Accepted Manuscript (Uncorrected Proof)

Title: The Effect of a Pilates Exercise Program on Kyphosis Angle and Electrical Activity of Muscles in Kyphotic Adolescent Women

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To appear in: ***Physical Treatments***

Received date: 2024/12/20

Revised date: 2025/04/28

Accepted date: 2025/05/31

First Online Published: 2025/08/08

Please cite this article as:

Mashhadi Alizadeh S, Khoshraftar Yazdi N, Alirezaei Noghondar F. The Effect of a Pilates Exercise Program on Kyphosis Angle and Electrical Activity of Muscles in Kyphotic Adolescent Women. ***Physical Treatments.*** Forthcoming 2026.

Abstract

Purpose: Correcting the abnormal alignment of the thoracic spine is essential, as it can influence muscle function. This study aimed to evaluate the effects of Pilates exercise on the thoracic kyphosis angle and muscle activity in women with functional Hyper kyphosis deformity.

Methods: Twenty-three women with Hyper kyphosis deformity were randomly assigned to the Pilates group (PG, n = 13) and control group (CG, n = 10). The PG Participated in 18 training sessions. Kyphosis angle was measured using an inclinometer, and muscle electrical activity was measured using surface electromyography (sEMG) in two stages, pre- and post-test. The exercises were performed over six weeks. Data was analyzed using ANCOVA analysis and independent t-test.

Results: A significant difference was observed in the amount of thoracic kyphosis between PG and CG (p=0.001). In addition, there was a reduction in the electrical activity of the upper trapezius muscles (p=0.001) and an increase in the electrical activity in the middle trapezius (p=0.001), the lower parts of trapezius muscles (p=0.001) and the erector spine muscles (p=0.001 p=0.04) in the PG in compare with CG.

Conclusion: Pilates exercises can significantly benefit those with thoracic kyphosis by improving spinal curvature and engaging surrounding muscles. These exercises enhance strength, flexibility, and coordination in the chest area. In addition, practical outcomes such as improved body image, reduced anxiety, and increased body awareness and training are also achieved after doing Pilates exercises. As a result, Pilates is an excellent choice for improving posture and strengthening supportive muscles.

Keywords: Pilates, Kyphosis, Electromyography, Woman

Highlights

- Correcting the movement patterns is very important in removing the abnormalities.
- Pilates exercises stabilize the spine by strengthening the core.
- Engaging the back muscles is crucial for sustaining balance.

Plain Language Summary

Performing Pilates exercises can help improve the kyphosis condition and strengthen the back muscles. In particular, the increase in electrical activity in the muscles related to this area indicates an increase in their strength and performance, which improves the structure and function of the spine. These findings can be an effective step in designing exercise and rehabilitation programs for teenagers with kyphosis and help improve their quality of life, especially considering that problems related to body posture can affect people's physical and mental health.

Introduction

Epidemiological research has indicated a significant occurrence of spinal postural deformities and musculoskeletal pain in adolescents (1). Kyphosis also increases with age. Forty percent of people over 60 and 55 percent of people over 70 years of age have kyphosis more significant than 40 degrees (2). Hyper kyphosis is a prevalent postural deviation that is linked to forward head posture and can lead to increased lumbar lordosis in more severe instances (3). Hyper kyphosis can cause various complications, including weakness of respiratory muscles and undesirable pressure on the heart (4, 5). Such conditions are believed to increase compressive forces on the vertebral joints and alter the lengths and strength of connective tissues, leading to musculoskeletal imbalances and pain (6).

Previous studies indicate that a deviation in one segment and the resulting alterations in the joints and muscles of that area can trigger a chain reaction, influencing other parts of the body and affecting various joints and muscles (7, 8). Vladimir Janda (1923–2002) suggested that Upper crossed syndrome (UCS) is an abnormal posture that specifically alters muscle activation patterns (especially in the neck, trunk, and scapular muscles) and movement patterns (scapular dyskinesis) along with postural deviations (forward head and shoulder posture and increased thoracic kyphosis) (8, 9). This syndrome is characterized by tightness of the upper trapezius (UT) and levator scapula, weakness of the deep cervical flexors, and the lower trapezius (LT) and middle trapezius (MT) (10). Hyper kyphosis can cause side effects such as slow walking, decreased balance, increased body sway, and disrupted muscle activity patterns. These side effects raise the risk of falls and diminish quality of life, underscoring the need for interventions to improve muscle recruitment strategies (11).

