Research Paper

The Effect of Eight Weeks Pilates Training on Functional Indicators and Postural Abnormalities in Older Men

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ABSTRACT

Purpose: Structural-oriented changes caused by aging among older people are common due to mobility poverty. This study investigates the effect of eight weeks of Pilates exercise training on functional indicators and postural abnormalities in older men.

Methods: In this quasi-experimental study with a control group, 26 men aged between 60 and 70 years were randomly divided into an experimental group (n=13) and a control group (n=13). The Pilates exercise program lasted eight weeks (three sessions per week) and each session for 55 to 60 min. Before and after the end of the training, functional indicators and postural abnormalities were measured. The paired t-test and the analysis of covariance were used within and between changes, respectively

Results: There was a significant difference between the group of Pilates exercises compared to the control group in the level of flexibility, upper body strength, and dynamic strength in elderly men. Cardiorespiratory function (6.60%), upper limb strength (17.28%), leg dynamism (19.34%), and lower limb muscle endurance (11.61%) were significantly improved after the training intervention. There was a significant difference between the two groups in postural abnormalities only in the genu varum. However, the variables of forward head 2.22%, scoliosis 1.02%, kyphosis 4.73%, and lordosis 6.04% significantly decreased after the training intervention.

Conclusion: Pilate's training has been linked to enhanced functional indicators and a reduction in abnormalities. Given the numerous benefits associated with Pilates, integrating it into public health exercise programs can prove to be a valuable addition. By making Pilates more accessible to a wider population and incorporating it into these programs, we can effectively enhance individuals' motivation to engage in physical activity. As a result, this will lead to an improved standard of living and overall quality of life for the population.

Keywords:
Pilates training, Aging, Abnormalities

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Highlights

- Pilates exercises significantly increased flexibility, cardiovascular respiratory system, upper body strength, dynamic strength, and muscle endurance in older men.

- There was a decrease in postural abnormalities, such as forward head, scoliosis, kyphosis, and lordosis in older men.

- Pilates exercises are one of the exercise programs that can play an important role in the physical performance and posture abnormalities of the elderly.

- Performing Pilates exercises can help improve musculoskeletal injuries, back pain, and joint problems.

Plain Language Summary

This study investigates how Pilates training affects older men's posture and physical fitness. After eight weeks, the men who did Pilates showed increased flexibility, heart and lung function, upper body strength, leg power, and leg muscle endurance. Additionally, their hunched posture, curved spine, and abnormal lower back curves improved significantly. The researchers recommend exercise programs, like Pilates, to help older adults improve their posture and overall fitness. However, because physical activity plays a crucial role in preventing and treating various abnormalities and indicators of physical fitness, experts recommend exercise counseling as a means to improve stature abnormalitis.

Introduction

Aging is a global phenomenon that affects both developed and developing countries. Population aging is also a serious concern for governments and the general public, as aging changes the face of society. This is a tangible concern because structural and functional degradation is seen in almost all the physiological systems of the body during aging [1]. Globally, the number of people over 60 years of age is increasing at an annual rate of 3%. Forecasts show that by 2050, elderly people will make up 22% of the population [2]. Aging is associated with progressive changes in the structure of musculoskeletal systems, such as excessive bone degradation, vertebral fractures, muscle weakness, and degenerative diseases that lead to chest hyperkyphosis [3]. Changes present in the muscular nervous system are noticeable in walking pattern features. The length of the steps is shorter and the speed of walking is slower [4]. Additionally, according to studies, more than 80% of patients aged 65 years or older who are hospitalized are caused by fall [5, 6].

Among the risk factors for falling in old age are reduced movement, imbalance, reduced muscle strength, and walking disorders [7]. Reduced movement is one of the main predictive of falls in older people [8]. In a study, Lopez et al. [9] regarding the prevalence of fear of falling, out of 147 studied samples, 133 elderlies were afraid of falling. Other studies report the prevalence of fear of collapse in the elderly with pelvic fractures between 29% and 92% [10]. However, in some elderly people, the fear of falling can turn into a debilitating illness, as falling fear is associated with negative consequences, including a reduction in doing things in everyday life, understanding physical health, and a lower quality of life [9]. Therefore, the diagnosis, treatment, and prevention of their problems have also become of great importance for improving their independence in life. The introduction of a fall prevention program makes the move critical for such age groups, especially for those living in residential nursing and care centers [11]. In addition, the elderly who live in retirement homes for long periods tend to be severely inactive and engage in sedentary activities most of the day [12]. Therefore, one of the exercise programs that can play an important role in the physical performance and mental impairment of the elderly is Pilates [2].

