Effects of thoracic kinesio taping on pulmonary functions, respiratory muscle strength and functional capacity in COPD patients: a pilot randomized controlled study

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Original Article

Effects of thoracic kinesio taping on pulmonary functions, respiratory muscle strength and functional capacity in patients with chronic obstructive pulmonary disease: A randomized controlled trial

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ABSTRACT

Context: Respiratory and peripheral muscle dysfunctions seen in Chronic Obstructive Pulmonary Disease (COPD) cause ventilatory limitation, dyspnea and inactivity, which then result in a reduction in functional capacity. Kinesio Taping (KT) is a rehabilitative technique performed by the cutaneous application of a special elastic tape, thus increasing muscle activation and blood circulation.
Objectives: To investigate the effects of KT application that was applied on respiratory muscles to improve pulmonary function, respiratory muscle strength and functional capacity in patients with COPD.
Patients and methods: In total, 27 COPD patients (16 in KT group, 11 in control group) were included. Thoracic KT was applied to facilitate the respiratory muscles along the subcostal area for KT group. Deep breathing exercises were applied to both groups. Interventions were done 2 days a week, through 6 weeks. Pulmonary function and maximal respiratory mouth pressures were measured with a spirometer. Severity of dyspnea and fatigue were assessed with Modified Medical Research Council dyspnea scale and Modified Borg Scale, respectively. Functional capacity was evaluated using six-minute walk test.
Results: Percentage predicted of forced expiratory volume in one second (FEV_1%), peak expiratory flow (PEF) value, percentage predicted of peak expiratory flow (PEF%) and walking distance were significantly increased in KT group ($p = 0.038$, $p = 0.011$, $p = 0.013$, $p = 0.004$, respectively). The severity of dyspnea and fatigue were reduced in KT group ($p < 0.05$). There was no significant change for other variables in-group and between-group analyses ($p > 0.05$).
Conclusions: Thoracic KT may be beneficial for improving pulmonary function and functional capacity in patients with COPD.

Introduction

Chronic obstructive pulmonary disease (COPD) is a systemic disease caused by excessive inflammation mainly leading to an injury in the airways and lung parenchyma.[1] Approximately one third of patients with COPD experience skeletal muscle wasting and dysfunction.[2] Peripheral and respiratory muscle dysfunction cause dyspnea, ventilatory limitation, inactivity and fatigue,[3] which then results in a reduction in functional capacity, quality of life and even overall survival.[4]

Lung hyperinflation is also a significant contributor to respiratory muscle dysfunction and dyspnea in COPD. Dynamic hyperinflation shortens the length of inspiratory muscles, particularly the diaphragm, resulting in functional muscle weakness.[5] Dyspnea and hyperinflation are also closely interrelated with physical activity limitation.[6]

Kinesio taping (KT) is a technique in which thin, cotton, latex free, elastic tapes are used for treating musculoskeletal injuries and a variety of other physical disorders.[7] Kinesio tape can be stretched up to 140% of its original length, imparting elastic energy when released.[8] Some studies have proposed that KT could have positive effects on muscle activation, joint repositioning, circulation of blood and lymph, and pain.[8–12] However, these studies have focused on the use of KT in the treatment of trauma and pain of the extremities' musculoskeletal disorders.[13]

Depending on the proposed effects, we speculated that if KT were applied to thorax, it could have some beneficial effects to restore respiratory muscle function and to reduce hyperinflation, thereby resulting in increased functional capacity for patients with COPD. We

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hypothesized that thoracic KT could significantly change pulmonary function and functional capacity in patients with COPD.

To our knowledge, no study has investigated the effects of KT on pulmonary function and functional capacity of patients with COPD. Previous studies have investigated the effects of KT applied to thorax on respiratory muscle strength and ventilatory efficiency in healthy individuals.[14–16] Except for one study conducted in COPD exacerbation,[17] no study has evaluated the effects of KT in respiratory diseases. Besides, most studies have used only one session of thoracic KT application and observed immediate or acute effects of KT.[14,16,17] In this study, we aimed to investigate the effects of a long-term thoracic KT application on pulmonary function, respiratory muscle strength, severity of dyspnea, severity fatigue and functional capacity in patients with COPD.

