectivity. Notably, our research is among the first to directly explore manual therapy's impact on pulmonary function in stroke patients. However, interpreting the results warrants consideration of limitations. Despite the significant results before and after treatment, the fact that no treatment was applied to the control group remains a limitation. Additionally, unequal participant numbers between the MT and control groups pose another limitation. Investigating only the immediate effects of MT is also a constraint; long-term effects merit further exploration. Although our sample size aligns with power analysis, larger studies may validate our findings. This study sets a groundwork for more comprehensive research endeavors.

In summary, this single-blind, randomized controlled trial demonstrated improvements in immediate increased respiratory muscle strength, and improvement in respiratory function in stroke patients undergoing MT compared with the control group. For this reason, MT can be applied together with conventional treatment to improve respiratory functions in stroke patients. The long-term effect of the application should be investigated in future studies on stroke rehabilitation.

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Conflict of Interest: The authors declared no potential conflicts of interest related to the research, authorship, and publication of this article.

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