Pilates has emerged as an effective method for addressing postural deviations by focusing on core strength, body awareness, and flexibility (12, 13). Research indicates that many individuals suffer from postural issues due to sedentary lifestyles, muscle imbalances, and improper movement patterns. Pilates specifically targets these areas, providing a comprehensive approach to improving posture (14). Pilates is an exercise method that positively influences posture by emphasizing control of the pelvis and trunk through specific muscle recruitment strategies (15). Additionally, Pilates exercises aim to correct posture while strengthening and lengthening the muscles, promoting a neutral pelvis and lumbar lordosis (15). Pilates exercises emphasize core stability and breath control, which promote the activation of the diaphragm, transversus abdominis, multifidus, and pelvic floor muscles. Previous research has examined the impact of Pilates training on biomechanical characteristics, primarily concentrating on spinal and lower limb alignment. Galyez et.al (2023) show that adolescents with thoracic Hyper kyphosis exhibited reduced thoracic kyphosis while standing relaxed, along with enhanced hamstring flexibility (13). Pilates training improves the stabilization of the pelvis and spine, flexibility, power, posture, and coordination between movements and breathing (16), therefore it may reduce the curvature of kyphosis and change the pattern of the electrical activity of the muscles.

It has been shown that 30 weeks of Pilates training improves posture and flexibility in women with Hyper kyphosis (17). Jung et.al (2014) showed that after three months of training, the electrical activity of the muscles in healthy people increased (18). Electrical muscle activity can provide useful information about the effectiveness of exercise and it can identify the muscle that is most active during exercise. Previous studies have examined the effects of Pilates exercises on posture (18). According to the study, it seems that the effects of these exercises on muscle activity have not been examined so far.

According to previous studies, the exercise program should emphasize chain reaction muscle to get the optimal results for postural correction. No study appears to have examined the effect of Pilates training on local and global muscles in people with kyphosis.

Therefore, the research hypothesis is whether Pilates exercises can affect the activity of the trapezius and erector spinae muscles, ultimately leading to positive changes in the kyphosis angle.

1. Material and Methods

Study design

This research is quasi-experimental, with pre-and post-tests. It was approved by the Research Ethics Committee of X. Participants completed and signed the informed consent form. The study was carried out following the Helsinki Declaration, and approval was obtained from the local committee on human research.

Participants

Twenty-three women diagnosed with functional kyphosis (Mean±SD age of 39.71±3.9 years, height of 160.34±6 cm, and mass of 65.43±8.2 kg) who met the inclusion criteria were included in the study. They were selected purposefully, and this was convenience sampling followed by random allocation assigned to the control group (CG) (n = 10) and Pilates group (PG) (n = 13) groups. The sample size was estimated using GPower software with ES = 0/35, α = 0/05, and power 0/9. The inclusion criteria were:

- having no history of trauma, injury or surgery, spinal fracture and any other disease in the last 6 months,

- having any regular exercise and Pilates training for the past two months,
- having postural changes such as functional thoracic kyphosis greater than 42 degrees (According to medical history and functional testing of forward and lateral bending)

Kyphosis angle and muscle activity of the selected muscles were measured at baseline. PG received the Pilates training program, while CG received no intervention. All assessments were repeated after six weeks. The PG performed Pilates exercise interventions for 6 weeks, three sessions per week. The training sessions were 35 minutes, which were gradually increased to 60 minutes and included warming up, Pilates exercises, and cooling down. The principles of Pilates exercises and how to perform the exercises in one session were explained to the subjects.