Patients and methods

Study design

This was a prospective, single-blinded, randomized controlled trial with a parallel design having an allocation ratio of 1:1. An investigator, who was unaware of the treatment allocation, screened patients for eligibility. Eligible patients were informed about the study and those who were willing to participate in the study signed the consent form. The patients were randomly assigned to one of the two groups using an online random allocation software program (GraphPad Software QuickCalcs, GraphPad Software Inc., La Jolla, CA, USA). CONSORT flow diagram of the study was shown in Fig. 1.

Patients

Patients recruited from the Department of Pulmonary Rehabilitation and assessed for eligibility. Inclusion criteria were (i) aged 40 years and older, (ii) having spirometric stage II-III COPD according to The Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2017,[18] (iii) able to read, write, and understand native language; and (iv) willing and able to attend the study. Exclusion criteria were (i) being in COPD exacerbation period, (ii) having neurological or musculoskeletal problems that would affect physical mobility, (iii) having unstable, severe heart disease(s) (heart failure, unstable hypertension, previous angina pectoris or myocardial infarction, heart valve problems), (iv) having scar, lesion or incision in the area of kinesio tape application, (v) previous use of kinesio tape, (vi) having skin sensitivity against kinesio tape, (vii) malignancy, (viii) use of analgesics during study period, (ix) having mental and cognitive disorders that would affect cooperation. All participants were assessed and received treatment applications in Pulmonary Rehabilitation Department of our faculty of medicine hospital of the university.

