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Pilates Exercises Improve Postural Stability, Ventilatory Functions and Functional Capacity in Patients with Chronic Obstructive Pulmonary Disease

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Abstract: ***Objective:*** *To investigate the effects of Pilates mat exercises on postural stability, ventilatory functions and functional capacity in patients with chronic obstructive pulmonary diseases(COPD)*
Methods: *a randomized controlled study involving 38 COPD patients were recruited from Elmataria teaching hospital, cairo, Egypt : 19 patients represents the study group and performed Pilates mat exercises for 12 weeks (three 60-min session per week) in addition to diaphragmatic breathing exercises and 19 patients represented the control group and performed diaphragmatic breathing ex only. The variables studied (before and after the intervention) were postural stability indices, ventilatory functions (FVC% of predicted and FEV1 % of predicted), and functional capacity (6 MWT).*
Results: *After the intervention postural stability indices, limits of stability scores, ventilatory functions and distance recorded in 6 MWT were significantly improved in study group (p≤0.05).*
Conclusions: *Our results show that Pilates mat exercises have beneficial effects on postural stability, ventilatory functions and functional capacity in patients with chronic obstructive pulmonary diseases.*
Keywords: *Pilates exercises, postural stability, ventilatory functions, functional capacity, COPD*

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I. Introduction

physical activity is an important clinical parameter causing morbidity and mortality in many chronic diseases . Physical activity level reported by patients is related to ventilatory functions decline in chronic obstructive pulmonary disease (COPD). (1)

Physical activity and body movements, have been reduced in patients with COPD (2,3). However, it is unknown at which clinical stage of the disease limitations of physical activity are manifested. Furthermore, the relationships between physical activity and clinical characteristics of the disease severity, such as the degree of airway obstruction, distance walked in 6 min, need to be further investigated (4)

Studies indicate that the 6-min walking distance (6MWD) might best reflect physical activity (3), while a recent study found that airway obstruction correlate better with physical activity than 6MWD (5).

Recently, postural stability has gained a lot of attention as an extra-pulmonary symptom for chronic lung diseases (6). Possible causes reported for postural stability impairment in patients with chronic obstructive lung disease (COPD) include hyperinflation, increased work of breathing and respiratory and peripheral muscle weakness. (6-9) It is now recommended to include assessments and rehabilitative approaches for postural stability in the pulmonary rehabilitation programs. (10)

The principles of Pilates exercises emphasize the improvement of breathing, concentration, control, axial elongation, and flexibility, which are associated with increased strength.(11)

Pilate exercises use approximately 50 simple repetitive exercises to create muscular contractions to provide gentle strength training for rehabilitation. These exercises are designed to improve muscle strength and endurance, flexibility, posture and balance; the exercises are easy to initiate and maintain. (12)

Pilates exercises include “five essentials” breathing, cervical alignment, rib and scapular stabilization, pelvic mobility and exercising the transverses abdominis. Each exercise is initiated by stabilization of core musculature including abdominal, gluteal, and paraspinal muscles in particular, and proceeds through a controlled range of motion to create an effective recruitment of motor units which enhance quality of performance. Each exercise is repeated a few times, so the body is exposed to new muscular and kinesthetic challenges. (13)

Pilates exercises can be performed either on a mat or on specialized equipment called a Reformer. In the mat class, participants sit or lie supine or prone and use gravity to stabilize the core. On the Reformer, a sliding horizontal platform within a box-like frame upon which a person sits, stands, kneels or reclines; resistance to movement is provided via springs attached to the moving platform and through a pulley system. The main resistance that is used throughout the series of Pilates mat exercises is the body weight. Changes in the lever lengths of limbs and body position can continue to challenge participants as their fitness levels increase. The psychological element of Pilates is evident in the focus on breathing during the execution of these exercises (14).