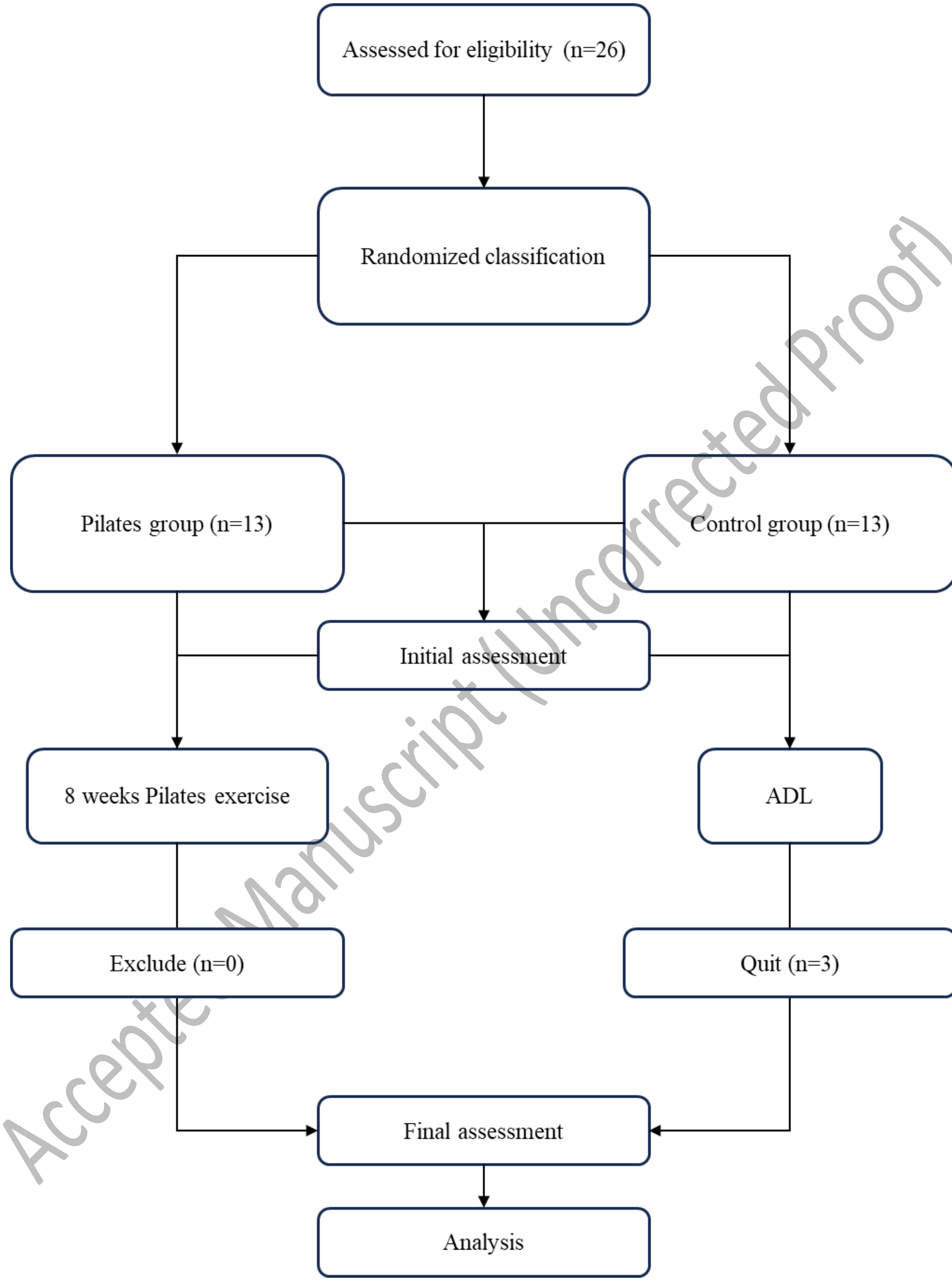

Fig. 1 Flow diagram

kyphosis angle

The inclinometer was used to measure the thoracic kyphosis angle, a valid and reliable tool (19). This tool was used over other existing methods due to its ease of use, analysis, and better access to the inclinometer. The measurement method was as follows: the participant was asked to stand in her anatomical position. Spinous process, the T_1_T_2 and T_{12}_L_1 vertebrae were marked. Then, the bases of the inclinometer, which is adjusted based on the distance between the two spinal processes of the two vertebrae, were placed on the spinous proses of T_1 and T_2. T_{12} and L_1 and the intervertebral angle were also measured. Measurements were performed with an inclinometer 3 times, and the average between the obtained angle and the kyphosis angle was calculated (19).

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Electrical activity of muscles

Electrical activity measured using surface Electromyography (sEMG) of selected muscles, including the UT, MT, LT, and erector spine in L_1 and L_2 vertebrae, was performed during maximal voluntary isometric contraction (MVIC). Participants applied their maximum force against the assessor`s fixed arm.

For the UT muscle, the electrodes were positioned along the line at a distance of 1.2 cm between the acromion and the C_7 vertebra. For the MT muscle, the electrodes were placed on the line at 1.2 cm between the inner border of the scapula and the spine, at the same level as the T_3 vertebra. For the LT muscle, the electrodes were positioned at an angle two-thirds of the way from the scapular root to the T_8 vertebra. To measure the electrical activity of the erector spinae muscles, the subject was placed in a supine position, and the electrodes were positioned six centimeters lateral to the spinous processes of the L_1 and L_2 vertebrae (19).