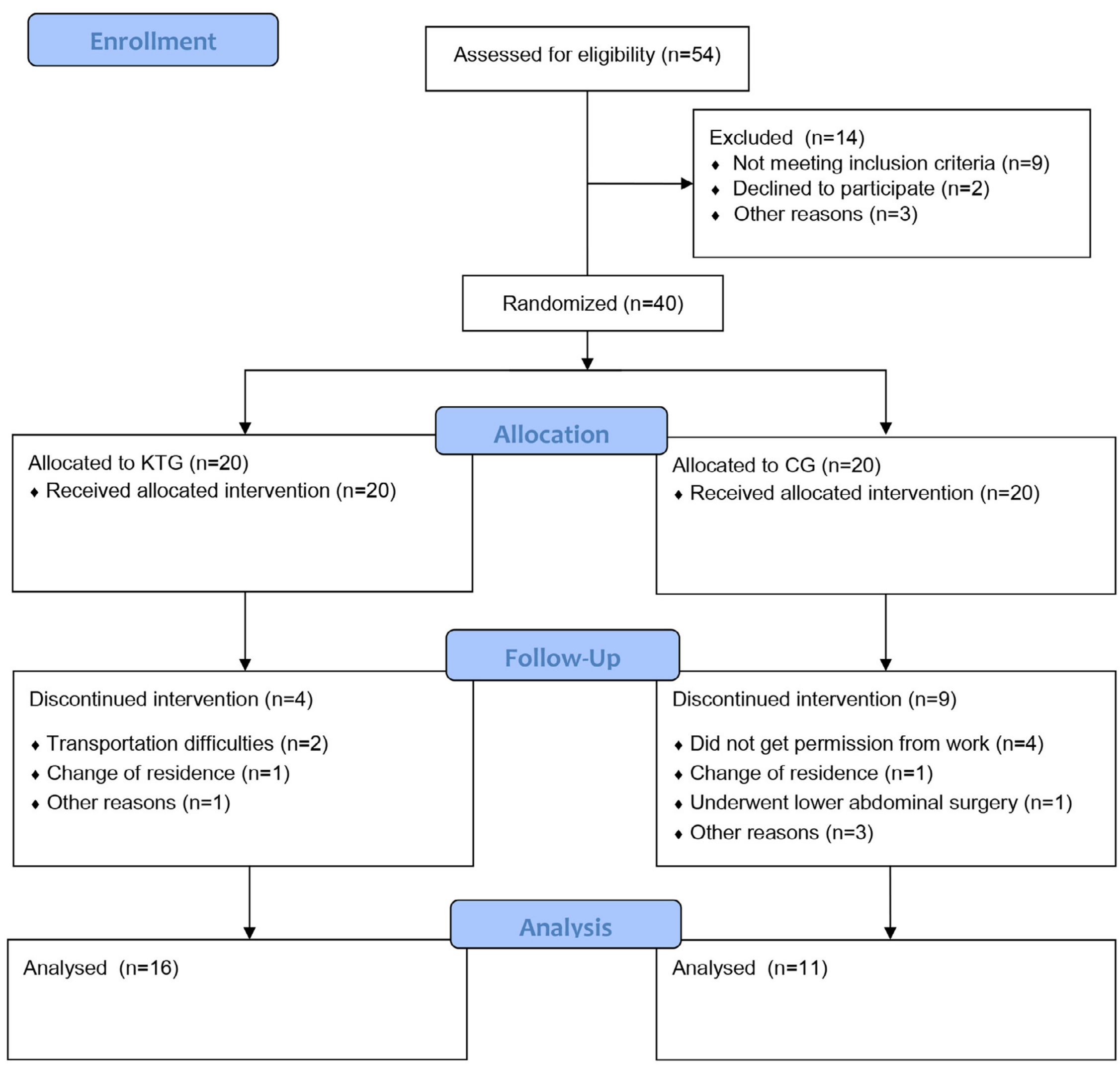

Fig. 1. Flow diagram of the study protocol.

Methods

Eligible patients were randomly allocated to Kinesio Taping Group (KTG), or Control Group (CG). CG received deep breathing exercises, each consisting of three sets of 10 repetitions, with 30 s of rest between each set.

KTG received deep breathing exercises plus thoracic KT application. The material used for thoracic KT application was Kinesio® Tex Gold™ (Kinesio Holding Corporation, Albuquerque, NM, USA), a 100% cotton, latex-free, 5-cm wide, elastic tape. Tape placement sites were chosen according to techniques and principles described by Kase et al.[8] Patients were instructed to sit upright on an armless chair with no back support, with knees flexed to 90°, feet on the floor and arms relaxed. Kinesio tape was applied anteriorly and posteriorly to facilitate respiratory muscles (primarily diaphragm) along the subcostal area. Anteriorly, the base point of an "I" shaped kinesio tape was applied on xiphoid process with 50–75% tension only on the linea alba and the tails of the tape were applied toward subcostal curvature with no tension. Posteriorly, a second "I" shaped kinesio tape was applied from the back. The base point of the tape was applied on the projection of 12th Thoracic vertebra with 50–75% tension and the tails were applied toward the ribs without any tension. Additionally, two more kinesio tapes were applied to upper trapezius area which lies between neck and acromion at both sides (left and right). Web-cut EDF (epidermis-dermis-fascia) technique were used (Fig. 2 and 3).[8] With this technique, it was aimed to relax these muscles which were over-contracted due to hyperinflation in COPD and to increase blood circulation in this region. No command about respiration like inhale or exhale were given to patients during thoracic KT applications.

Fig. 2. Thoracic kinesio taping application, anterior view.

Fig. 3. Thoracic kinesio taping application, posterior view.

All interventions were done two days a week, through six weeks for both groups by a physiotherapist. Sessions were held at the same time every Monday and Thursday of the week. Therefore, KT was applied with a 3–4 day-interval. Patients were instructed to take the tape off before the subsequent application.[8] Patients in both groups were also instructed to perform deep breathing exercises as home exercises, each to be performed three sets of 10 repetitions, every day. Adherence to home exercises was obtained verbally in each session. All patients continued their routine drug treatment for COPD during the study period. No additional intervention was applied.

