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The Effects of Manual Therapy and Inspiratory Muscle Training on Respiratory Parameters in Young Adults with Postural Problems: A Randomized Trial

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Abstract

Objective: It was aimed to compare the effects of manual therapy (MT) and Inspiratory Muscle Training (IMT) on respiratory functions and postural problems of young adults in this study.

Material-Method: Thirty-five volunteers were randomly allocated into IMT and MT groups. All participants received twenty minutes of IMT twice a week for four weeks. Eight sessions of manual therapy were applied to the MT group in addition to IMT. Forced Expiratory Volume in 1 Second (FEV1), Forced Vital Capacity (FVC), FEV1/FVC ratio, Peak Expiratory Flow (PEF), forward head posture (FHP), and thoracic hyperkyphosis were evaluated before and after the treatments.

Results: Although there were significant improvements in the FEV1, FVC, FEV1/FVC ratio, and PEF scores of the MT group ($p<0.05$), no significant difference was found in the IMT group at the post-treatment ($p>0.05$). The comparisons of post-treatment scores of the FEV1, FVC, FEV1/FVC ratio, and PEF between the groups revealed greater improvements in the MT group than IMT group ($p<0.05$). Significant changes were demonstrated in postural problems in the two groups ($p<0.05$). However, no significant differences were analyzed between the group in the comparison of the post-treatment postural changes ($p>0.05$).

Conclusion: We observed in our study that IMT and MT might be effective in correcting FHP and thoracic hyperkyphosis in young adults. It was recommended to add MT to IMT for the young adults with thoracic hyperkyphosis and FHP, due to greater improvements shown in the respiratory functions in our study.

Keywords: Inspiration, Kyphosis, Manual Therapy, Posture, Respiratory Muscles

INTRODUCTION

Young adults are prone to have postural problems such as thoracic hyperkyphosis and forward head posture (FHP) due to prolonged static postures in computers and mobile phones. The prolonged anterior shifting with the FHP may lead the thoracic hyperkyphosis, stiffness in the thorax, and flattening in the diaphragm.[1] Thoracic hyperkyphosis, defined as a thoracic curvature higher than normal ranges, is among the reasons that decrease the mobility of the thorax and the respiratory functions.[2] Previous studies claimed that the increase in thoracic kyphosis and the decrease in the mobility of the thoracic spine are associated with the decrease in respiratory functions such as Forced Expiratory Volume in 1 Second (FEV1) and Forced Vital Capacity (FVC).[2] FHP is suggested to cause impaired respiratory functions due to biomechanical effects on accessory inspiratory muscles such as the scalene muscles, and the sternocleidomastoid muscles.[1] Previous researchers showed that FVC, FEV1, and accessory inspiratory muscle strength were lower in the individuals with FHP, in comparison with the non-FHP individuals.[3] Manual therapy (MT) consisting of different techniques (manipulation, joint mobilization, and soft tissue mobilization) applied to the cervical and thoracic spine have been shown to lead to a significant reduction in thoracic hyperkyphosis and FHP.[4,5] Previous studies revealed that MT includes spinal manipulative therapy, manual diaphragm release, and rib cage mobilization can be an effective approach to improve respiratory function by increasing the mobility of the thoracic region and diaphragm.[6] Previous researchers have shown beneficial effects of spinal thoracic manipulations on the FEV1, FVC, and Peak Expiratory Flow (PEF) in people with thoracic hyperkyphosis, chronic neck pain, stroke, and chronic obstructive pulmonary disease (COPD).[6-8] The underlying mechanism of the increase of respiratory functions after the MT was claimed as an increase in joint mobility, increase of the inspiratory muscle length, and decrease of muscle tone and pain.[6,8,9] The effectiveness manual diaphragmatic release technique in patients with COPD also has been suggested in previous studies.[10,11]