To assess the MVIC of the UT muscle (Fig. 2, A), the subject was seated perpendicular to the chair at some distance from the back. She raised her arm to a 90-degree abduction angle while flexing and rotating her neck outward. The tester applied resistance to prevent head extension and excessive arm abduction (20, 21). For the MT muscle (Fig. 2, B), the participant was positioned supine with the shoulder in horizontal abduction and external rotation, close to the head in alignment with the MT muscle fibers. Resistance was applied to the arm (22). To measure the MVIC of the LT muscle (Fig. 2, C), the participant remained supine while raising the arm toward the LT muscle fibers, with resistance applied to the arm (21). The subject was placed supine for the erector spinae muscles (Fig. 2, D), with the pelvic, knee, and ankle areas secured.The subject performed trunk extension to the maximum degree facilitated by the resistance applied (22). One person did this for all participants in two assessment stages.

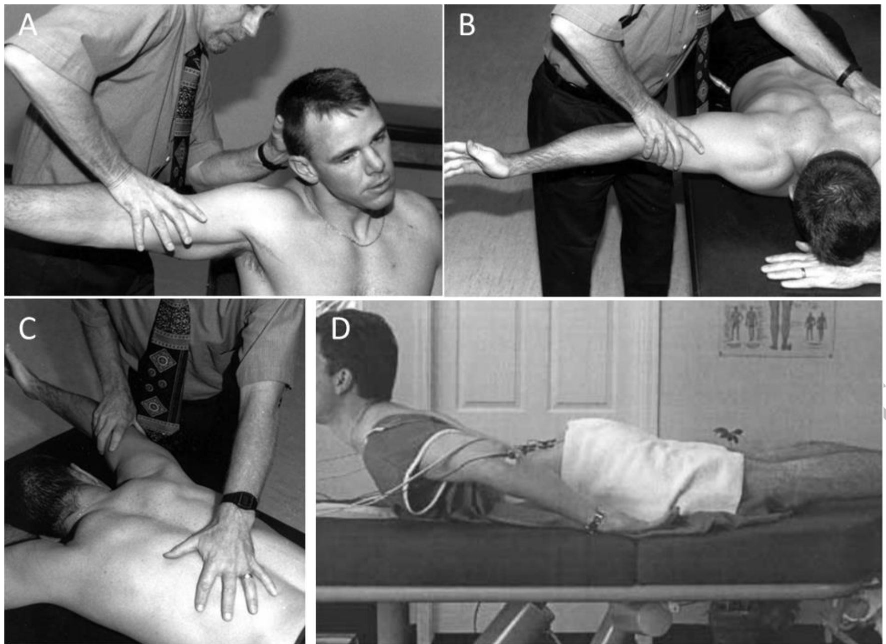

Fig. 2 Evaluation maximal voluntary isometric contraction

The placement of the participants and the position of the assessor are important points in performing these tests.

Bipolar Ag/AgCl surface electrodes with an active area of about 1 cm were positioned with a center-to-center spacing of 2 cm along the muscle fibers. The location of the electrode on the examined muscles was determined and marked by the researcher according to the recommendations of SENIAM instruction (19). By carefully removing the hair, abrading, and cleansing the skin, low impedance was achieved in the interface between the skin and electrode. Other electrical devices were kept away from the measuring device to reduce noise. Electrical muscle activity was recorded at a sampling frequency of 1000 Hz during maximal voluntary muscle contraction. The EMG signals were automatically amplified and recorded utilizing the Biopac system (Biopac, Santa Barbara, CA). To provide a clear picture of the EMG data and to compare and interpret the differences, the maximum voluntary contraction of individuals (calculated by following the curve) was compared in 3 attempts. After each test, the person rested in a neutral position for 30 seconds (21). EMG signals collected during MVIC tests were carefully examined for noise, and the first and the last few seconds of each attempt, which were less stable, were removed and then processed with 2^{nd} order low-pass Butterworth filter (20-500 Hz) and full wave rectified. Subsequently, the root mean square was calculated, and its maximum value was extracted from the desired range.

Pilates exercise

The PG participated in Pilates exercises for 6 weeks, attending three sessions each week. Each training session began at 35 minutes and gradually extended to 60 minutes, including a warm-up, Pilates exercises, and a cool-down period. Participants were educated on the principles of Pilates and how to execute the exercises during each session properly. Initially, participants performed two sets, each set 6 rep, which progressed to 2 sets of 10 repetitions over the 6 weeks (23). The detailed exercise protocol is listed in the appendix.

Data analysis

Raw data was processed using Matlab R2018b (IBM Inc, Chicago, USA) software. The mean value of 3 attempts was calculated and represented for Further analysis.

Statistical analysis

The Shapiro-Wilk test was employed to assess the normality of distribution for all variables. The independent sample T-test was utilized to identify initial differences between groups. Paired sample t-tests were used to compare within groups. An ANCOVA was used to compare post-training values between PG and CG, using baseline values as covariates. Statistical analysis was conducted with SPSS version 27 for Windows (SPSS Inc, Chicago, IL, USA) using a significance level of $p < 0.05$.

