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Review Article

Pilates Training: for Improving Respiratory Function a Systematic Review

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ABSTRACT

Background: The aim of this study was to systematically review the researches based on the effects of pilates exercises on pulmonary function and static respiratory pressures.
Materials and Methods: MEDLINE, Elsevier, ProQuest, PubMed, Scopus, Springer and Google databases were explored till December 2017. Studies published in English language were included. The respiratory and cardiac parameters studied along with other musculoskeletal parameters were considered in this study. Out of the total 41 studies reviewed, 11 studies met our inclusion criteria.
Results: Significant improvements in respiratory pressures were observed post pilates training in various subjects. Some parameters of the pulmonary function were also improved along with the improved thoracoabdominal mobility.
Conclusion: Based on the findings of the present study pilates exercises are suggested for enhancing the respiratory function and pressures in varied subjects.
Keywords: Maximal Inspiratory Pressure, Maximal Expiratory Pressure, Pulmonary function test, systematic review, pilates exercises.

INTRODUCTION

Pilates exercises comprises of physical and mental training, which focuses on body perception thereby linking the body and mind. [1] It mainly works on six essential and interconnected principles: centering, concentration, control, precision, breathing and movement flow. [2] These days pilates has gained recognition in both rehabilitation and fitness programs [3] and are being extensively used for the physical conditioning and, for rehabilitation and prevention and are thus found to be associated with wellness. [4] The pilates exercises predominantly aim to develop the overall strength and flexibility of the body, with primary focus on core, good posture, alignment and synchronization between breaths and movement. [3]

In these exercises one is requisite to learn breathing properly as an important element of each exercise. [5] The inspiration always takes place to prepare for the move and the expiration occurs while carrying out the movement. [6-8] This proper breathing aids in controlling movements and these exercises can be deemed as indirect strategy for training the respiratory muscles. [5] Studies have shown that greater respiratory endurance, lung volumes and, inspiratory and expiratory flow rates have been noticed in people performing physical activity. [10]

Different studies involving various subjects have shown varied effects of pilates exercises on cardiac and pulmonary system. It was shown in cystic fibrosis subjects that pilates training lead to an increase in maximal inspiratory and maximal expiratory pressures but no changes were observed in

FEV_1 and FVC. [11] In patients with renal transplantation it was noticed that pilates training lead to more significant improvement in FEV_1 and FVC as compared to controls. [12] Fernandes et al found a significant decrease in heart rate and improvement in peak VO_2, maxVO_2 and maximum ventilation in healthy volunteers post pilates training. [13]

Based on these findings and the fact that breathing is the most essential element in pilates exercises, the objective of the current study was to conduct a systematic review of literature to synthesize the evidence on effect of pilates exercises on respiratory function. If this evidence supports these effects, then the pilates rehabilitation could be suggested when the aim is to improve the pulmonary function and static respiratory pressures in different conditions. The questions to be looked upon in this study are: (1) Is there any effect of pilates exercises on respiratory parameters? (2) Which parameters are best improved?

METHODS

This systematic review included the data available without any limitation from the following databases; MEDLINE, ProQuest, Google Scholar, Springer and PubMed.

Search Strategy:

The search was done by using the key words: pilates exercises, respiratory muscle, ventilatory function, pulmonary system, respiratory dysfunction, chest mobility.

Inclusion Criteria:

Studies with following criteria were involved: effect of pilates exercises on pulmonary function, and cardiorespiratory fitness, and being published in English language. The studies involving the parameters other than pulmonary function were excluded.

RESULTS

Description of studies:

Forty one studies were identified and on the basis of inclusion criteria 30 studies were excluded and only 11 studies were included in this study, [1,11-13,20-26] and a total of 352 subjects participated in these studies. Both males and females were included in 8 studies and in three studies only female participants were enrolled. Out of the total 352 subjects included in these studies, healthy volunteers: 132, cystic fibrosis: 19, cardiac surgery:14, renal transplantation: 40, ankylosing spondylitis: 55, 16 chronic heart failure, 20 post stroke, and chronic renal failure: 56, participated. The total number of subjects undergoing pilates training ranged from 7 to 28. The total duration of treatment ranged from 10 sessions to 36 sessions, varying from 5 sessions a week protocol to one session per week. Full details of each study are provided in Table 1.