Pilates exercises have become a crucial means for the elderly population to maintain and enhance their physical and mental well-being. A thorough examination of the current literature reveals that conservative interventions, such as physiotherapy and various exercise routines, can effectively alleviate symptoms associated with spinal deformities [13]. The significance of consistent participation in physical activity for the improvement of physical health has been recognized for a substantial period. Engaging in physical activities not only helps alleviate psychological stress but also improves posture, reduces the risk of chronic diseases, manages weight, and promotes psychological well-being [13].

Pilates exercises combine body and mind and can be used to maintain muscle endurance and thereby improve muscle strength, control, and flexibility [14]. In Pilates exercises, the six main elements focused on the functioning of the main muscles are used to create and maintain stability, focused cognitive attention to execute each movement, control the execution of the exercise, accuracy, and perform the movements in an integrated and interconnected manner throughout the entire function and to optimize respiratory function and enhance the integration of the mind and body of respiratory rhythms [14]. By choosing the right exercises and managing the diet, Pilates programs can effectively treat spinal column disorders [15]. Emery et al. [16] have demonstrated that the Pilates exercise method is an effective physical technique for reducing pain and improving the kyphosis angle in patients with spinal column deformities. This method corrects poor body posture, strengthens the muscles that contribute to it, and promotes body balance, thus reducing spinal column abnormalities. Furthermore, Pilates increases spinal column flexibility, offering relief from these abnormalities

The effectiveness of Pilates exercise is evident in its ability to improve mental well-being, enhance performance capacity, and overall quality of life [17]. In recent years, there has been a growing of research investigating the efficacy of Pilates training [18]. Numerous studies consistently support the positive impact of Pilates exercises on various aspects of health, physiotherapy, and rehabilitation [19]. Pilates exercises effectively address musculoskeletal injuries, weakness, and specific concerns. For instance, Kovách et al. [20] discovered that elderly individuals who participated in six months of Pilates exercises experienced significant improvements in upper body strength, flexibility, physical movement (particularly dynamic balance), and aerobic endurance. Another study by Meikis et al. [21] investigated how Pilates interventions affect the physiological and mental health of individuals aged 55 years and above. The results showed that practicing Pilates exercises had a moderate impact on various aspects of physiological health, including muscle strength, balance, endurance, flexibility, walking ability, and overall physical performance.

As we age, our balance and coordination can deteriorate, increasing the likelihood of falls and other accidents. Pilates exercises, which emphasize controlled movements and body awareness, can be beneficial for older adults in improving their balance and coordination, reducing the risk of falls, and enhancing overall mobility [22]. These exercises specifically target the core muscles that are crucial for maintaining good posture, balance, and stability. By engaging these muscles, Pilates can help older adults improve their overall strength and flexibility, ultimately reducing the risk of falls and injuries [23]. Given the growing elderly population, it is becoming increasingly important to prioritize physical and mental well-being. Pilates exercises provide a safe, effective, and accessible option for older adults to enhance their strength, flexibility, balance, and overall quality of life [24]. Incorporating Pilates into their routine enables older adults to lead a more active and independent lifestyle, decreasing the risk of falls, injuries, and chronic health conditions. In short, the prevention of the disorder is more important than the after-treatment. Advancement also depends heavily on teaching the right principles and maintaining the right situations [25]. One of the methods that has been proven to prevent and cure postural abnormalities is exercising, which can improve all physical readiness and health factors [26] and help maintain and correct body posture by balancing muscles [27]. Therefore, due to the proper training and correction of postural abnormalities, their rate of infertility increases with age and can be prevented by taking proposed measures for any physical and mental problems in the future. Given that different sports exercises can have different effects on performance indicators and cardiovascular disorders, there has been little research into examining the effects of Pilates exercise on these indicators. This study investigates whether Pilates exercises affect performance indicators and postural abnormalities in older men. Accordingly, the present study compares the effects of eight weeks of Pilates-selected exercise on performance indicators and postural abnormalities in older men.

