ARCHIVES OF HELLENIC MEDICINE: ISSN 11-05-3992

ORIGINAL PAPER
ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

ARCHIVES OF HELLENIC MEDICINE 2025, 42(4):548–553
ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2025, 42(4):548–553

The effect of clinical Pilates combined with routine physiotherapy on respiratory function in patients with non-specific low back pain

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OBJECTIVE **To examine whether a change in respiratory function could be observed after clinical Pilates exercises in patients with chronic low back pain of non-specific etiology.** METHOD **The participants were adults, having low back pain for more than three months and being diagnosed with back pain of non-specific etiology. Assessments included spirometry and chest expansion for evaluating respiratory functionality. A pain intensity 0–10 scale and the Quebec Back Pain Disability Scale were used to assess pain and functionality. All assessments were performed at the beginning and at the end of the program.** RESULTS **Seven patients completed all ten sessions that included electrophysical agents, massage and four different clinical Pilates exercises. A statistically significant difference was found in FEV_1%, FEV_1/FVC%, chest expansion and Quebec Back Pain Disability Scale and the current pain intensity ($p<0.05$).** CONCLUSIONS **Clinical Pilates exercises combined with routine physiotherapy seems to have a positive effect in the respiratory function of patients with low back pain of non-specific etiology.**

Η επίδραση των κλινικών ασκήσεων Pilates σε συνδυασμό με τη συνήθη φυσικοθεραπεία στην αναπνευστική λειτουργία ασθενών με οσφυαλγία μη ειδικής αιτιολογίας

Περίληψη στο τέλος του άρθρου

Key words

Clinical Pilates
Low back pain
Physiotherapy
Respiratory function

Submitted 9.6.2024
Accepted 6.7.2024

The presence of pain in the lumbar spine or higher levels can lead to variations in the posture of the body to form an antalgic position. This often results in a flexed pattern of the thoracic spine.[1] As the motion of the thoracic spine involves concomitant motion of the ribs, restricted rib mobility affects the breathing process, thus limiting the degree of lung expansion and functionality of the respiratory system.[1] In patients with chronic low back pain, respiratory function is often limited and underestimated clinically.[2] Interestingly, the contrary has been found to be true, as dysfunction of the respiratory system reduces one's ability to stabilize their low back during lifting tasks.[3] We should bear in mind that the diaphragm plays a vital role in contributing to spinal stiffness through the influence of intra-abdominal pressure, mechanical effect, and attachments of the diaphragm.[4] Under laborious tasks with increased respiratory demand, its role as a stabilizer is certainly compromised.[4] This could explain why significant diaphragmatic fatigability is observed in patients with low back pain.[5] It has been noted that these patients' altered breathing pattern could be the cause for diaphragmatic dysfunction.[6] Improving the function of respiration is no less important than improving the back extensor endurance and posture.[5] It is quite interesting that thoracic mobilization has a beneficial effect on respiratory parameters.[1,7] And even when self-mobilization is used, there is beneficial effect in chest expansion.[8] Similar findings were noticed in patients with non-specific low back pain, that prior the intervention had significantly reduced diaphragmatic mobility and respiratory muscle endurance.[9,10]

The study of the effect of diaphragmatic breathing during the performance of clinical Pilates exercises and

the potential benefits on respiratory function will help to identify further positive effects of the approach, broadening the scope of its application. Breathing during Pilates has been found effective in improving chest expansion, reducing dyspnea, and increasing the functional capacity in other populations even in chronic obstructive pulmonary disease (COPD) patients.[11,12] It will also be an additional therapeutic intervention in the physiotherapists' quiver for the treatment of chronic back pain of non-specific etiology and will increase the patient's functional capacity, as well as a confirmation of the literature on the association between low back pain and respiratory function, underlining the need for a holistic approach to patients with musculoskeletal diseases.

Thus, the aim of the study was to examine whether clinical Pilates exercises in patients with chronic low back pain of non-specific etiology could have a beneficial effect in the respiratory function of these patients, as this population has not extensively studied.

MATERIAL AND METHOD

Participants

The participants were adults, diagnosed with back pain of non-specific etiology, referred to a physiotherapy in a private clinic. To be included in the study, participants should have reported low back pain for more than 3 months, not being diagnosed from any other pathology based on imaging examination. Women who were pregnant, patients with fracture of the spine, chronic respiratory disease, and smokers (more than 1/2 pack per day) were excluded from the study. Patients were included in the program after signing an informed consent.