2. Results

Table 1 presents the baseline demographic data and characteristics of all variables for each group.

Table 1 Demographic characteristics of the groups (Mean±SD)

Demographic Characteristics	PG	CG	*p*-value
Age (years)	38.84±3.99	39.6±3.99	0.34
Height(cm)	161.53±5.63	159.01±6.49	0.50
Mass (kg)	66.23±8.95	64.2±7.62	0.46
Body Mass Index (kg/m^2)	21.7±3.2	22.1±3.5	0.30

* Significance at the level of $p < 0.05$, p: between group. PG: Pilates Group; CG: Control Group.

There was no significant difference in any demographic or outcome variables between groups.

Pre and post training results for kyphosis angle and electrical activity of muscles are reported in table 2 and figure 3.

Table 2 Within group of kyphosis angle and electrical activity of selected muscles in PG and CG

Variable	group	Pre-test	Post-test	t	*p*-value	*EF*
Kyphosis Angle (degree)	PG	56.15±7.31	44.92±7.11	16.86	0.001*	1.5
	CG	55.53±6.89	56.5±6.33	1.24	0.24	0.14
Right Upper Trapezius (volt)	PG	0.23±0.08	0.1±0.03	6.3	0.001*	2.36
	CG	0.15±0.03	0.17±0.04	1.1	0.29	0.57
Left Upper trapezius (volt)	PG	0.2±0.09	0.13±0.06	5.21	0.001*	0.93
	CG	0.17±0.08	0.2±0.09	1.55	0.15	0.35
Right middle Trapezius (volt)	PG	0.13±0.04	0.2±0.07	5.26	0.001*	1.27
	CG	0.11±0.05	0.09±0.04	1.42	0.18	0.44
Left middle Trapezius (volt)	PG	0.15±0.08	0.21±0.08	5.58	0.001*	0.75
	CG	0.15±0.08	0.1±0.05	3.79	0.004*	0.76
Right lower Trapezius (volt)	PG	0.17±0.9	0.25±0.07	4.4	0..001*	0.16
	CG	0.3±0.21	0.23±0.16	1.87	0.09	0.24
Left lower Trapezius (volt)	PG	0.15±0.08	0.23±0.1	4.27	0.001*	0.88
	CG	0.19±0.1	0.11±0.05	3.1	0.01*	1.06
Right erector spine (volt)	PG	0.04±0.02	0.03±0.02	2.72	0.02*	0.5
	CG	0.06±0.02	0.04±0.01	1.7	0.12	1.33
Left erector spine (volt)	PG	0.03±0.1	0.05±0.02	4.85	0.001*	0.33
	CG	0.04±0.02	0.03±0.02	2.72	0.02*	0.5

* Significance at the level of p <0.05, p: within group. PG: Pilates Group; CG: Control Group.

Table 3 ANCOVA results to compare measures of kyphosis angle and electrical activity of selected muscles between groups

variable	F	*p*-value	Effect size
Kyphosis Angle (degree)	148.33	0.001*	0.93
Right Upper Trapezius (volt)	20.26	0.001*	0.5
Left Upper trapezius (volt)	25.17	0.001*	0.77
Right middle Trapezius (volt)	21.39	0.001*	0.69
Left middle Trapezius (volt)	62.41	0.001*	0.85
Right lower Trapezius (volt)	29.81	0.001*	0.73
Left lower Trapezius (volt)	26.19	0.001*	0.64
Right erector spine (volt)	4.4	0.04*	0.18
Left erector spine (volt)	22.12	0.001*	0.63

* Significance at the level of p <0.05.