The aim of this study was to find out the effects of Pilates exercises on postural stability, ventilatory functions, and functional capacity in patients with COPD**.**

II. Subjects and methods

A prospective, randomized controlled study was conducted between septembr 2018 and march 2019. Thirty eight male patients aged between 40 and 50 years diagnosed with COPD, their BMI ranged from 25-34.9(overweight and class I obesity) were screened to be enrolled into 12 weeks blinded study. They were recruited from outpatient clinics of the Elataria teaching hospital, Cairo, to participate in this study. This study was approved by the Ethics Committee for Scientific Research of the Faculty of Physical Therapy, Cairo University. Informed consent for participation and publication of the results of the study was provided. The participants underwent initial evaluation. Inclusion criteria were as follow: COPD patients had to be free of an exacerbation for at least 2 months. Post-bronchodilator spirometry was performed. Moderate COPD [forced expiratory volume in 1 s/(FEV1)/forced vital capacity <70% predicted and 50%≤ FEV1 <80% predicted][15]. Smoking index of less than 10 packs/year,

Exclusion criteria were as follows: severe COPD (FEV1<50% predicted) (15), oxygen-dependent or mechanically ventilated patients, decrease cognition level, musculoskeletal or neurological abnormalities, and presence of visual or hearing disorders that can affect balance

Each patient underwent an initial medical screening by the physician. Documentation of clinical history was done, and explanation of the study protocol and objectives was done for all the participants who were asked to maintain their pharmacological treatment and normal daily activities and lifestyle throughout the study. Patients were randomly assigned using opaque envelop into two groups by an investigator who was not implicated in this study :

Group A, the study group, who received mat Pilates training in addition to diaphragmatic breathing exercises

Group B , the control group received only diaphragmatic breathing exercises

Outcome measures

The two groups were subjected to the same initial tests: baseline measures before training and after 12 weeks at the end of exercise training program:

postural stability which was assessed with Biodex Balance System (BBS) (Biodex, Inc., Shirley, NY, USA) using 'Postural Stability Test (PST) for static postural stability and 'Limits of Stability Test (LOST) for dynamic postural stability (16). In PST, subjects are instructed to stand still on the platform and the displacement of the centre of gravity (COG) is quantified for anteriorposterior (AP) and medial-lateral (ML) axes. PST gives three types of outcome measures: overall stability index, AP stability index and ML stability index. Higher scores indicate worse postural stability. LOST evaluates the ability to move the centre of gravity in desired directions. Subjects are instructed to stand on the platform and lean in eight directions to control the cursor displayed on the screen and try to move the cursor inside the target circles. LOST provides scores for all eight directions as well as an overall score. Higher scores indicate better performance which means a better dynamic postural stability.

Pulmonary function test was performed using a spirometer (COSMED Pony FX; COSMED, Italy) according to the guideline of American Thoracic Society (ATS) and European Respiratory Society (ERS) (17). Forced vital capacity (FVC), FEV1, FEV1/FVC were measured and expressed as percentages of the predicted values.

Functional capacity was assessed with the 6-min walk test (6MWT) according to the guideline of ATS (18) Patients were instructed to walk as fast as possible between two cones positioned 30m apart and the distance walked in 6 min was recorded. Oxygen saturation and heart rate were also measured before and after the test using a pulse oximetery.

Intervention

Pilates exercises:

The activities were performed on a mat, with participants wearing no shoes, for better contact with the ground. The activity program included respiratory, postural, and abdominal exercises, as well as exercises for the trunk, upper limbs, and lower limbs. (19)

Mode of exercise: The Pilates training program sample Duration of exercise : each session include three phases: - An initial (7-10) minutes warm up phase in the form of (breathing , arm circles ,hip rolls) - Pilates phase 40 minutes that consisted of 5 types of exercises (bent knee, pelvic bridge, Side kick front ,Side kick back , Single Leg Circle) duration of each one from 7-8 minutes - Finally, cool down phase (7-10) minutes in the form of (neck stretch, knee stretch , breathing) Frequency: Exercise training was done three times per week for twelve weeks

intensity of the exercises: warm up phase :9-11 on Borg scale

- Pilates phase : moderate intensity at 12- 14 on Borg scale , and finally cool down phase : 9-11 on Borg scale(20)

Diaphragmatic breathing exercises: Exercises were performed as two sets for 5 repetitions with the rest intervals of 5–6 tidal breaths between the exercises to avoid respiratory muscle fatigue and hyperventilation (21), three times per week for twelve weeks

Data analysis

Statistical analysis was conducted using SPSS 20.0 statistical program (SPSS Inc., USA). Paired Sample T-test was used for within group comparisons and Independent Samples T-test was used for between-groups comparisons depending on the distribution properties of the data. . The results were considered significant with p values ≤ 0.05.

