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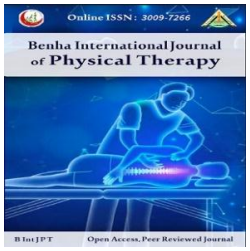

Original research

Effect of kinesiotape versus diaphragmatic breathing exercise on physical performance and oxygen saturation in post covid-19 patients: a comparative study

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Abstract

Background: The post-COVID-19 condition is a group of durable physical, cognitive, and/or psychiatric symptoms that last for greater than 12 weeks following COVID-19. Until now, there has been no exact rehabilitation program for improving physical performance and oxygen saturation. **Purpose:** To compare the impacts of kinesiotape (KT) and diaphragmatic breathing exercises on physical performance and oxygen saturation. **Methods:** Sixty post-COVID-19 patients were allocated into three groups. Group A: 20 patients were given pursed-lip breathing and Cognitive Behavior Therapy (CBT) for 6 weeks. Group B: 20 patients were given diaphragmatic breathing exercises in addition to pursed-lip breathing and CBT for six weeks. Group C: 20 patients were given KT in addition to pursed-lip breathing and CBT for 6 weeks. Outcome measures included: Physical performance evaluated by a six-minute walk test (6MWT), and oxygen saturation measured by a pulse oximeter. The assessment was done at baseline and six weeks after treatment. **Results:** Three groups showed a statistically significant improvement in 6MWT and oxygen saturation after treatment compared to before treatment ($p < 0.001$). But group B had a significantly higher 6MWT and oxygen saturation in comparison with both group A and group C ($p < 0.05$). **Conclusion:** Diaphragmatic breathing exercises added to pursed-lip breathing and cognitive behavior therapy are more effective than KT in the rehabilitation of post-COVID-19 patients.

Keywords: Cognitive behavior therapy, Diaphragmatic breathing exercise, Post COVID-19, Kinesiotape.

Introduction

The SARS-CoV-2 virus first appeared in Wuhan, China in December 2019, causing the COVID-19 disease. It quickly spread worldwide, resulting in a global pandemic.[1] Post COVID-19 symptoms were observed in 86% of individuals who had recovered from COVID-19. 30% of the individuals experienced symptoms of chest pain as well as dyspnea. Dyspnea, or shortness of breath, is a prevalent symptom that continues to affect patients even after recovering from

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COVID-19. Multiple studies have reported that between 23% and 66% of patients had significant ongoing dyspnea for 8-12 weeks after being discharged, with a small number of individuals needing additional oxygen support[2].

Some people can develop a variety of longstanding symptoms like dyspnea, fatigue, and functional activity limitations. These symptoms are identified as post COVID-19 disorder or long COVID. Until now, there is has been no specific medication therapy for patients suffering from post COVID-19 condition[3]. Long-term follow-up studies declared persistent symptoms for patients suffering from post COVID-19 condition as dyspnea, fatigue, and physical and psychological complications even in non-hospitalized patients, this condition reduces functional capacity and health status [4,5]. The use of suitable physiotherapy as an element of a multidisciplinary strategy helps manage these problems, based on the clinical practice guidelines[6,7]. Multiple studies have shown that physiotherapy rehabilitation benefits COVID-19 patients[7]. Furthermore, physiotherapy interventions, including breathing exercises and chest physiotherapy can be effective therapies in post COVID-19 patients[8].

Breathing exercises are becoming more popular due to their proven role in enhancing blood oxygenation and utilizing the greater capacity of the lungs [9, 10]. With advanced research, different therapies are suggested to treat post COVID-19 complications such as pursed-lip breathing exercise which is efficient in improving dyspnea in COVID-19 patients[11]. Moreover, Cascella et al [12] concluded that breathing exercises can be used to help post COVID-19 patients regain their normal breathing capacity. Furthermore, it has been confirmed that after diaphragmatic breathing exercise, has improved the pulmonary functions, as well as physical performance of post COVID-19.[13]