Inspiratory Muscle Training (IMT) consists of resisted breathing exercises to improve the strength of respiratory muscles and aerobic capacity of healthy adults and patients. IMT is a technique aimed to improve the strength and endurance of the inspiratory muscles with a pressure threshold device.[12,13] Recent research demonstrated that the treatment program that combined the MT and IMT further increases thoracic mobility, inspiratory muscle activity, and respiratory functions in smokers, healthy adults, and individuals with chronic obstructive pulmonary disease (COPD), asthma, and stroke.[14-17] Several researchers revealed that respiratory exercises might have beneficial effects on FHP and thoracic hyperkyphosis. It was stated that the addition of MT and therapeutic exercise protocol to IMT in healthy and asthmatic individuals was more effective than IMT in improving FHP and thoracic hyperkyphosis.[14] In a previous study was suggested that the mechanism of improvements in the FHP with respiratory exercises was associated with the reduction of the activity of upper trapezius, sternocleidomastoid, scalene, and cervical erector spinae muscles.[18] However, the research about the effects of IMT and MT on respiratory functions and postural problems is limited in the literature. In this regard, the aim of our study was to evaluate the effects of MT and IMT on the FEV1, FVC, tiffeneau index (FEV1 / FVC), PEF, FHP, and thoracic hyperkyphosis in young adults.

MATERIAL AND METHODS

Thirty-five university students, between the ages of 18-24 years old, non-smoking, with thoracic hyperkyphosis and FHP, and with low physical activity levels according to International Physical Activity Questionnaire-Short Form (IPAQ)[19] participated in this study. Individuals with moderate or high levels of physical activity, history of traumatic deformity in the thoracic spine, scoliosis of 20° and above, cervical trauma, cervical spine surgery, asthma, cancer history, heart disease, diabetes, hypertension, systemic disorders, smoking history and used oral corticosteroids or antibiotics within one month were excluded from the study. Ethics committee approval was obtained and all participants gave informed consent (Ethic File Number: 69396709-300).

The participants were randomly allocated to IMT (n=16) and MT groups (MT: n=19) by the coin toss. All the interventions were applied twice a week for four weeks and at least two days between sessions. All the measurements were performed pre-intervention and at the end of the four-week of interventions. All measurements and applications in the study were carried out by the same physiotherapist MicroQuark (COSMED, Albano Laziale, Italy) USB spirometer was used for the measurements of respiratory functions. The measurements were performed by the 2019 updated spirometer measurement standardizations of the American Thoracic Society (ATS) and European Respiratory Society (ERS)[20]. After three tests performed by the standards, FEV1 and FVC were determined and recorded by the test device with the highest total, as suggested by ATS. FEV1, FVC, FEV1/FVC ratio, and PEF scores were recorded.

Thoracic hyperkyphosis was determined by Occiput Wall Distance (OWD) measurement. Participants were asked to touch their occiput against the wall with their back and heels resting and touch the wall and head facing forward. The presence of thoracic hyperkyphosis was considered positive if the wall could not be touched with the occiput. During the measurement, two rulers were used. The first ruler was placed parallel to the floor on the occiput, and the second ruler was placed between the first ruler and the wall to measure the vertical distance. Since there were studies that it would be more accurate to use C7 in measurement. The perpendicular distance from the C7 spinous process to the wall was also measured in the same position in this study.[21] Both measurements were repeated three times in a row with a short rest period and the mean values were recorded.

FHP was evaluated with a Cervical Range of Motion (CROM) device. The CROM device is a reliable method for the measurement of FHP.[22] The participants were asked to sit upright on the chair and not to move their heads. The head forward arm was attached to the CROM mainframe and the lower end of the control arm (vertebra locator) was held by the investigator on the C7 spinous process. The vertebra locator was placed at a 90° angle with the forward arm of the CROM with the help of a bubble indicating that the instrument was straight. The distance between the participant's bridge of nose and C7 was recorded in centimeters. This measurement was repeated three times in total and mean values were calculated. The mean values greater than 17 centimeters are considered as the presence of FHP.[22]

Intervention Protocols

Inspiratory muscle training (IMT)