Outcome measures

Demographic and clinical characteristics (age, gender, body mass index, history of smoking, number of medications, education level, marital status, working status) of all participants were recorded before the treatment.

The outcome measures were pulmonary function, respiratory muscle strength, severity of dyspnea, severity of fatigue and functional capacity. All outcomes were assessed both before and after the treatment (at the end of sixth week).

Pulmonary function was measured using a spirometer (Jaeger MasterScreen Pulmonary Function Testing System, CareFusion Corporation, Basingstoke, UK). Forced expiratory volume in one second (FEV_1), percentage predicted of FEV_1 (FEV_1%), forced vital capacity (FVC), percentage predicted of FVC (FVC%), FEV_1/FVC, peak expiratory flow (PEF) and percentage predicted of PEF (PEF%) were recorded. To perform the measurement, subjects were instructed to sit on an armless chair with back support while their knees flexed to 90° and nostrils occluded by a nose clip. Then they performed a maximal inspiration followed by a forced expiration, exhaling as much air as possible three seconds. This maneuver was repeated three times, and the highest scores were recorded for analyses.[19]

Maximal respiratory mouth pressures were used to determine respiratory muscle strength and evaluated using a mouth pressure device (micro RPM, Micromedical, England). Measurements were made with patients in a sitting position and with a nose clip. Maximal inspiratory pressure (MIP) was measured to determine inspiratory muscle strength. Patients were asked to perform a forceful inspiration against the occluded mouthpiece of the device. Maximal expiratory pressure (MEP) was measured to determine expiratory muscle strength. Patients were asked to perform a maximal expiratory effort and sustain it for 1–2 s. Each maneuver was repeated three times for both MIP and MEP and the highest (absolute) values were recorded in cmH_2O. Percentage predicted of maximal pressures that were automatically given by the device itself were also recorded and used for analysis.[20]

Severity of dyspnea was measured using Modified Medical Research Council (mMRC) scale.[21] Severity of fatigue was assessed using Modified Borg Scale (MBS). MBS rating varies between 0 and 10 points, with higher scores indicating more severe fatigue.[22]

Functional capacity was evaluated using six-minute walk test (6MWT), which was indicated as a valid, reliable and useful test in patients with at least moderate-to-severe impairment by American Thoracic Society (ATS).[23,24] The test was performed according to the guidelines published by ATS.[24] In an indoor area, two cones were placed 30 m apart on a flat surface and each of them marked three meters by pieces of tape. Before the test, patients were informed about how to perform the test and encouraged to walk as fast as possible to get the maximum distance. The perceived exertion-fatigue according to modified Borg scale was questioned during the test. At the end of the sixth minute, the six-minute walk distance (6MWD) was recorded.

Statistical methods

The sample size was calculated in Open Source Epidemiologic Statistics for Public Health (Open Epi Version 3.1) program using the data from a previous study that evaluated MEP of individuals before and after diaphragmatic taping (14). Considering the changes between before and after taping in MEP (5.5% $\pm$ 6.59), an alpha value of 0.05, and power of 80%, the estimated sample size was nine participants per group.

All data were analyzed using Statistical Package for Social Sciences (SPSS) software (IBM Corporation, version 25.0 for Windows). Descriptive statistics were summarized as frequencies and percentages for categorical variables. Continuous variables were presented as mean and standard deviation where normally distributed, and median and interquartile range where not normally distributed. The variables were investigated using visual (histograms, probability plots) and analytical methods (Shapiro–Wilk's test) to determine whether or not they are normally distributed. Results were reported as baseline, post-intervention and change (Δ) values, comparing post-intervention and baseline values. Mann–Whitney *U* test was used to compare baseline characteristics and Δ values, and Wilcoxon test was used to compare variables before and after treatment in each group. The association between categorical variables was tested using Chi-square test. A 5% type-I error level was used to infer statistical significance ($p < 0.05$).