III. Results

Demographic data of the participants are presented in Table 1. No significant differences were found between both groups in age, weight BMI, FEV1% of predicted, and EV1/FVC% ((P> 0.05).

Table 1: Demographic characteristics of the participants

Variable	Study group: (n=19)	Control group: (n=19)	p-value
Age(yrs)	43.o5±2.07	42.09±3.08	0.12
Weight(kg)	82.27 ± 5.6	80±3.8	0.18
BMI(kg/m^2)	32.4±2.6	31±3.1	0.17
FEV1 predicted (%)	62.72±3.34	63.59±3.61	0.24
FEV1/FVC (%)	49.25±6.36	47.73±4.2	0.41

Data were represented as mean±SD ; No significant differences(P> 0.05); FEV1/FVC, forced expiratory volume in 1^{st} second/forced vital capacity ; BMI: body mass index.

Results of postural stability, ventilatory functions and 6MWT

Between group comparisons

Data presented in (table 2) revealed that there were no significant differences concerning all the dependant variables including variables of postural stability tests , limits of stability tests, ventilatory functions and distance walked in 6 MWT pre-intervention, while there were significant differences in these variables in post intervention measurements in favor of study group ($P \leq 0.05$)

Within group comparisons

Study group

Data presented in table 2 revealed that there were significant improvement concerning all dependant variables including variables of postural stability tests , limits of stability tests, ventilatory functions and distance walked in 6 MWT($P \leq 0.05$) when comparing pre and post test results.

Control group:

Data presented in table 2 revealed that there were no significant differences concerning dependant variables including that of postural stability tests, limits of stability tests, and distance walked in 6 MWT(P>0.05) when comparing pre and post test results, while there were significant differences in ventilatory functions (FEV1% predicted FVC% of predicted) (($P \leq 0.05$)

Table 2: pre and post mean values of postural stability , ventilatory functions and 6 minute walk test in both groups

Variable	Study group: (n=19)	Control group: (n=19)	p-value	Study group p-value (pre and post intervention)	Control group p-value (pre and post intervention)
Postural stability test					
Overall SI -pre	3.54±0.34	4.12±0.11	0.12	0.000*	0.31
Post	1.98±0.12	3.96±0.33	0.005*		
A/P- pre	2.98±0.94	3.11±0.14	0.21	0.001*	0.53
Post	1.23±0.16	3.02±0.21	0.002*		
M/L- pre	0.98±0.26	0.96±0.16	0.16	.000*	0.812
Post	0.12±0.11	0.94±0.21	0.001*		
Limits of Stability Test					
Overall Score-pre	51.43±12.6	49.9±12.65	0.112	0.000*	0.614
Post	60.34±15.8	47.6±11.5	0.002*		
Forward DS- pre	55.67±15.8	56.37±16.9	0.14	0.001*	0.512
Post	64.98±12.76	54.78±19.46	0.001*		
Backward DS-pre	46.75±19.2	48.37±11.9	0.21	0.001*	0.231
Post	59.21±15.32	52.51±12.41	0.012*		
Right DS-pre	52.17±15.4	51.27±11.6	0.36	0.001*	0.11
Post	65.38±11.66	53.26±14.21	0.001*		
Left DS-pre	51.67±12.8	50.67±11.8	0.101	0.001*	
Post	62.38±12.96	53.18±17.22	0.001*		0.15
FCV (%) pre	82.12±17.34	78.65±15.76	0.25		
Post	90.65±23.34	82.23±13.44	0.006*	0.002*	0.013*
FEV1 (% of predicted) pre	62.72±3.34	63.59±3.61	0.34	0.005*	0.03*
Post	71.65±2.65	67.87±4.34	0.003*		
6MWT-pre	465±54	470±41	0.632	0.003*	0.612
Post	623±52	490±55	0.004*		