The participants in the IMT group (n=16) only performed IMT. For all intervention groups, IMT was performed with Powerbreathe Classic-Light Resistance (Powerbreathe, IMT Technologies Ltd., Birmingham, UK) device. To determine the intensity of the training, MIP values were measured with the help of the respiratory pressure meter-RP Check (MD Diagnostics Ltd. RP Check MIP & MEP) device before each training. The pressure corresponding to 50% of the initial MIP value in the Powerbreathe (IMT Technologies Ltd., Birmingham) device was determined as intensity. IMT was applied for 20 minutes, two days of each week, for four weeks. During each IMT session, the participants were asked to maintain diaphragmatic breathing. Each IMT session included five breaths and five sets with 30 seconds between each set. IMT program has previously been used by several studies to improve respiratory muscle strength.[14,17]

Manual therapy (MT)

In addition to IMT, a total of eight sessions of MT (manipulation, joint mobilization, and soft tissue mobilization) approaches, two days a week for four weeks and at least two days between sessions; were applied by an experienced physiotherapist to the participants in the MT group. MT approaches included manual diaphragm release, thoracic mobilization, and thoracic high-velocity low amplitude (HVLA) thrust manipulation and cervical mobilization.

The participants were in a supine position, while the physiotherapist was standing behind the person, in contact (pisiform, hypothenar region, and the last three fingers) with the lower part of the seventh and tenth costal cartilages during the manual diaphragm release. Throughout the breathing, the physiotherapist raised his hand slowly to accompany the rising movement of the ribs and deepened the contact during expiration. The maneuver was carried out in two sets of 10 deep breaths. During the thoracic mobilization, the participants were asked to cross their arms in front of the chest while sitting. The physiotherapist stood behind the participant, wrapped the crossed arms of the participant with his left arm, and performed stretching, extension, lateral flexion, and thoracic rotation with his right hand. For the thoracic HVLA thrust manipulation, the participants were asked to cross their arms in front of the chest, with their hands on the opposite shoulder, in the supine position. The physiotherapist first grasped the participant's neck and shoulders with his supporting hand and placed his upper chest on the subject's elbows. The physiotherapist positioned his other hand on the transverse processes of the lower vertebrae of the localized hypomobile vertebrae. Then, the physiotherapist placed his supporter hand on the subject's elbows and applied HVLA thrust in the posterior-anterior and inferior-superior directions with the help of her body. For the cervical mobilization; the physiotherapist wrapped the right arm around the participant's face around the back of the neck and placed it on the localized hypomobile vertebrae. The physiotherapist positioned her supporting hand's index finger and thumb on the lower vertebrae of localized hypomobile vertebrae. Mobilization was performed using the right hand in the directions of flexion, extension, right-left rotation, and lateral flexion.

Statistical analysis

Priori power analysis was performed using the G-Power 3.1 program, and the sample size was calculated as 42, with a large effect size (0.8), a significance level of 0.05, and a power of 0.80. Due to the COVID-19 pandemic, the study was completed with 35 subjects. According to posthoc power analysis for the 34 sample size, with a large effect size (0.8) and significance level of 0.05 the statical power of this study was 0.74.

The statistical analyses were carried out using IBM SPSS Statistics software, version 20 (SPSS, Chicago, IL, USA). The normal distribution of the data was obtained from the Shapiro-Wilk test in the study. Mean, standard deviation, and percentage were calculated in the measurement data. The comparison of outcome measurements between pre-treatment and post-treatment within the groups was examined by Student's paired t-test. The post-treatment changes were measured with an independent sample t-test. Pearson correlation analysis was used to examine the relationship between the pre-treatment values and post-treatment values of OWD and C7-Wall distance measurements. The level of significance was set as $p<0.05$.

RESULTS

Thirty-five university students (20.94±1.55 years; 17 female and 18 male) were recruited in this study (Table 1).No statistically significant differences were analyzed between the pre and post-treatment FEV1, FVC, FEV1 / FVC, and PEF of the participants in the IMT group (p>0.05). A statistically significant improvement was found in the FEV1, FVC, and PEF of the participants of the MT group in comparison between the pre and post-treatment (p<0.05). However, no statistical change was found in the comparison of FEV1/FVC measurements before and after the intervention in the MT group (p> 0.05). We found a significant improvement in the comparison of the pre and post-treatment values of FHP measurements and OWD and C7-wall distance measurements in both intervention groups (p<0.05; Table 2).