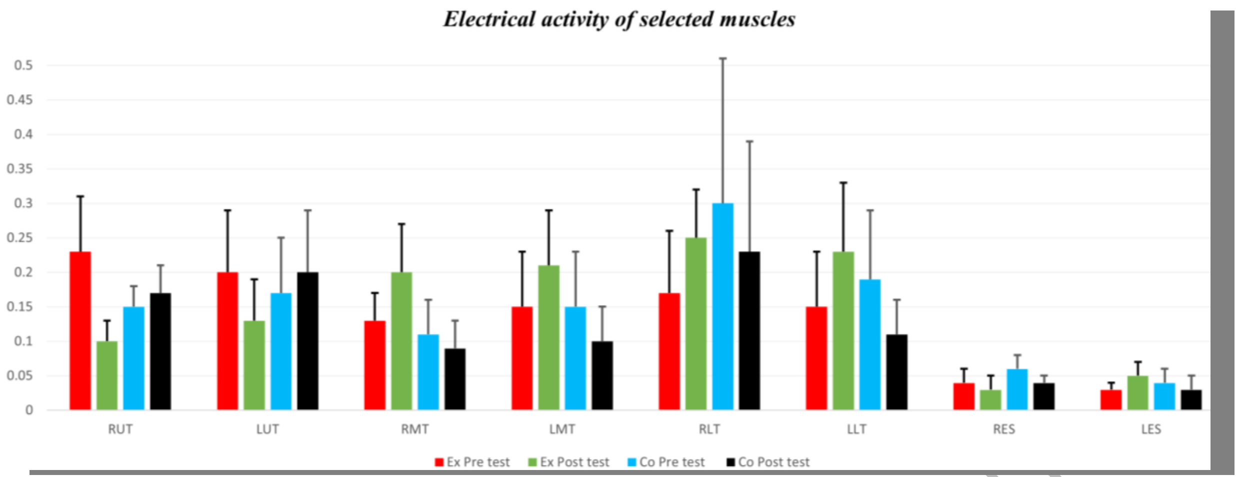

Fig. 3 Pre and post training results for electrical activity of muscles

Ex: Experimental, Co: Control. The highest level of activity among the selected muscles was in the lower trapezius muscles on both the right and left sides.

There were Significant decreases in kyphosis angle for PG (p = 0.001) but not for CG. Significant differences were observed in electrical activities of the left and right UT, MT, and LT muscles (p=0.001) and erector spine muscles (p<0.05) in within-group comparison in PG (p<0.05). In addition, there were significant differences in the electrical activity of the left MT and LT muscles (p <0.05) and right erector spine muscle in the CG (p = 0.02).

ANCOVA results reveal significant differences in the post training values of PG and CG (p <0.05) (table 3).

Additionally, these differences were significant in the PG compared to the CG (P <0.05).

4. Discussion

This study assessed the effectiveness of Pilates exercises compared to a CG regarding the kyphosis angle and the muscle activation of key scapular stabilizers and erector spinae in women with hyper kyphotic posture. The mean EMG amplitude of the UT, MT, and LT and the kyphosis angle were measured. According to the results of this study, the thoracic kyphosis angle was in PG but not CG. These results pointed out that the Pilates method positively affects the kyphosis angle. It has been shown that corrective exercises or interventions that aim to correct kyphosis angle should emphasize stretching exercises for pectoral muscles and strengthening exercises for core extensor muscles (4). Pilates exercises emphasize correcting posture, strengthening and lengthening muscles, enhancing core stability, and improving breath control, all aimed at achieving a neutral pelvis alignment and lumbar lordosis (15).

Pilates plays a crucial role in strengthening the deep abdominal and lumbar muscles. These muscles provide stability and support for the spine, influencing overall body movements (24). A strong core supports proper posture by aligning the spine and reducing strain on surrounding muscles. Pilates encourages awareness of body alignment, helping practitioners learn to maintain good posture in various positions, whether sitting, standing, or engaging in physical activities. Improved posture can alleviate back pain and discomfort associated with muscle imbalances (14).

The results showed a reduction in the electrical activity of the trapezius and erector spine muscles in PG. One of the possible reasons for the reduction in the electrical activity of the UT muscles may be a decrease in the tension of these muscles. People with kyphosis due to the distance of shoulders from the midline of the body may experience tension in these muscles (25). This excessive tension causes more motor unit requirements and, as a result, increases muscle activity (26). Therefore, following the reduction of the kyphosis angle, the tension of the UT muscle may be reduced, and as a result, the electrical activity of this muscle may be lowered.

In addition, the mean electrical activity of the right and the left MT and the right and the left LT muscles increased in PG. The reason for the changes in the electrical activity of the MT and LT muscles after 6 weeks of Pilates exercise may be explained as follows: In kyphosis, upper rotation and scapular abduction occur, which may be due to the weakness of the lower and MT muscles. As a result, less electrical activity was observed in the pre-test due to the weakness of these muscles. Weakness leads to muscle fatigue, which reduces the transmission speed of afferent messages. It also affects the presynaptic-postsynaptic mechanism and the potential action position at the environmental level. This causes the inability to transmit nerve signals or the inability of the muscle to respond to nerve stimulation and their pattern of electrical activity to change. Therefore, the increase in electrical activity of the MT and LT muscles is likely due to the strengthening of these muscles and the correction of the abnormality after 6 weeks of Pilates exercises in PG. The electrical activity of the left MT muscle was in the CG after 6 weeks. The electrical activity of the lower right trapezius muscle in the post-test was not significantly different from that of the pre-test in the CG. This is probably due to a lack of exercise and physical activity in the control group or the superiority of the right limb of the subjects. Lack of training in this muscle causes weakness, and the use of superior limbs causes muscles on the opposite side of the body to be less active. These factors might cause a reduction in the electrical activity of the other side.