Effect of Pilates on Respiratory muscle strength:

The respiratory muscle strength was assessed and compared pre and post among the participants performing pilates in 5 studies. [1,11,21-23] Out of these five studies, three [1,11,23] showed a significant improvement in maximal inspiratory as well as maximum expiratory pressures (MIP and MEP), whereas, in a study done by Sarmento et al, [22] both pilates and conventional training programs lead to a significant increase in MIP. So, total four studies showed improvement in MIP and three studies showed improvement in MEP. Cordeiro et al found that in subjects post cardiac surgery pilates training lead to no change in MIP and MEP. [21]

Effect of Pilates on Pulmonary function:

Pulmonary function was assessed using spirometry in 5 articles. [1,11,12,21,23] In a study by Franco et al [11] pilates training caused no significant change in forced expiratory volume in 1s (FEV_1) and forced vital capacity (FVC), a similar finding was observed by Jesus et al showing no significant improvement in FVC, FEV_1 and FVC/FEV_1 post pilates training. Giacommini et al [1] showed a significant improvement in maximum voluntary ventilation (MVV) and peak expiratory flow (PEF) after pilates training but no

improvement was noticed in FVC, FEV_1 and FEV_1/FVC. In a study by Waked et al [12] a similar significant improvement in FEV_1 and FVC among the participants of pilates as well as conventional training group post renal transplantation. Another study by Cordeiro [21] showed a significant increase in FVC after pilates training post cardiac surgery.

Effect of Pilates on other cardio-respiratory parameters:

The effect of pilates on VO_{2max} was assessed in three studies [20,24,26] in a study by Fernandes et al [13] significant improvement in peak VO_2, maxVO_2 was seen post pilates exercises Also heart rate, respiratory exchange ratio (RER), oxygen equivalent (EQO_2), maxEQO_2 and maximum ventilation were evaluated and were found to be significantly improved. In another study done on stroke a significant improvement in VO_2 max and VO_{2max} per kg was observed post pilates and conventional training. [26] Gildenhuys et al [24] found no change in VO_{2max} after pilates training. In a study by Guimaraes et al 1 it was noticed that pilates training in chronic heart failure subjects lead to an increase in peakVO_2, cardiopulmonary exercise time, ventilation at peak effort and decrease in diastolic blood pressure. Jesus et al [23] assessed the thoracoabdominal mobility along with other parameters in subjects with ankylosing spondylitis and found a significant increase in all three levels after pilates training. Chest expansion was investigated in ankylosing spondylitis subjects by Altan et al and a significant improvement post pilates was noted. [25]

DISCUSSION

The objective of this study was to systematically review the studies assessing the effect of pilates exercises on pulmonary function and static respiratory pressures in subjects with varying conditions. In this review only 11 studies were included and their results were classified into three categories. This systematic review shows that pilates training is helpful in improving the respiratory function among different subjects. The pilates training was helpful in increasing the respiratory muscle strength and pulmonary function.

Effect of Pilates on Respiratory muscle strength:

Out of the total 11 studies included, respiratory muscle strength was assessed in 5 studies. 4 studies reported a significant improvement in MIP whereas, three studies showed a significant improvement in MEP post pilates training. The increase in respiratory muscle strength could be due to the overall improvement in respiratory muscle system, the mechanical characteristics of chest and abdominal wall are accountable for increasing the strength of respiratory muscles, as the contraction of diaphragm and other respiratory muscles provides stabilization to the trunk and also stimulates the development of respiratory muscle strength. [14] Incorporation of the breathing along with the movements and, the used postures may have attributed to the increase in respiratory muscle strength. Moreno et al suggested that the stretchings done in global postural re-education method could have lead to an increase in the length of sarcomeres and have resulted in a more stronger contraction, that was reflected as an increase in strength of respiratory muscles and thereby, an improvement in respiratory pressures. [15]

Effect of Pilates on Pulmonary function:

Various pulmonary functions were evaluated in 5 studies. One study showed an increase in MVV and PEF, and other two studies showed an improvement in FVC. Also an increase in FEV_1 was noticed. In Pilates, all exercises are associated with breathing, and the respiratory muscles also undergo contractions along with the other muscles of the body while performing the movements. The expiratory muscles remain activated during both inspiration and expiration. Due to the opposing force exerted by the expiratory muscles, the

inspiratory muscles will be required to exert a stronger force of contraction, to descent its dome. [6-9] The pattern of breathing used is regarded as a therapy as it decreases the pace and increases the depth. [16] Pilates exercises assist in gaining muscle balance, so that the muscle's strength and flexibility is enhanced, and the coordination of breathing is improved and is responsible for extreme strengthening of muscles of abdomen and other muscles that are insertion in torso. [17] Pilates improves the oxygen in tissues, and the coordination occurring on breathing. This method promotes the respiratory rehabilitation and leads to a better ventilation and perfusion. [7]

Effect of Pilates on other cardio-respiratory parameters:

VO_{2max} was assessed in 3 studies and a significant change was noticed in two studies post pilates training. The other parameters including Heart rate, RER, EQO_2, maxEQO_2 and maximum ventilation were also improved. The improvement in VO_2max suggested that the Pilates programme lead to the cardiovascular adjustments that resulted in enhanced vascular responses to the exercise thereby assisting in controlling local circulation in the muscles. It has been suggested that these exercises may benefit the cardiopulmonary physiology, thereby making it possible for the subject to attain an effective respiratory rate. [13] Chest expansion was assessed and found to be improved in two studies. In accordance with the basic principles of pilates method, the muscles of the abdomen are accountable for the dynamic stability of the torso. While executing the exercises this stabilization is an element of principle of centralization and is also called the "powerhouse". This outcome of this principle is the enhanced thoracoabdominal mobility as it allows the combined activation of trunk muscles, abdominals and diaphragm. A better thoracic and abdominal mobility could be credited to the enhanced flexibility of the trunk leading to a good and improved chest muscle tone, flexibility and respiratory efficiency. [18,19]

CONCLUSION

The included studies in this review evaluated the effects of pilates method on pulmonary volumes, maximal static pressures, VO_{2max} and chest mobility. According to the findings of this study, pilates method is effective in improving the respiratory muscle strength and thoracoabdominal mobility, but little evidence is available for the impact of pilates on FEV_1 and FVC. Pilates exercises are suggested to be prescribed to enhance the performance of respiratory muscles and more research should be carried to know their effectiveness forced expiratory volume and capacities.

Table 1: Details of the studies included in the analysis of the effect of pilates exercises on pulmonary function and respiratory muscle strength in varied subjects.

Author (year) Design	Hee Sung Lim et al (2017) [27] Randomised controlled trial	M.Tinoco-Fernandez et al (2016) [14] Single group study	Waked et al (2016) [13] Randomised controlled trial	M.B.Giacomini et al. (2016) [1] Uncontrolled clinical trial	Sarmento et al (2016) [23] Randomised controlled trial	Jesus et al (2015) [24] Non randomised placebo control clinical trial
Subjects (n)	20 (post-stroke; 10 pilates and 10 control) (11 males and 9 females)	45 (healthy volunteers) (10 males and 35 females)	40 (post renal transplantation; 20 in pilates and 20 control group) (24 men and 16 women)	16 (healthy volunteers) (only women)	56 (chronic renal patients; 28 in pilates and 28 in control) (30 males and 26 females)	21 (healthy volunteers; 11 in pilates and 10 in control) (only females)
Respiratory variables	RHR, VO_{2max}, $VO_{2\ max}$ per kg	VE, RR, VO_2, VCO_2, RER, EQO_2, $EQCO_2$, max. VO_2, and max. VE	FEV_1 and FEV_6	MIP, MEP, MVV, FVC, FEV_1, PEF, $FEF_{25-75\%}$, FEV_1/FVC	MIP and MEP	SVC, ERV, IRV, FEV_1, FEFP, MVV, IP_{max}, EP_{max} and thoracoabdominal mobility