Another suggested treatment is Cognitive Behavior Therapy (CBT) which has a large effect in enhancing the physical as well as psychological health of COVID-19 patients[14]. The CBT for psychological distress during COVID-19 showed significant results in improving psychological problems.[15]

Aside from traditional treatments, KT is a treatment tool in which thin, cotton, latex-free as well as elastic tapes are utilized for enhance inflamed areas and promote circulation[16]. A study made by Akselim et al.[17] examined the rehabilitation of patients with COVID-19, the study stated rehabilitation interventions alone are insufficiently successful, therefore KT should be used in conjunction with conventional rehabilitation techniques. Furthermore, pulmonary function, dyspnea, as well as fatigue were all significantly enhanced in COPD patients who were given KT in conjunction with breathing exercises[18]. Also, Desai et al[19] confirmed that KT applied to the diaphragm has a good prognosis for diaphragm muscle weakness.

Even though these long-standing symptoms of post COVID-19, until now there is no exact rehabilitation program available[20]. Unfortunately, there is a lack of adequately randomized control studies investigating rehabilitation protocol for post COVID-19 patients, so this study may help in rehabilitation by using new modalities by investigating effect of KT versus diaphragmatic breathing exercise on physical performance and oxygen saturation in post COVID-19 patients.

Methods

This was a Comparative study pre- and post-test parallel groups randomized controlled trial. It took place from March 2023 to November 2023.

Sample size calculation:

The G*POWER statistical program (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) was used to calculate the sample size. A power of 80%, an effect size of 0.42, and $\alpha = 0.05$ were used in the calculation. The results of the 6MWT pilot study, which included 5 participants in each group, showed that a total of 60 participants would be needed for this study.

Participants:

Sixty patients of both genders with post COVID-19 condition were selected from dar eltaafi for medical rehabilitation. The inclusion criteria included Screening must have taken place at least four weeks after the initial positive COVID-19 swab [21, 22], aged 18-45 years old, non-hospitalized, both sexes were included, their BMI ranged from 18.5 to 24.9 kg/m², individuals who engage in low to moderate levels of physical

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activity, as measured by the Arabic version of the International Physical Activity Questionnaire (IPAQ) and able to read and write. Participants weren't allowed to take any drugs that would affect their ability to exercise, including beta-blockers or antiretroviral medicine, or taking part in any other clinical trial that involved intervention[23], pregnancy[17], had significant hepatic or renal dysfunction[24], new onset of arrhythmia and myocardial ischemia[13], hospitalized, cardiovascular disease, chronic pulmonary disease, active infection, serious endocrine or metabolic diseases[25], cognitive impairment, patients with red flag indicators including chest pain, life-threatening drop in oxygen saturation, musculoskeletal or neurologic limitations, and unconscious patients[26], and contraindications for using KT as malignancy, infection, cellulitis, open wound, DVT, or previous allergic reaction to KT [18].

Randomization:

Sixty patients with post COVID-19 condition were recruited from Dar El-Taafi for medical rehabilitation/ Banha/ Qaliobia. During assessment for eligibility twenty-seven patients dropped out during treatment; sex patients for refusing to share in the study and twenty-one patients not met criteria for inclusion while sixty patients completed the study as shown in Figure (1)