Materials and Methods

Current applied and semi-experimental method studies were compared with pre- and post-examination designs with two groups of subjects. The statistical community of the study consisted of men aged over 60 years old (60 to 70 years old). A total of 26 elderly men were randomly divided into two equal groups, consisting of the intervention group (n=13) and the control group (n=13). The randomization process was conducted by a statistician using an electronic sequential number allocation page, with the help of Microsoft Excel software. Once the allocation sequence was established, a separate researcher, who was unaware of the study, placed the numbers into opaque envelopes and sealed them. This researcher had no involvement in any other aspects of the study. Afterward, the participating volunteers chose an envelope and opened it to reveal their assigned group. The envelope and the number inside were then excluded from any further randomization procedures.

The number of samples was determined using the G*Power software, version 3.1 and was determined based on the study of Koh and Park, 2017 [28]. Accordingly, the α level of 0.5, the statistical power of 0.8, and the effect size of 0.3 were considered and based on the number of samples recommended by the software, 24 people were estimated. Considering the likelihood of a decrease in the number of trends during the study, 26 people were targeted and voluntarily participated in the current study. All participants signed written informed consent forms. The present study was conducted according to the Helsinki Declaration on research ethics and involved no risk to the subjects.

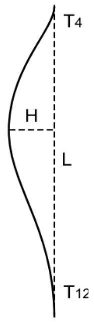
In the first phase, the research was initially focused on the cooperation, benefits, and potential risks of participating in the study and explained to the volunteers that they could discontinue cooperation at any stage of the study if they were unwilling. The information obtained was kept confidential and researchers only published the overall and grouped results without naming or identifying them. The eligible criteria were inactivity (<120 min of moderate to intense physical activity per week), lack of experience in performing Pilates exercises, or any fitness program based on improving the level of physical fitness, being healthy (non-use of medication or any medication that causes water retention), not exercising and not having regularly exercised during the six months before the exercise program and without musculoskeletal damage. Meanwhile, the exclusion criteria were not participating in two sessions of exercise, having a history of metabolic diseases such as cardiovascular, liver, cancer, stroke, or muscle diseases, nervous muscle failure to perform sports, specific disorders of the spinal column (spondylolysis or spondylolisthesis), scoliosis of the abdomen with an angle of more than 10 degrees, progress to severe knee arthritis and severe disabilities.

The subjects voluntarily participated in the study based on the conditions of the study and consciously signed the consent form. In the study phases, the principles of the Helsinki Declaration and the opinions of the Ethics Committee in Research were recognized. All training sessions were under the supervision of a sports physiologist.

To evaluate the body composition of the subjects, this study employed a range of specialized tools. Height was measured using the Seca meter, a precision instrument manufactured in Germany, with a sensitivity of 5 mm. For assessing hip and pelvis circumference, we utilized a tape measure from Mabis, a reputable Japanese company, which also offered a precision of 5 mm. Weight measurements were obtained through the use of the Beurer digital scale, specifically the PS06-PS07 model, manufactured by a renowned German company, with a sensitivity of 100 grams.

Meanwhile, to measure the postural abnormalities of the chessboard was used. On this board, the middle line is counted with a distinctive color, a branched line. It uses a square with dimensions of 100×200 cm, which is divided in length and width into square meters of 5 cm and in a blurred way. From the New York test and the plumb line, various symptoms, such as forward head, scoliosis, kyphosis and lordosis, matched with any of the three sides, back and forward disorders were identified and indicated. The genu varum was designed by the designer according to the gap between the leg and knee. The subjects without the cover comfortably and normally stood behind the tester (the eyes looked at one point in front of the other, the distance between the legs was about 15 cm and the hands hung alongside the body), waited about 3 min, and then the measurement was done. We define the spinous process in T4 and T12. The initial procedure involves placing the flexible ruler precisely on the spinous process of the T4 to T12 vertebrae, aligning it meticulously with the contour of the subject's back. Once the ruler was properly positioned, without modifying its curvature, we carefully traced the surface of the ruler that made contact with the skin, thereby transferring the curve onto the designated paper. Subsequently, we connected the two extremities of the traced curve to generate a line referred to as "L." Then, we established the "H" line by connecting the point on the back exhibiting the most pronounced curvature to the aforementioned "L" line. Lastly, we utilized the subsequent formula to determine the kyphosis angle. For the sake of precision, it is essential to repeat this methodology twice for each participant and account for the average of these three angles [29]. An angle equal to or greater than 40 degrees is known as dorsal hypokyphosis, based on the Equation 1.