Data are reported as mean ± standard deviation.; SI: Overall stability indices; A/P: Anteroposterior.; M/L: Mediolateral.,; FVC: forced vital capacity; FEV1: forced expiratory flow in first second; 6MWT: 6-min walk test; *: significant (P≤0.05)

IV. Discussion

COPD would be considered as the third major cause of death by the year 2020 (15). The most earnest manifestation of COPD is dysfunction of skeletal muscle, and this is clearly shown in early dyspnea and fatigue after minimal exertion (22).

The Pilates method is an exercise program of body and mind that is gaining acceptance and popularity worldwide. (23)

Pilates program include movements which allow improvements in flexibility, range of motion strength, fitness, coordination, postural alignment and blood circulation .(24)

the current study demonstrated that 12 weeks of mat palates exercises significantly improved postural stability, ventilatory functions and functional capacity in patients with moderate COPD

It was reported that the hyperinflation in patients with COPD limits the contribution of trunk to postural stability by forcing the sternum outward and consequently reducing the thoracolumbar spine mobility also, Hyperinflation also causes inspiratory muscle weakness by putting a mechanical disadvantage on the diaphragm which is one of the core muscles. When the function of diaphragm is impaired, its sensory and motor contribution to postural stability also reduced (25).

In agreement with our results, twenty four subjects aged 65 to 81 enrolled in a ten week exercise program in which they were randomly assigned to a traditional strength plus flexibility group, a Pilates based-training group and a no exercise control group. Results of this study indicated that Pilates are effective for improving static balance in elderly adults (26).

In our opinions Additional research specifically on individuals who are prone to balance disturbances or falling needs to be conducted before any generalizations that can be drawn of the effectiveness of Pilates exercises in fall prevention.

pulmonary functions were investigated on 50 sedentary females with a mean age of 60 years The participants were randomly assigned in to a control group (n = 25) and an intervention group (n = 25). The control group maintained their usual activities without participating in any structured exercise, whereas the intervention group performed mat Pilates exercises for an 8-week period . The program consisted of 3, nonconsecutive, 60-minute sessions per weeks. Spirometry was done before and after training with Pilates, significant improvements ($P < .05$) were found in FEV1, forced expiratory flow at 25% of forced vital capacity (FVC), peak inspiratory flow, peak expiratory flow (PEF), and mean forced expiratory flow. Given those results, it was concluded that physical training programs using Pilates can improve lung function in older, sedentary individuals and can improve impaired exercise capacity and physical function .(27)

contradicting to our results, a clinical trial was conducted with 19 patients with cystic fibrosis, 7 men and 12 women. The patients performed a weekly session of Pilates exercises for 60 minutes, for a total treatment period of 4 months. The variables studied before and after intervention were FVC, FEV1, maximal inspiratory pressure [MIP]) , and maximal expiratory pressure (MEP). After the program, a significant increase in MIP was found in male patients, whereas significant increases occurred in MIP and MEP for female patients, respectively. However , no significant differences were found in FVC and FEV1. The results of that study showed the beneficial effects of application of the Pilates method for respiratory muscle strength in the studied patients, however lack of improvement of ventilatory functions may be attributed to decreased frequency of exercise(28)

Research has highlighted the benefits of physical exercise, taking into account different modalities, and has found improvements in % lean mass and VO2max. (29)

Eyigor el al(30) addressed the effect of Pilates exercises as a new approach to improve functional capacity, fatigue , depression and quality of life.

In conclusion: our results show that Pilates mat exercises have beneficial effects on postural stability, ventilatory functions and functional capacity in patients with chronic obstructive pulmonary diseases. So therefore we advice the addition of these exercises in pulmonary rehabilitation program of such patients.

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Conflicts of interest

There are no conflicts of interest

AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study

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