Participants who received MT had greater improvement in the FEV1, FVC, and PEF (p<0.05). However, no statistically significant difference was found in the comparison of the changes in FEV1/FVC, FHP, OWD, and C7-wall distance measurements between the groups (p>0.05; Table 2).

Table 1. Demographic characteristics of participants

		IMT n (%)	MT n (%)	
Gender	**Female**	8 (50)	9 (47.4)	
	Male	8 (50)	10 (52.6)	
		Mean (SD)	**Mean (SD)**	**p***
Age (years)		20.5 (1.41)	21.32 (1.6)	0.543
Height (cm)		171.25 (8.53)	169.73 (1.6)	0.347
Weight (kg)		67.37 (11.55)	70.36 (14.47)	0.308
BMI (kg/m^2)		22.88 (2.91)	24.26 (3.50)	0.295

BMI: Body Mass Index; IMT: Inspiratory Muscle Training; MT: Manual Therapy; SD: Standart Deviation; *Independent sample t test p<0.05.

Table 2. Post-training outcome measures and changes between post and pre-intervention scores

	IMT			MT			Between the groups
	Baseline Mean (SD)	**Change Mean (SD)**	**p***	**Baseline Mean (SD)**	**Change Mean (SD)**	**p***	**Δ p****
FVC	4.25 (0.77)	0.06 (0.71)	0.726	3.9 (0.68)	0.63 (0.94)	0.009	0.020**
FEV1/FVC	86.76 (4.4)	0.03 (5.39)	0.982	85.53 (5.02)	1.85 (5.87)	0.185	0.332
PEF	7.26 (1.57)	0.38 (2.26)	0.512	6.55 (1.41)	2.13 (1.56)	0.001	0.014**
FHP	18.63 (1.42)	0.87 (1.51)	0.003	18.16 (1.36)	0.84 (1.48)	0.001	0.81
OWD (C7)	7.41 (1.8)	2.00 (1.86)	0.001	7.32 (1.38)	2.93 (1.29)	0.001	0.094
OWD (C0)-Wall	5.92 (2.52)	2.88 (2.30)	0.000	5.76 (1.33)	3.47 (1.77)	0.001	0.398

FEV1: Forced expiratory volume in the first second; FVC: Forced Vital Capacity; PEF: Peal Expiratory Flow; FHP: Forward Head Posture; IMT: Inspiratory Muscle Training; MT: Manual Therapy; OWD: Occiput Wall Distance; SD: Standard Deviation; *Paired Sample t test; ** Independent Sample T test p<0.05.

DISCUSSION

FEV1, FVC, and PEF are suggested as gold measurements for the decision of obstructive pulmonary diseases such as COPD and asthma.[23,24] Previous studies revealed that FEV1 and FVC are decreased in individuals with thoracic hyperkyphosis and FHP due to biomechanical effects on inspiratory muscles.[1-3] MT applied to the diaphragm, cervical and thoracic region have been shown to increase respiratory functions.[6] In our study, an increase was observed in the FEV1, FVC, and PEF at the end of the MT intervention. However non-significant increase was found in the comparison of the FEV1/FVC ratio before and after the intervention in the MT group. In contrast, Wall et al. stated a single session of MT applied to the thoracic spine and thorax is not effective to improve the FEV1, FVC, and FEV1/FVC ratio in healthy adults.[25] However, previous studies showed improvements after the MT among the patients.[6,8,9] In a recent review, Roh et al. revealed that MT might be beneficial to decrease the FEV1 and FVC; and increasing FEV1/FVC[6]. Park and Chon found that thoracic mobilization might be effective to improve FVC and PEF in patients with chronic low back pain[9]. Joo et al. suggested that a single thoracic spinal manipulation might increase the FVC and FEV1 of individuals with stroke[8]. In our study, it was suggested that the administration of long-term (two days a week for four weeks) MT to healthy non-smokers might be caused a significant change in FEV1, FVC, and PEF.