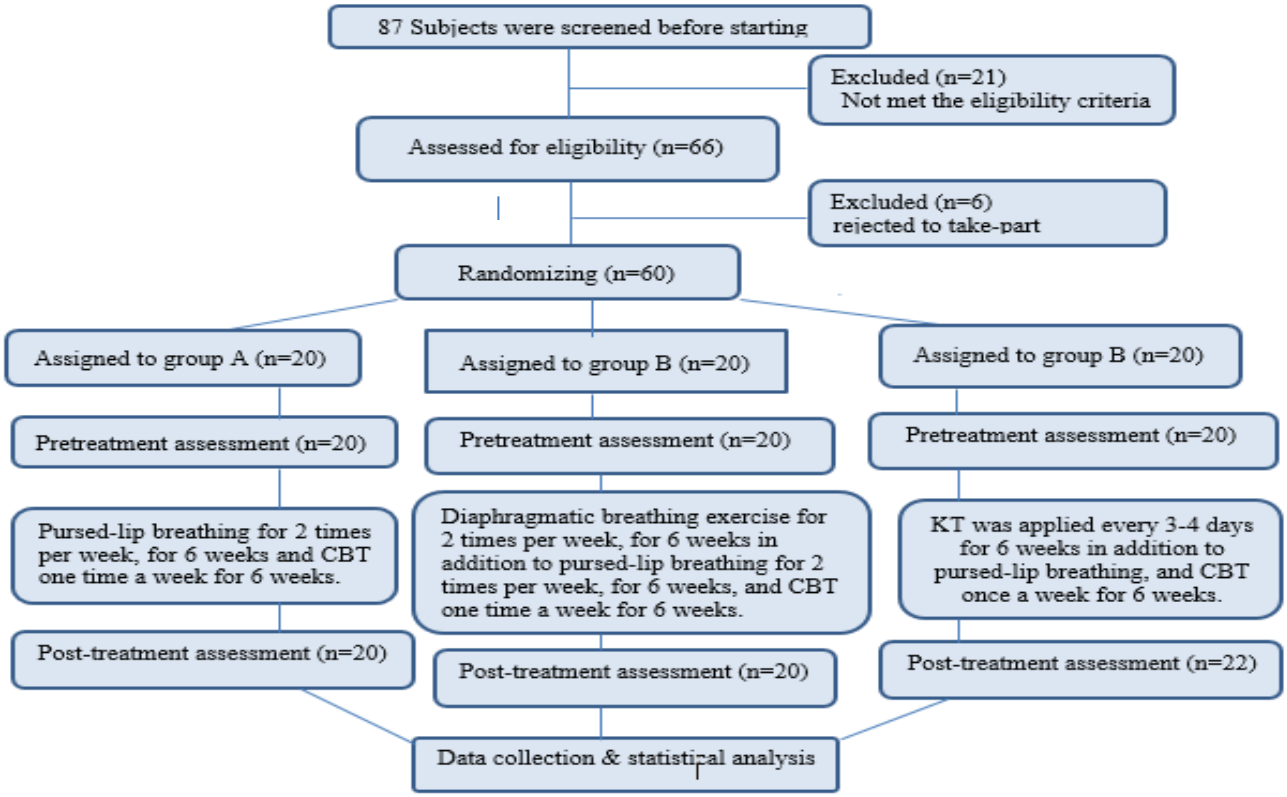

Figure 1: Flow chart of the study

Patients were included randomly using by random generator and permuted blocks of same size into three equal groups, Group A (Control Group): that involved 20 patients, Group B (Diaphragm group): that involved 20 patients, Group C (KT group): that involved 20 patients. The aim, rationale, and study benefits are explained for each subject. After that, they signed a consent form according to Helsinki protocol.

Ethics approval and participate consent:

The research's protocol received approval from the Faculty of Physical Therapy's Ethical Committee at Cairo University (P.T.REC/012/004370) and Clinical Trails Registry (NCT05770193), prospectively

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registered before beginning this study, each patient who provided informed consent was given a thorough explanation of the study's protocol. This study has been conducted by the Declaration of Helsinki, which is part of the World Medical Association's Code of Ethics for Research Including Humans.

Instruments

An Electric treadmill (SPRINT F8055A/4, CHINA) was used to measure physical or functional performance[27, 28].

A pulse oximeter was used to measure oxygen saturation, bases on the US Food and Drug Administration (FDA), an iMDK (C101A2) pulse oximeter was used, having FDA and European certificates[29].

Ares KT (Ares Uncut, made in Korea), a 100% cotton, latex-free, 5-cm wide, 5-m length, can be easily cut and applied on the affected area, nonrestrictive, can be worn in the pool and shower (waterproof), elasticity to extend, allow free ROM, available in different colors (orange, green and blue) and can be worn on skin for an extended period (up to five days) even with water[30-32].