Results

Of the 54-screened COPD patients, 40 (74.07%) met the inclusion criteria and were willing to participate. Of the 20 patients in KTG, four were dropped out during follow-up period (two had difficulties with transportation, one changed the residence, one had unidentified reasons). In CG, there were 20 patients, of whom nine were discontinued intervention (four did not get permission from work, one changed residence, one underwent lower abdominal surgery, three had unidentified reasons). In total, 16 patients in KTG and 11 patients in CG were analyzed in terms of all outcomes. The analyses were by original assigned groups (Fig. 1).

Table 1
Comparison of baseline demographic and clinical characteristics of the groups.

	KTG, (n = 16)		CG, (n = 11)		*p* value
	Mean	SD	Mean	SD	
Age (years)	64.81	7.20	67.00	9.36	.245
BMI (kg/m^2)	28.70	7.39	26.73	5.51	.402
Smoking (pack-year)	34.87	30.31	41.20	33.02	.655
Number of medications	3.56	2.36	2.64	2.46	.295
FEV1 (L/s)	1.51	0.62	1.24	0.55	.348
FEV1 (%)	52.00	16.60	45.04	16.83	.400
FVC (L/s)	2.51	0.72	2.18	0.70	.208
FVC (%)	69.70	16.71	63.33	12.80	.246
FEV1/FVC (%)	58.69	8.84	54.84	11.91	.348
PEF (L/s)	4.17	1.64	3.38	1.50	.236
PEF (%)	54.89	18.59	48.20	17.22	.401
MIP (%)	82.69	20.51	69.18	19.00	.061
MEP (%)	49.62	21.49	53.36	21.64	.693
6MWD (m)	435.75	115.18	373.45	108.04	.103
Dyspnea (mMRCs)	1.62	0.96	2.00	1.34	.539
Fatigue (MBS)	3.87	3.61	2.45	2.77	.317

Mann–Whitney *U* test: $^*p < 0.05$.
KTG, Kinesio taping group; CG, control group; BMI, body mass index, FEV1, forced expiratory volume in 1 s; FEV1 (%), percentage predicted of forced expiratory volume in 1 s; FVC, forced vital capacity; FVC (%), percentage predicted of forced vital capacity; PEF peak expiratory flow; PEF (%), percentage predicted of peak expiratory flow; MIP, maximal inspiratory pressure; MIP (%), percentage predicted of maximal inspiratory pressure; MEP, maximal expiratory pressure; MEP (%), percentage predicted of maximal expiratory pressure, 6MWD, six-minute walk distance; mMRCs, modified Medical Research Council scale; MBS, modified Borg scale.

There was no statistically significant difference in terms of demographic and clinical characteristics between the groups after the baseline assessment ($p > 0.05$) (Table 1). Additionally, no significant difference was found in distribution of demographic characteristics (gender, education level, marital status, working status) between groups (Chi square analysis, $p > 0.05$).

Tables 2 and 3 show the comparisons before and after treatment in each group and comparisons of mean differences between groups. In KTG, FEV_1%, PEF, PEF%, severity of dyspnea, severity of fatigue and 6MWD showed a statistically significant improvement as compared to baseline ($p < 0.05$). In CG, there was no statistically significant difference in any of the outcomes ($p > 0.05$). When the mean differences between groups were analyzed, there were no statistically significant differences found in any of the variables ($p > 0.05$). No harms or unintended effects (pain, rash) were found in either group.

Discussion

The aim of the present study was to investigate the effects of long-term thoracic KT application on pulmonary function, respiratory muscle strength, severity of dyspnea, severity of fatigue and functional capacity in patients with COPD.

The results of this study showed that six-week thoracic KT applied together with deep breathing exercises significantly improved pulmonary function, perceived severity of dyspnea and fatigue, and had a positive effect on functional capacity in patients with COPD. However, it failed to improve either expiratory or inspiratory muscle strength. Furthermore, between group analyses of the mean differences showed that there was no superiority of one intervention over the other in changing either of the outcomes.