The average electrical activity of the right and the left erector spine increased in PG. The reason for the changes in the electrical activity of the erector spine muscles is that these muscles are the backbone of the spine and the central stabilizers of the body. These muscles become stretched and weak due to Hyper kyphosis (23). This weakness causes the inability to transmit nerve signals to the muscles, and the strategy of invoking the muscle to stabilize the joints changes, followed by a change in the movement program (18). The reason for the increase in electrical activity of the muscles is that straightening the spine after 6 weeks of Pilates exercise strengthens these muscles and returns them to normal alignment thus changing the muscle response to nerve signals. According to the principle of centrality in Pilates, movements are designed so that with every performance, the central parts of the body, including the transverse abdominal muscles, the internal and external obliques, and erector spines, which are the body's central stabilizers and mobilizers, get involved (27).

The reason for the positive effect of Pilates on the electrical activity of muscles can be explained by the fact that according to scientific findings, muscle tone or tension depends on two factors: the basic viscoelastic properties of muscle soft tissue and the degree of activation of muscle contraction network (28).

Viscoelastic properties include shortness, stiffness, and length loss, while the contractile network includes increased contractile activity. The muscles may shorten or tighten to compensate for the shortening of contractile fibers or retraction of extra muscular connective tissue or adjacent fascia. The combination of the two muscle properties causes a relaxed muscle tone.

Stiff muscles have a higher muscle tone and a lower irritability threshold. This means that these muscles are easily called for movements (28). Due to abnormality, the neural control unit may temporarily change the strategy of recruitment of the muscles for joint stability. This change in activation patterns affects muscle balance and movement patterns, ultimately altering the motor program and leading to reciprocal inhibition of the muscles. Reciprocal inhibition is a neuromuscular condition that occurs when a muscle becomes more active than normal, and to cause stimulation, the nerve signal increases (8). This reduces stimulus and increases the inhibitory signal to its antagonist's muscle. In addition, habitual postures can stretch the muscles for a considerable amount of time, which is called postural weakness. Postural weakness might be due to inhibition caused by muscle stiffness.

These exercises emphasize slow, controlled movements that require focus and balance and train the body to respond more effectively to weight shifts or changes in direction. This is supported by timely muscle activation (12). Delaying muscle activation in different situations has different effects, including decreased balance. Pilates exercises can change muscle timing, and neuromuscular adaptations also occur with continued practice (12, 29).

Muscle weakness caused by excessive traction also inhibits spindle activation and can increase sarcomere units. These changes can affect the pattern of electrical activity in the muscle (30). Because of Pilates principles that affect posture and also according to centrality, one should always keep the transverse abdominal muscle in voluntary contraction while performing these exercises. This increases the intra-abdominal pressure and tension of the thoracolumbar fascia and provides strong support for muscle contraction before limb movements (30). Contraction of other abdominal muscles stabilizes the spine and provides suitable conditions in the joint movement chain for the correct movement of the limbs (31). Therefore, it is possible to focus on the imbalance of the target muscles in the kyphosis instability and to create muscle balance with the least amount of energy.

Pilates is a good way to practice body awareness and postural control (29). Research has shown that Pilates exercises lead to more activation of deep abdominal and core stabilizer muscles (32). Proper distribution of forces and reduction of compressive forces in the joints of the motor chain are created following the stability in the body's center. Dysfunction in this area can affect other parts of the motor chain, start the deviation of the spine from regular, and start injuries and abnormalities in this area.

The limitations of this study include the small sample size; employing larger samples would facilitate more robust and accurate generalizations of the results. Additionally, the study lacked a follow-up period; future research should incorporate a follow-up assessment to evaluate the persistence of the effects of the exercises. Furthermore, implementing blinding for the evaluator could enhance the accuracy and reliability of the results.

5. Conclusion

Equilibrium is created due to Pilates exercises in the motor chain, and the muscles are in the correct position regarding strength and flexibility. These factors can affect electrical activity, which is the result we are aiming for. Six weeks of Pilates exercise emphasizing core stabilizer improved the severity of kyphosis and muscle activity. The reduction of UT muscle activity and erector spine, along with the increased activity of the MT and LT muscles, is related to a reduction in the kyphosis angle. It can effectively reduce the kyphosis angle and create balance in weakened and shortened muscles. Future studies could explore the long-term effects of Pilates on kyphosis, particularly with extended follow-up periods to assess the sustainability of improvements in muscle activity and spinal alignment, while also incorporating Pilates into preventive health strategies to benefit individuals at risk of developing kyphosis, especially among populations engaged in activities that lead to postural imbalances.