Procedure:

Physical performance was measured via the 6MWT. The patient was standing on the treadmill [27, 28], and the researcher next to him to adjust speed as he was instructed to walk at his normal pace or a comfortable pace in addition to walk as long as possible for six minutes, then the distance on the screen of the treadmill was recorded in the patient's record sheet.

To assess oxygen saturation, the patient was sitting in in a relaxed position for 5 minutes to rest then the oximeter was attached to his thumb after that the oxygen saturation was read on the screen, it was recorded in the patient's record sheet and the oximeter was removed from his thumb[33, 34].

Interventions:

Cognitive behavioral therapy

A structured, 6-session psycho-therapeutic intervention, occurring once weekly, the sessions were performed according to the CBT session structure provided by Cully & Teten[35]. The cognitive intervention was designed to assist patients in correcting previous misunderstandings about COVID-19 info and management approaches. as: (1) providing info on COVID-19 and post-COVID-19 knowledge, real-time COVID-19 epidemic information including the number of patients discharged or treated, and (2) providing clear and easy answers to understand patients' questions. The purpose of the behavioral intervention to (1) Keeping self-monitoring of symptoms like fever and dyspnea that may arise after developing COVID-19; (2) Learning relaxation strategies like music therapy as well as breathing relaxation; (3) Encouraging patients to maintain contact with relatives and friends[36].

Pursed-lip breathing

The patient was placed in a long sitting and then told to take a 2-second nasal breathing in, purse his lips as if blowing out a cake's candles, and then take a 4- to 6-seconds of slow exhalation through his pursed lips. This should be repeated 5 to 10 times. A physical therapist administered the intervention to every participant twice weekly for duration of six weeks.

Diaphragmatic breathing exercise

The patient in group B was asked to rest for 5 minutes and then lie supine on a flat surface with a pillow below their head for support, the physical therapist put one hand on the patient's abdomen while the other was over the patient's upper chest. During inhalation, keep your other hand completely motionless and the hand over the abdomen, moves upward during exhalation, hold your other hand as motionless as possible and the hand over the abdomen moves downward. Inhalation was done via the nose and exhalation was done through the mouth[37].

Figure 2: Diaphragmatic breathing exercise

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The diaphragmatic breathing exercise consisted of 3 sets per day of 10 repetitions, with 30-60 seconds of rest among each set [13]. Patients were requested to perform diaphragmatic breathing exercise as home exercise, 3 sets of 10 repetitions, each day; verbal instruction was given to adhere to home exercise was obtained verbally in every session. The intervention was conducted two days a week, for six weeks for all patients by the researcher[18].

Kinesiotape

The patient in group C was sitting and with a marker pen the xiphoid process was marked anteriorly and the 12th thoracic vertebra was marked posteriorly then the tape was applied by the researcher over the diaphragm muscle both anteriorly and posteriorly.

Sites for taping were selected using methods detailed by Kase et al.[38] The anterior approach involved applying the base point of a "I" shaped KT over the xiphoid process while maintaining a tension of 50–70% on the linea alba. The tape's tails were then directed into the subcostal curvature. An additional "I" shaped KT was placed from behind to the posterior. Using a tension of 50 to 70 percent, the tape was affixed at the base point to the protrusion of the 12th thoracic vertebra, while the tails were pulled toward the ribs. The tape was applied every three to four days for six weeks[18].

Figure 3: Kinesiotape application

Data analysis

To compare the gender distribution among groups, we used a Chi-squared test, and to compare the participant's characteristics, we used an ANOVA test. The Shapiro-Wilk test was used to ensure that all variables had normally distributed data. We used Levene's test for homogeneity of variances to determine if the groups were similar to each other. To compare the effects of each group on 6MWT as well as oxygen saturation, a mixed MANOVA was conducted. Next, for each set of multiple comparisons, post hoc tests were performed with the Bonferroni correction. A significance criterion of $p < 0.05$ was established for all statistical tests. For this study, we used SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA) to carry out all statistical analyses.