Skeletal muscle dysfunction seen in patients with COPD directly affects functional exercise capacity.[25–27] Since respiratory muscles are also striated muscles structurally, they become fatigued after overwork. The ongoing fatigue leads to inhibitor signal generation and a reduction in motor commands, which then results in respiratory insufficiency in patients with COPD.[28] Dynamic hyperinflation is also a major contributor to functional exercise limitation in COPD.[29] Increased lung volume reduces the length of inspiratory muscles and causes functional muscle weakness.[5] Especially, the action of the diaphragm on the rib cage is affected negatively.[30]

The kinesio tape is claimed to have positive effects on muscle activation, joint repositioning, circulation of blood and lymph, and pain.[9] Restoration of correct muscle function by supporting weakened muscles, correction of misalignment by reducing muscle spasm, removal of lymphatic fluid or hemorrhage under the skin through enhanced local circulation, reduction of pain through stimulation of sensory afferents are the proposed mechanisms of action postulated by the manufacturer and some researchers.[8,10–12] Thoracic KT was designed to assist expiratory ventilation. The kinesio tape is pulled peripherally across the natural movement of thorax during inspiration, and while exhaling, elasticity of the tape would aid expiration by countermovement.[8] Depending on these proposed effects, we applied thoracic KT to patients with COPD and detected an increase in FEV_1%, PEF, PEF% values and functional capacity.

Effects of KT on pulmonary function and ventilator efficiency have been little investigated. Only one study conducted in patients with COPD exacerbation did investigate the effects of one-session KT application on pulmonary function and concluded that measures of FEV_1 and PEF were not significantly improved after use of KT. The authors believed that only one session of KT was not enough to create significant changes in pulmonary function of these subjects.[17] Our results indicated that this belief could be true, thus we found a significant increase in measures of PEF, PEF% and FEV_1% after six-week (12 sessions) of KT application in patients with COPD. Results of Malehorn et al.'s study also supported our findings. They found that

Table 2
Mean changes in functional capacity and pulmonary function test variables of groups over 6-week treatment.

	KTG					CG						
	Baseline		6th week			Baseline		6th week				
	Mean	SD	Mean	SD	*p* value	Mean	SD	Mean	SD	*p* value	Between groups, *p* value¥	Effect size (Cohen's *d*)
FEV1 (L/s)	1.51	0.62	1.61	0.71	0.059	1.24	0.55	1.33	0.69	0.646	0.236	<0.01
FEV1 (%)	52.0	16.6	55.31	19.2	**0.038***	45.0	16.8	46.5	17.3	0.386	0.266	0.28
FVC (L/s)	2.51	0.72	2.64	0.82	0.255	2.18	0.70	2.21	0.80	0.790	0.604	−1.34
FVC (%)	69.7	16.7	72.9	18.3	0.187	63.3	12.8	64.5	11.6	0.248	0.748	0.24
FEV1/FVC(%)	58.7	8.8	60.7	14.3	0.336	54.8	11.9	59.5	14.1	0.229	0.637	−0.38
PEF (L/s)	4.17	1.64	4.89	1.95	**0.011***	3.38	1.50	3.51	1.88	0.424	0.076	0.72
PEF (%)	54.9	18.6	63.9	21.1	**0.013***	48.2	17.2	49.9	21.4	0.386	0.125	0.69
6MWD (m)	435.7	115.2	482.9	96.8	**0.004***	373.4	108.0	385.3	97.0	0.130	0.159	0.72

Wilcoxon Signed Rank test: *$p < 0.05$ (in-group analyses).
Mann−Whitney *U* test: ¥$p < 0.05$ (between group analyses of the changes).
KTG, Kinesio taping group; CG, control group; FEV1, forced expiratory volume in 1 s; FEV1 (%), percentage predicted of forced expiratory volume in 1 s; FVC, forced vital capacity; FVC (%), percentage predicted of forced vital capacity; PEF, peak expiratory flow; PEF (%), percentage predicted of peak expiratory flow; 6MWD, six-minute walk distance.