The effects of IMT on FEV1 and FVC remain inconsistent between healthy individuals and patients, with some research showing improvements in the FEV1 and FVC after the IMT and others not. In a previous study, three weeks of IMT in rugby players did not show significant increases in FEV1 and FVC.[26] Ramos et al. also did not show significant increases in FEV1 and FVC at the end of the twelve sessions of IMT in roller hockey players[27]. In a systematic review, HajGhanbari et al. did not reveal a significant increase in FEV1 after IMT in the athletes[28]. Our results showed similarly no significant effects in the FEV1, FVC, and PEF after the eight weeks of IMT. On the other hand, IMT showed beneficial effects on the FEV1, FVC, and PEF of patients with respiratory muscle weakness, obstructive pulmonary diseases, expiratory flow restrictions, and healthy smokers in the previous studies.[12-15] In a recent review Shei et al. suggested that these heterogeneous results might be related to different training protocols, study populations, and sample size[29].

We observed a greater increase in FEV1, FVC, and PEF in the MT group than in the IMT group. Alvarez et al. similarly observed an increase in the PEF after the IMT combined with cervical and thoracic MT in moderate smokers[17]. However, they did not show a significant increase in the FEV1 and FVC. Villanueva et al. demonstrated no significant effects in the FEV1, FVC, and PEF after the IMT and IMT combined with cervical and thoracic mobilizations in individuals with asthma[14]. The explanation of these results was hypothesized by Villanueva et al. as no significant improvement in the thoracic hyperkyphosis[14]. The mechanism of the observed improvement in the pulmonary functions after the IMT combined with MT was thought as a possible increase in joint mobility and inspiratory muscle length in our study.

Our results showed that there was a significant decrease in the degree of thoracic hyperkyphosis and FHP in both groups after the treatment, although the two treatment groups were not superior to each other. While a few studies aimed to compare the effectiveness of IMT combined with MT and IMT alone, the results of these studies were not consistent with each other. In agreement with our results, Alvarez et al. suggested IMT combined with cervical and thoracic MT is beneficial to decreasing FHP and thoracic kyphosis in healthy individuals with moderate smoking[17]. However, they did not observe an improvement in postural measurements after the IMT alone. Villanueva et al. reported that IMT combined with MT and therapeutic exercise was more effective than the IMT alone for improving FHP in individuals with asthma, while they did not demonstrate significant improvement at thoracic kyphosis after the two interventions[14]. In contrast, in a previous study, a four-week respiratory muscle exercise program significantly reduced the angles of thoracic and lumbar curvatures.[30] Haghighi et al. also reported that the degree of thoracic hyperkyphosis decreased significantly after 12 weeks of IMT[31]. The data obtained from our study reinforced the relationship between the musculoskeletal and respiratory systems. The mechanism of improvement in the FHP is thought to be related to the reduction of the activation of the inspiratory accessory muscles. It was also thought that the pressure in the spine with thoracic expansion might be related to the decrease in the degree of kyphosis.

This study had some limitations. There is no consensus about the most relevant measurement to assess the effectiveness of IMT. MIP, maximal expiratory pressure, transdiaphragmatic pressure, the thickness of diaphragm muscle, and respiratory muscle power output have also been used to assess responses to IMT in previous studies. In our study, we did not measure the MIP to determine respiratory muscle strength. Also, it was impossible to blind the participants and the therapist because of the type of interventions in our study. Due to the COVID-19 pandemic, an equal number of participants in both groups could not be provided in this study.

In conclusion; this study showed that the addition of MT involving the diaphragm, cervical and thoracic region to the IMT might improve respiratory functions in healthy individuals with thoracic hyperkyphosis and FHP. It was also demonstrated that IMT alone and IMT combined with MT might be effective in the reduction of FHP and thoracic hyperkyphosis in healthy individuals.

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