Results

***Subject characteristics*:**

Shapiro-Wilk test for normality showed that the measured variables were normally distributed. Levene's test for homogeneity of variance showed that the groups were homogeneous ($p > 0.05$). All three groups' patients' characteristics are shown in Table (1). No significant difference has been detected in age, BMI, as well as gender distribution ($p > 0.05$).

Table 1: The Basic characteristics of participants.

	Group A	Group B	Group C	p-value
Age, mean ± (SD), years	27.05 ± 3.76	26.30 ± 5.38	26.40 ± 5.28	0.87
BMI, mean ± (SD), kg/m²	23.75 ± 1.44	23.78 ± 1.21	23.07 ± 1.36	0.17
Sex, n (%)				
Females	5 (25%)	3 (15%)	7 (35%)	0.34
Males	15 (75%)	17 (85%)	13 (65%)	

SD: standard deviation; p-value: level of significance

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Impact of treatment on 6MWT and oxygen saturation

Mixed MANOVA was conducted to investigate the effect of treatment on 6MWT and oxygen saturation. The results of the mixed MANOVA showed that the interaction between treatment and time was significant. (F = 4.73, p = 0.001, Partial Eta Squared = 0.15). The main impact of time was statistically significant (F = 100.91, p = 0.001, Partial Eta Squared = 0.78). The results showed that the treatment had no statistically significant main impact (F = 1.38, p = 0.05, Partial Eta Squared = 0.24).

Within group comparisons:

Three groups showed a statistically significant improvement in 6MWT and oxygen saturation after treatment compared to before treatment ($p < 0.001$). Oxygen saturation as well as the percentage of change in 6MWT were 54.29 and 21.64 % in group A, 48.18% and 69.79 % in group B, and 33.71% and 66.1 % in group C, respectively. (Table 2).

Between group comparison:

Before treatment, there was no statistically significant difference among the groups ($p > 0.05$). After treatment, group B had a significantly higher 6MWT and oxygen saturation in comparison with both group A and group C ($p < 0.05$), whereas group A and group C did not differ significantly in these variables ($p > 0.05$) .

Table 2: Mean 6MWT and O2 saturation pre and post-treatment of groups A, B and C

	Group A	**Group B**	**Group C**	**p-value**		
	mean ± SD	**mean ± SD**	**mean ± SD**	**A vs B**	**A vs C**	**B vs C**
6MWT (m)						
Pre treatment	.50 ± 60.56٢٩٣	286.00 ± 53.45	274.75 ± 59.35	0.91	0.56	0.81
Post treatment	357.00 ± 73.85	424.00 ± 64.97	367.30 ±56.26	0.006	0.87	0.02
MD (% of change)	-63.5 (21.64%)	-138 (48.25%)	-92.6 (33.71%)			
	p = 0.001	p = 0.001	p = 0.001			
O2 saturation (%)						
Pre treatment	97.65 ± 0.87	97.45 ± 0.99	97.35 ± 1.03	0.79	0.59	0.94
Post treatment	98.20 ± 0.62	98.80 ± 0.41	98.35 ± 0.58	0.003	0.66	0.03
MD (% of change)	-0.57 (54.29%)	-0.67 (69.79%)	-0.78 (66.1%)			
	p = 0.001	*p = 0.001*	*p = 0.001*			

SD, Standard deviation; MD, Mean difference; -value, Level of significance

Discussion

The current study was carried-out to compare between the impacts of KT against diaphragmatic breathing exercise in patients suffering from post-COVID-19 condition. The results of this study showed improvements for measured variables in three groups; however, the diaphragmatic group (group B) showed better improvement than group A and group C.

The significant improvement in 6MWT in the diaphragm group can be attributed to diaphragmatic exercise that strengthens the respiratory muscles and enhances respiratory function which decreases physiological and psychological stress[39] and improve aerobic capacity[40].

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The present finding was supported by Ahmed et al.[41] who examined the impact of aerobic training in addition to breathing exercises on patients with post COVID-19 condition and the results showed improvements in physical performance as evaluated by 6MWT.