Rehabilitation program

Patients received an intervention of clinical Pilates exercises combined with usual physiotherapy. The usual physiotherapy care comprised electrotherapy, massage, laser, and transcutaneous magnetic stimulation in the lumbar spine. The patients attended 10 sessions in a period of 3 weeks. Each session had an average duration of 80 minutes. The clinical Pilates exercises were performed by a physiotherapist accredited in clinical Pilates and consisted of four different exercises: (a) Pelvic press, (b) bridge, (c) single leg stretch, and (d) opposite arm and leg reach (bird dog).[13] The patients were instructed diaphragmatic breathing, and this was performed during the effort. The patients fulfilled 3 sets of 12 to 15 repetitions (depending on the endurance of each patient), for each exercise in 30–40 minutes.

Assessments

Pulmonary function (FEV_1%, FVC% and FEV_1/FVC%) was measured with the spirometer Spirolab III, MIR009 according to the guidelines of the American Thoracic Society.[14] Prior to performing the spirometry, patient's height and weight were measured and their age and sex were also recorded. The test was performed in an upright sited position, with feet flat on the floor and with legs uncrossed. It is well documented that there is no difference in the amount of air the patient can exhale from a sitting position compared to a standing position as long as they are sitting up straight and there are no restrictions. The patients were asked to perform three maneuvers and the best was recorded. Chest expansion was measured with a rated tape at the fourth intercostal space, with the arms being positioned at the side, at the sited position.[15] The patient was asked to exhale fully, and this initial measurement was recorded. Next, the patient was asked to inhale deeply, and the measurement was repeated. The difference between the two measurements represented the extent of chest expansion. Pain intensity was measured with a Visual Analogue Scale (VAS) from 0 to 10.[16] VAS has been found to be a valid and reliable scale that can be used in clinical practice as an outcome measure tool.[16,17] Prior to intervention, patients were asked their pain intensity during the past couple of days. The dysfunction caused by back pain was assessed with the Quebec Back Pain Disability Scale. This is a condition-specific questionnaire for patients with low back pain.[18] It involves 20 daily activities with a rating from 0 (no effort) to 5 (not able to) depending on the ease or difficulty to perform each activity. The daily activities can be categorized into six domains: bed/rest, sitting/standing, ambulation, movement, bending, handling of large or heavy objects. The maximum total score is 100 and represents the highest degree of disability. The scale has been adapted in Greek and its reliability and validity has been confirmed.[19] All measurements were performed at the beginning and the end of the therapeutic program in random order. The study was approved by the Ethics Committee of the University of West Attica (protocol number 59931/28.6.2022).

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (IBM SPSS), version 21.0. Dependent variables were tested for normality of distribution (Shapiro-Wilk test). Descriptive methods were used to present data via mean (standard deviation, SD) and median (interquartile range, IQR) statistics, as the sample was small. Both parametric (dependent samples T-test) and non-parametric (Wilcoxon signed-rank test) tests for pre-post comparisons of dependent variables were used for the main analysis. A p-value of <0.05 was considered statistically significant.

RESULTS

Ten patients participated in the study. Two of them withdrew for personal reasons and a woman because of pregnancy. Finally, seven participants (five women/two men) completed the intervention. The participants' char-

acteristics are presented in table 1. All participants stated that this was their first time they attended a clinical Pilates program, and six of them stated that they had physiotherapy sessions again in the past.

After the program completion, including clinical Pilates exercises all outcomes measures showed statistically significant increase ($p<0.05$) when checked with both parametric and non-parametric tests (tab. 2). Lumbar pain was significantly reduced (mean±SD: 4.4±1.3 to 1.6±0.9, $p<0.001$), along with the score of Quebec Back Pain Disability Scale (mean±SD: 34.71±17.4 to 14.00±8.5, $p<0.05$). Statistically significant differences were also found with the Wilcoxon signed-rank test for pain and disability pre-post differences.

DISCUSSION

To our knowledge, the present study was the first study that attempted to examine the effect of clinical Pilates combined with usual physiotherapy in adults with chronic low back pain of non-specific etiology and showed evidence of improvement in respiration volumes, chest expansion, pain symptoms and disability.