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Appendix

Protocol (First week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat	10 min	10 sec
Main exercise	Four-point kneeling	30 sec × 2 reps	10 sec Child pose
	Table tope	2 set × 6 reps	10 sec Child pose
	Child pose	30 sec	10 sec
	C-curve	3 set × 6 reps	Pulling the legs into the abdomen
	Single leg raise with pointe and flex toes and small single leg circle		
	Shoulder bridge		
	Single leg stretch		
	Star		
	Cobra		
	Child pose	30 sec	
	Chest stretch	4 reps	
	Hamstring stretch	10 sec	
Cool-down	Spine stretch	5 min	

Protocol (Second week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat	10 min	10 sec
Main exercise	Table tope	2 set × 6 reps	10 sec Child pose
	Threading a needle		10 sec Child pose
	Can-can		Cradle
	Mermaid		Cradle
			10 sec Child pose
	C-curve	2 set × 8 reps	Pulling the legs into the abdomen
	Star		
	Shoulder bridge		
	Single leg stretch		
	Cobra		
	Dimond	4 reps	10 sec
	The saw	4 reps	
	Chest stretch	4 reps	
	Hamstring stretch	10 sec	
Cool-down	Spine stretch	5 min	Spine stretch

Protocol (Third week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat, Ignorant waiter	10 min	10 sec
Main exercise	Table tope	2 set × 8 reps	10 sec Child pose
	Can-can (Single leg and double straight leg)		10 sec Child pose
	Mermaid		Cradle
	Side bridge		Cradle
			10 sec Child pose
	C-curve	2 set × 8 reps	Pulling the legs into the abdomen
	Single leg stretch		
	Shoulder bridge		
	Cobra		
	Dimond	4 reps	10 sec
	Star	2 set × 8 reps	10 sec Child pose
	The saw	6 reps	10 sec
	Chest stretch	6 reps	
	Hamstring stretch	20 sec	
Cool-down	Spine stretch	5 min	Spine stretch

Protocol (Fourth week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat	10 min	10 sec
Main exercise	Ignorant waiter with TheraBand	2 set × 6 reps	10 sec Child pose
	Table tope with TheraBand	2 set × 8 reps	
	Push-up	2 set × 6 reps	
	Can-can (double straight leg)		
	Mermaid		Simplified open-leg cradle
	Shoulder bridge	2 set × 8 reps	Pulling the legs into the abdomen
	Roll-up with TheraBand		
	Criss Cross		
	Star		10 sec Child pose
	Cobra		
	Dimond		
	Darts		
	The saw	6 reps	
	Chest stretch	8 reps	
	Hamstring stretch	20 sec	
Cool-down	Spine stretch	5 min	Spine stretch

Protocol (Fifth week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat	10 min	10 sec
Main exercise	Ignorant waiter with TheraBand	2 set × 8 reps	10 sec Child pose
	Table tope with TheraBand	2 set × 10 reps	
	Push-up	2 set × 8 reps	
	Can-can (double straight leg)		cradle
	Mermaid with side bridge	2 set × 10 reps	Simplified open-leg cradle
	Shoulder bridge	2 set × 10 reps	Pulling the legs into the abdomen
	Roll-up with TheraBand		
	Criss Cross		
	Star		10 sec Child pose
	Cobra		
	Dimond		
	Darts		
	The saw	8 reps	
	Chest stretch	8 reps	
	Hamstring stretch	30 sec	
Cool-down	Spine stretch	5 min	Spine stretch

Protocol (Sixth week)	Exercise	Time and sets	Rest
Warm-Up	Pilates standing, breathing, one-legged stance, one-arm overhead squat	10 min	10 sec
Main exercise	Ignorant waiter with TheraBand	2 set × 10 reps	10 sec Child pose
	Table tope with TheraBand		
	Push-up		
	Can-can (double straight leg and with Pelvic rotation)		cradle
	Mermaid with side bridge		Simplified open-leg cradle
	Shoulder bridge		Pulling the legs into the abdomen
	Roll-up with TheraBand		
	Criss Cross		
	Star		10 sec Child pose
	Cobra		
	Dimond		
	Darts		
	The saw	8 reps	
	Chest stretch	8 reps	
	Hamstring stretch	30 sec	
Cool-down	Spine stretch	5 min	Spine stretch