Other variables	TUG	Heart rate, Body fat and max HR	QOL	Abdominal wall thickness of transverse abdominis, Internal oblique and external oblique	Total steps, length of stay in hospitals and Barthel Index	WC, HC, WHR, NC, AFL, LLA
Intervention	Pilates group- pilates exercises, 1 hour session for 3 times in a week for 8 weeks. Control group- conventional exercises (strengthening and walking) for 5 days a week for 8 weeks.	10 week pilates program, 1 hour sessions, 3 days/week	Control group- only medical care. Pilates group- pilates exercises once a day, 5 days/week for 3 weeks.	60 min session, 2 sessions /week for 8 weeks	30 mins session of pilates training or conventional physical therapy/day for 10 days	2 weekly pilates sessions of one hour for 12 weeks for pilates group and no exercises in control group
Results	Both pilates and conventional exercises showed a significant improvement in all variables, RHR, VO_{2max}, $VO_{2\ max}$ per kg and TUG. A significant difference was noticed in TUG test between both groups.	Significant decrease in body fat percentage. HR, RER, $EQCO_2$ and Max. EQO_2 was significantly decreased whereas, Peak CO_2, Max.VO_2 and Max ventilation was significantly improved.	Significant increase was seen in scores of QOL, FEV_1 and FEV_6 in pilates group when compared with control group.	Significant improvements were seen in MIP, MEP, MVV and PEF, whereas, FVC, FEV_1 and FEV_1/FVC showed no significant change.	Both pilates and conventional physiotherapy group showed a significant improvement in functionality, MIP and total steps. No significant difference was found between the two groups.	Thoracoabdominal mobility was improved at all three levels in pilates group. also significant improvement in MIP and MEP was seen in pilates group. control group showed significant improvement in MEP and thoracoabdominal mobility at axillary level.
Author (year) Design	Cordeiro et al (2015) [22] Prospective controlled and randomised clinical trial	Franco CB et al (2014) [12] Clinical trial	Gildenhuys, G.M et al (2013). [25] Randomised control trial	G.V Guimaraes et al (2012) [21] Randomised control clinical trial	Altan et al (2011) [26] Randomised prospective, controlled single blind trial	
Subjects (n)	14 (postoperative cardiac surgery; 7 in pilates and 7 in control)) (9 men and 5 women)	19 (cystic fibrosis) (7 males and 12 females)	50 (healthy volunteers; 25 in pilates and 25 in control) (only females)	16 (chronic heart failure; 8 in pilates and 8 in control) (11males and 5 females)	55 (Ankylosing spondylitis; 30 in pilates and 25 in control) (30 men and 25 women)	
Respiratory variables	MIP, MEP and VC	FVC% predicted, FEV_1% predicted, MIP and MEP	$VO_{2\ max}$	Peak VO_2, pulse VO_2, RER, VE/VCO_2	Chest expansion	
Other variables			Agility, sit to stand one rep test, sit to stand five rep test, pick up weight test	HR rest, HR_{max}, SBP rest, SBP max, DBP rest, DBP_{max}, exercise time	BASDAI, BASFI, BASMI, Ankylosing spondylitis QOL questionnaire	
Intervention	Pilates group- two sessions /day for 5 days a week Control group - Routine physical therapy	Pilates -1 session of 60 mins/week for four months	Pilates- eight weeks pilates exercises, one session of 60 mins, 3 sessions/week	Conventional- 15 min warm-up, 30 min aerobics and 15 min calisthenics. Pilates- conventional+20 min pilates	Pilates- 1 hour session, 3 times/week for 12 weeks. Control group- usual care	

Results	MIP and MEP were improved but were statistically non significant in pilates group. Vital capacity showed a significant increase in pilates group as compared to control group	MIP was increased significantly in male subjects and both MIP and MEP were improved in females. No change in FEV_1 and FVC was noticed in males and females.	Pilates training lead to significant improvement in agility, STS-I, STS-5 and pick-up weight test, but no change was seen in VO_{2max}. In control group agility and pick-up weight test was significantly improved.	Pilates group showed a significant increase in peak VO_2, ventilation and O_2 pulse post pilates exercise.	Chest expansion was found to be increased in pilates group at end of 12th week but no change between the groups was noticed at 24th week. Also BAFSI and BASMI was improved at 12th week as well as 24th week in pilates group. BASDAI was improved at 12 week but no difference at 24th week.
Abbreviations: Maximum aerobic capacity,VO_2max; Resting heart rate, RHR; Timed up and go test, TUG; Maximum heart rate ,HRmax; Maximum Ventilation, maxVE, Waist circumference, WC; Hip circumference, HC; Waist hip ratio, WHR					

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