The findings of our study provided further proof regarding the positive effect than clinical Pilates have in functionality of the respiratory system in chronic low back pain of non-specific etiology as there is strong association between them.[9,20] Chronic lumbar pain affects the strength, endurance, and mobility of the diaphragm.[2,5,9] The diaphragm is not only an inspiratory muscle but a spinal posture stabilizer as well.[21] Patients with chronic back pain of non-specific etiology, often adopt an antalgic posture to overcome painful stimuli during activities of daily living.[1] This seems to lead in biomechanical changes of the posture and support of the trunk, which in turn affect the thoracic spine, resulting in a reduction of lung expansion and consequently of respiratory volumes. The adoption of an abnormal breathing pattern in patients with chronic back pain makes them prone to paroxysmal episodes of pain.[20] Clinical Pilates exercises have a beneficial effect on painful pathologies of the spine[22,23] and on back pain of non-specific etiology.[24,25] Enhancing the ability of the individual to maintain posture, will decrease the load on the diaphragm that acts both as stabilizer and inspiratory muscle. Clinical Pilates exercises could play an important role in pulmonary rehabilitation as the breathing pattern adopted when performing them helps to increase the strength of the respiratory muscles, increase volumes, achieve better ventilation and diffusion.[8] Further, diaphragmatic breathing, encouraged during the performance of the clinical Pilates exercises, leads to increased mobility of the ribs as patients give emphasis on increasing all diameters of the chest. Each inhalation has been found to increase the intercostal space leading progressively to an increased chest expansion.[26] Although, diaphragmatic breathing presents differences in relation to usual lateral breathing adopted in clinical Pilates, in the present study we were able to notice the same positive effects. Additionally, diaphragmatic breathing has been found to have greater effect that lateral breathing in COPD population, when differences in respiratory pattern were examined.[27] Yet, we should take into consideration the pathophysiology of COPD.

A recent publication has also underlined the positive effect of the holistic approach of Pilates in cardiorespiratory fitness.[8,28] The neuromuscular stimulation and the body-mind connection are two key components of this approach. The positive results of Pilates method could be attributed to the guiding principles of the Pilates.[29] The authors assumed that centralization (this is the ability to maintain control of the pelvis, spine, in order to provide a stable base-core) allowed the recruitment of the trunk muscles, abdominal wall and diaphragm, which resulted in the improvement of the thoracoabdominal mobility and thus in respiratory mechanics.[29] The present findings were in accordance with a recent randomized clinical trial involving 62 healthy women that reported significant

Table 1. Participants' data.

Gender	5 females and 2 males
Age (mean±SD)	39.16±16.57 years
Body mass (mean±SD)	71.71±13.06 kg
Height (mean±SD)	1.74±0.09 m
Duration of symptoms (median-IQR)	12 (6–96) months

SD: Standard deviation, IQR: Interquartile range

Table 2. Pre- and post-intervention measures of the variables of lung function and chest expansion ($p<0.05^*$ between pre- and post-measurements).

	Pre-intervention (baseline)		Post-intervention	
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)
FEV_1%	84.71±6.4	81 (80–90)	89.86±6.5*	90 (86–93)*
FVC%	89.57±8.6	86 (81–98)	95.00±7.3*	98 (87–102)*
FEV_1/FVC%	97.86±7.2	100 (90–104)	99.86±6.7*	101 (94–105)*
Chest expansion	2.4±0.8	2.1 (1.6–3.5)	2.6±0.9*	2.2 (1.8–3.8)*

FEV_1: Forced expiratory volume in one second, FVC: Forced vital capacity, SD: Standard deviation, IQR: Interquartile range

improvement in inspiratory muscle strength and exhaled volumes after 16 sessions of clinical Pilates.[30] It was noted that deep diaphragmatic breathing during the exercises could be the explanation for these results. Other studies have included an inspiratory training program to enhance this effect.[31] Our findings are in accordance with a recent study of women with chronic low back pain, that compared clinical Pilates program to a home-based exercise program.[32] Clinical Pilates was found to alleviate pain and to improve FVC in the intervention group, but without showing statistical difference in relation to the control in terms of the respiratory function.[32] In our study, the implementation of routine physiotherapy along with the clinical Pilates could have a significant impact on pain relief, thus a part of the improvement noted could be related to this relief.