KT applied on the chest of healthy individuals could augment ventilatory efficiency without the participants being aware of it.[16]

The results of studies investigating the effects of KT on muscular strength are controversial. Moreover, only few studies examined effects of KT on respiratory muscle strength.[14,15,17] Sari et al. investigated the immediate effects of KT applied on diaphragm and accessory respiratory muscles on maximal respiratory strength in healthy individuals and found no improvement in either inspiratory or expiratory muscle strength.[14] The results of a meta-analysis on 19 trials also indicated that the use of KT in healthy adults was not able to improve muscle strength, regardless of which muscle group it was applied.[31] Most studies, which found no significant change in muscle strength, have examined only immediate effects of KT and suggested that future studies should investigate the effects of a long-term KT application.[32,33] Depending on this, we examined the effects of a six-week KT that was renewed within 3−4 days. However, we found no significant improvement in respiratory muscle strength of patients with COPD, the muscle strength of whom was also relatively lower compared to that of healthy individuals. On the other hand, Daitx et al. found that one day of KT application was effective to improve MIP and MEP values after 24 h in patients with COPD exacerbation. However, the other received interventions (e.g. drug therapy) for the exacerbation, and possible healing of increased symptoms due to exacerbation could have been affected the results of their study. Unfortunately, no information about other interventions or symptoms was provided by the authors.[17]

One possible explanation of why we did not find an increase in respiratory muscle strength could be the unique shape of diaphragm muscle. In the muscle technique of KT, taping must be done according to the anatomic and biomechanical properties of the muscle. Therefore, the origin and insertion of the muscle, and the direction and pennation angle of muscle fibers must be considered. However, the shape, localization and movements of diaphragm might have limited the proper taping technique.

The study conducted by Lee et al. found that KT added to inspiratory muscle training through four weeks was effective for improving MIP. However, no significant change was observed in pulmonary function (PEF, FVC, FEV_1, FEV_1/FVC).[15] On the contrary, we found significant increase in PEF, PEF%, FEV_1% and no significant change in MIP, MEP after use of KT. Given these results, it may be concluded that KT might be more effective when combined with pulmonary rehabilitation modalities. Whereas, it may improve MIP when combined with inspiratory muscle training,[15] and pulmonary function when combined with deep breathing exercises. However, to clearly elucidate these effects, more research is needed on this issue.

To our knowledge, literature reports no studies investigating the effect of KT on functional capacity in patients with COPD. One randomized controlled study investigated the effect of KT on 100-meter walk test in patients underwent laparoscopic cholecystectomy. Results showed a significant decrease in the time required to cover a 100-meter distance in the KT group in comparison with the control group.[34] Hombrados et al. investigated the effects of diaphragmatic KT on 6MWT performance in healthy subjects. As a result, they found that KT did not produce any significant changes in the variables measured during 6MWT.[35] However, they applied KT only once and solely during the test, which might have lessened the possible effect. Whereas in our study, six-week long KT application caused both statistically and clinically meaningful increase in functional capacity of patients with COPD. Additionally, the fact that the functional capacity

Table 3
Mean changes in respiratory muscle strength, severity of dyspnea, and severity of fatigue of groups over 6-week treatment.

	MIP absolute (cmH_2O)		MIP (%)		MEP absolute (cmH_2O)		MEP (%)		Dyspnea (mMRCs)		Fatigue (MBS)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
KTG												
Baseline	80.4	28.0	82.7	20.5	86.4	32.4	49.4	15.6	1.69	0.19	3.97	3.61
6th week	77.8	27.1	83.2	22.5	86.4	33.2	49.6	21.5	1.06	0.93	2.31	2.55
p value	0.856		0.679		0.501		0.856		**0.007***		**0.046***	
CG												
Baseline	57.6	22.1	69.2	19.0	75.2	23.2	53.4	21.6	2.00	1.34	2.45	2.77
6th week	54.9	16.6	67.7	18.2	70.6	32.3	55.1	18.7	1.91	1.22	2.27	2.33
p value	0.756		0.689		0.534		0.689		0.564		0.527	
Between groups, *p* value¥	0.570		1.000		0.621		0.824		0.061		0.271	
Effect size (Cohen's *d*)	−2.25		−2.99		−0.13		−0.16		0.56		1.35	