Furthermore, Pathare & MacPhail[42] confirmed enhancement in physical performance as evaluated by 6MWT following physical therapy interventions (diaphragmatic breathing exercise) for a case with post COVID-19 condition and after treatment the patient was able to perform household tasks without fatigue, allowing her to back to work safely in the future.

Additionally, a study was carried-out by Liu et al.[43] to identify the effects of respiratory rehabilitation on patients with COVID-19 after discharge from the hospital. Breathing exercises, diaphragmatic breathing, stretching, as well as home program are all part of the respiratory rehabilitation program. The results showed significant improvements in physical performance as measured by 6MWT.

The current results are similar to previous results that have demonstrated beneficial outcomes from diaphragmatic breathing exercise by Al Chikhanie et al.[44] who reported significantly greater 6MWT enhancement in COVID-19 patients. Also, Hermann et al. [45] confirmed that distance walked in 6MWT improved significantly after applying diaphragmatic breathing exercise to patients following COVID-19.

However, Tomruk et al.[18] found that there was no superiority of diaphragmatic breathing exercise over KT in COPD patients. The reason for this contradiction may be as a result of the relatively small sample size (only 27 patients).

About oxygen saturation, a significant improvement in oxygen saturation of the diaphragm group when compared to that of the control group and KT group after-treatment. No significant difference has been detected among the control group and the KT group.

The significant increase in group B can be attributed to diaphragmatic breathing exercise which reduces bronchospasm and oxygen desaturation[46]. Also, diaphragmatic breathing requires more oxygen to reach the lungs roughly 1.5 to 2 times more than with regular breathing[47]. Furthermore, it has been confirmed that diaphragmatic breathing assists with both its ascent and descent during inspiration and expiration, so reducing the work of breathing and enhancing oxygenation[48].

It's worth mentioning that improvement in oxygen saturation, can also be because the diaphragm is the primary inspiratory muscle used in spontaneous breathing and at the level of T-12 vertebrae there is the Aortic hiatus, maximum diameter of the descending aorta at its junction with the diaphragm so maximum blood supply[49].

The current results came in agreement with a new study made by Gokulakrishnan et al.[50] who investigated the effect of diaphragmatic breathing exercise among post COVID-19 patients and COPD patients. The results revealed significant improvement in oxygen saturation measured by a pulse oximeter.

This interesting finding is parallel to the outcomes reported by Chintamani & Burungale,[34] who examined the impact of diaphragmatic breathing exercise on COVID-19 patients. The results had shown improvement in oxygen saturation measured by pulse oximeter.

Additionally, Muthoharoh et al.[51] investigated the impact of diaphragmatic deep breathing exercise on COVID-19 patients. The results revealed that there was a significant enhancement in oxygen saturation evaluated by pulse oximeter. Also, a study made by Destanta et al.[52] to investigate the impact of diaphragmatic deep breathing exercise on oxygen saturation in active smokers. The exercise resulted in significant improvement in oxygen saturation measured by pulse oximeter.

However, Daitx et al.[53] found that standard physical therapy plus KT on the diaphragm is better than standard physical therapy alone in increasing oxygen saturation for patients with COPD. The reason for this contradiction may be as a result of the relatively small sample size and short intervention period (24 hours).

Limitations:

Nonetheless, given our positive outcomes in this study, it should be noted that the present study has certain limitations; specifically, there are no available concomitant ultrasonography or

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electromyography tests to evaluate the diaphragm strength. Furthermore, measuring the extent to which intervention improved peripheral muscle function is additionally not possible. Different subgroups (based on age or disease severity, for example) cannot be analyzed since the sample is too small.

Conclusion

Within the scope of this study, the following conclusion was warranted: Diaphragmatic breathing exercise could provide an additional effect in the treatment and rehabilitation for post COVID-19 condition; as it improves physical performance and oxygen saturation.

Declarations

- ***Consent for publication:*** I attest that all authors have agreed to submit the work.
- ***Availability of data and material:*** Available.
- ***Competing interests:*** None
- ***Funding:*** No fund
- ***Conflicts of interest*****:** no conflicts of interest.

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