Clinical recommendations, in order to augment this beneficial effect, underline the importance of an exercise frequency greater than two or three times a week, with each session lasting at least 60 minutes, with a minimum cumulative training of 20 hours. Optimal results could be achieved if performed for three to six months.[33] Attention should be given to incorporating all training principles. We should not forget that this exercise program is unique as the person needs to perform the exercises with precision; thus in full concertation trying to keep control while combining breathing.[34] It is well pointed out from a Delphi survey study that indications for Pilates in this specific population include primarily maladaptive movement patterns and lack of body awareness, and then poor breathing pattern, poor postural control, psychosocial factors associated with pain, reduced lumbar spine mobility and weak lumbar spine stabilizing muscles.[34,35] Regarding the use of special equipment, it seems that data from different studies are controversial and need further investigation.[3]

The main limitation of the present study is the small sample, the lack of a control group and additional outcomes, such as inspiratory strength and endurance that could provide us with more information on the status of the diaphragm. As the improvement of the respiratory variables due to the reduction of pain intensity in the present study was the effect of the implementation of both clinical Pilates exercises and routine physiotherapy, it is a challenge for further research studies to clarify the attribution of solely clinical Pilates. In regard to our pain assessment tool, although VAS has been found to be a valid and reliable scale, it has a subjective nature, and this should be kept in mind. Additionally, the lack of follow-up assessments, prevents us from monitoring the sustainability of the improvements noted in respiratory function. These results will help physical therapists to understand the impact of the musculoskeletal system pathology on the respiratory system and the holistic approach required to explore different pathologies to maximize the effectiveness of their treatment program.

In conclusion, the present study offered an additional perspective for the implication of clinical Pilates combined with routine physiotherapy in patients with back pain of non-specific etiology, as it provided evidence of improvement in pain intensity and daily activities, as well as in lung function and chest expansion. To reach clearer conclusions, randomized clinical trials in this field should be conducted. Further investigation of the dosage, the combination of exercises and the use of instruments will offer a better understanding not only of the program itself but on how to augment its effectiveness in different populations.

ΠΕΡΙΛΗΨΗ

Η επίδραση των κλινικών ασκήσεων Pilates σε συνδυασμό με τη συνήθη φυσικοθεραπεία στην αναπνευστική λειτουργία ασθενών με οσφυαλγία μη ειδικής αιτιολογίας

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Αρχεία Ελληνικής Ιατρικής 2025, 42(4):548–553

ΣΚΟΠΟΣ Να εξεταστεί εάν θα μπορούσε να παρατηρηθεί αλλαγή στην αναπνευστική λειτουργία μετά από κλινικές ασκήσεις Pilates. **ΥΛΙΚΟ-ΜΕΘΟΔΟΣ** Οι συμμετέχοντες ήταν ενήλικες, με συμπτώματα για >3 μήνες και είχαν διαγνωστεί με οσφυαλγία μη ειδικής αιτιολογίας. Οι αξιολογήσεις περιλάμβαναν σπιρομέτρηση και έκπτυξη του θώρακα για την αξιολόγηση της αναπνευστικής λειτουργικότητας. Η οπτική αναλογική κλίμακα (VAS) έντασης πόνου 0–10 και η κλίμακα αναπηρίας σχετιζόμενη με οσφυαλγία (Quebec Back Pain Disability Scale) χρησιμοποιήθηκαν για την αξιο-

λόγηση του πόνου και της λειτουργικότητας. Όλες οι αξιολογήσεις έγιναν στην αρχή και στο τέλος του προγράμματος. **ΑΠΟΤΕΛΕΣΜΑΤΑ** Επτά ασθενείς ολοκλήρωσαν και τις δέκα συνεδρίες που περιλάμβαναν ηλεκτροφυσικά μέσα, μάλαξη και τέσσερις διαφορετικές κλινικές ασκήσεις Pilates. Στατιστικά σημαντική διαφορά βρέθηκε στο FEV_1%, στο FEV_1/FVC%, στην έκπτυξη του θώρακα, στην κλίμακα Quebec και στον πόνο ($p<0,05$). **ΣΥΜΠΕΡΑΣΜΑΤΑ** Οι κλινικές ασκήσεις Pilates σε συνδυασμό με φυσικοθεραπεία ρουτίνας φαίνεται να έχουν θετική επίδραση στην αναπνευστική λειτουργία ασθενών με οσφυαλγία μη ειδικής αιτιολογίας.

Λέξεις ευρετηρίου: Αναπνευστική λειτουργία, Κλινικές ασκήσεις Pilates, Οσφυαλγία

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