Wilcoxon Signed Rank test: *$p < 0.05$ (in-group analyses).
Mann−Whitney *U* test: ¥$p < 0.05$ (between group analyses of the changes).
KTG, Kinesio taping group; CG, control group; MIP (%), percentage predicted of maximal inspiratory pressure; MEP (%), percentage predicted of maximal expiratory pressure; mMRCs, modified Medical Research Council scale; MBS, modified Borg scale.

of the control group was not significantly increased in our study also suggests that this effect might be caused by the addition of thoracic KT to the deep breathing exercises.

A randomized controlled study conducted by Tantawy et al. investigated the effects of KT on functional capacity and postoperative pain after laparoscopic abdominal surgery. Since postoperative pain causes a decline in patients' activity and reduces respiratory muscles' function, they hypothesized that KT could decrease pain and cause an increase in functional capacity. Eventually, they found that eight-day of KT significantly decreased pain and caused an increase in 2-minute walk distance at 3rd and 8th days postoperatively.[36] In our study, there were no patients with chest pain. Contrary to the results of Tantawy et al.'s study, the increase in functional capacity of patients with COPD in our study may not be due to reduction of pain, but a decrease in severity of dyspnea and fatigue.

The effect of KT on the excursion of the diaphragm and the local blood flow of scalene and upper trapezius muscles might support relaxation of accessory respiratory muscles. It could be one explanation for the improvement in severity of fatigue and dyspnea in this study, since relaxation of these muscles leads to a decrease in both energy expenditure and oxygen consumption.[37]

The major strength of this study is that, to the best of our knowledge, ours is the first study that has investigated the effectiveness of thoracic KT on pulmonary and functional capacity in patients with COPD. Another strength is that we regularly applied thoracic KT through six weeks unlike most studies in which only one session of KT had been applied. In this respect, our study also provides information on the dose of KT application in patients with COPD.

One possible strength of the study could be that all patients were submitted to full spirometry before inclusion to study, then the diagnosis and staging of COPD was made by a chest physician. Additionally, in order to maintain homogeneity, only patients with stage II-III were enrolled. However, this inclusion criteria might have led to a limitation because it had reduced the total number of patients enrolled.

In this study, we could not conclude the precise cause for the improved FEV_1%, PEF and PEF% since we did not assess the possible underlying mechanisms of action that KT created. Further studies should implement relatively objective methods such as electromyography, ultrasonography or magnetic resonance imaging technologies to detect these mechanisms.

In conclusion, this study has shown that the addition of thoracic KT application to deep breathing exercises may be beneficial for improving some pulmonary function parameters such as FEV_1%, PEF and PEF% and functional capacity in patients with COPD. Severity of dyspnea and fatigue may also be decreased by the addition of thoracic KT. On the other hand, thoracic KT failed to improve respiratory muscle strength of the patients. Further studies should investigate the add-on effect of thoracic KT in pulmonary rehabilitation programs designed for patients with COPD.

Informed consent and ethics

The local university ethics committee provided ethical approval, with the ethical protocol number 1925-GOA. The research has been carried out with Declaration of Helsinki. All eligible patients were informed about the study and those who were willing to participate signed the consent form.

Declaration of Competing Interest

The authors report no conflict of interest.

Contributions

Murat Tomruk, PT, PhD: Literature search, data collection, study design, analysis of data, manuscript preparation.

Elvan Keleş, PT, MSc: Literature search, data collection, manuscript preparation.

Prof. Sevgi Özalevli, PT, PhD: Literature search, study design, manuscript preparation, review of manuscript.

Assoc. Prof. Aylin Özgen Alpaydin, MD, PhD: Literature search, review of manuscript.

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