1. $\Theta = 4 \arctan(2H/2)$



Flexibility (sitting on a chair and reaching)

The flexibility test was measured in cm and showed the flexibility of the lower body. By sitting in front of the chair, the subject stretched the superior leg placed the non-predominant leg in a 90-degree bend position, and brought the fingers of the hands as close to the toes of the stretched leg as possible for the subject.

Cardiorespiratory index (6 min of walking)

In the 6-min walking test, the person walks for 6 min and the greater traveled distance shows the better the person's performance conditions. For this, a 10-m path was considered, and the subject was asked to walk this path in a round-trip fashion until the time of 6 min was over, and from the end, we measured the distance traveled.

Dynamic balance (time to get up and go)

In the dynamic balance test, the subject must sit correctly on the chair with handles. A cone is placed on the ground at a distance of 3 m from the chair. When the test-takers command to move is announced, the subject must stand up and walk with regular steps in a straight line up to a distance of 3 m. After reaching the specified place, the subject should return to the chair and sit on it. With the movement command, the stopwatch is turned on and the test time ends when the subject sits on the chair.

Upper body strength (forearm with a 3.63 kg weight for 30 s)

The purpose of the upper body strength (forearm with a 3.63 kg weight for 30 s) test is to evaluate upper body strength in elderly people. The test started by sitting on a chair and holding a 2 kg dumbbell for women and a 3.63 kg dumbbell for men in the dominant hand, as well as the number of times a person lifts and lowers the weight for 30 s. Doing the forward movement will hit the arm and the person's record will be recorded.

Dynamic power of the leg (getting up and sitting for 30 s)

The subject on a chair with a height of 43 cm, performs the movement of sitting and standing for 30 s while placing both hands in front of the body on the chest and the times of sitting and standing up in 30 seconds are considered as points.

Endurance of lower limb muscles (2 min of walking)

The purpose of the endurance of lower limb muscles test is to measure the aerobic endurance of elderly people. The subject walked on a designated path for 2 min, and the number of correct steps during this period was recorded as the subject's record.

Pilates is a comprehensive exercise method that focuses on strengthening the core muscles, improving balance, and enhancing flexibility. The selection of specific exercises in Pilates is based on individual goals and needs. In this study, the participants were elderly men who were unable to perform various types of sports movements. Therefore, Pilates exercises were chosen for this age group for the following reasons.

Core muscle strengthening: Pilates exercises target the muscles of the abdomen, back, and hips, which helps improve body balance and stability.

Improved flexibility: Pilates includes stretching exercises and controlled movements that help increase joint range of motion and muscle flexibility.

Improved focus and body awareness: Pilates emphasizes awareness of body movements and mental focus during exercise to improve movement control and coordination. The exercise program, three times a week for eight weeks, included Pilate's exercise. The subjects performed the test exercises between 8 AM and 10 AM, with a minimum coverage. The exercise program consisted of four sections that explained how to work and control the intensity of exercise (repetition, seat, rest, rating of perceived exertion, and heart rate), the warm-up section, the main body exercise, and cooling. The workout schedule for each session included 5 min of warm-up with stretch movements (six stretches for at least 30 s) and the main exercise body consisted of 14 movements, from the selected Pilates moves (the first week started with 10 moves, and the pair of weeks were added to the movements at the end, ending with 14 moves in the eighth week). The cooling program included 5 min of stretching movements. Four repetitions of each pilates

Table 1. Pilate's training protocol

Training Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Sessions	3	3	3	3	3	3	3	3
Frequency	4	4	6	6	8	8	10	10
Sets	3	3	3	3	3	3	3	3
Rest between sets (s)	30-60	15-30	30-60	15-30	30-60	15-30	30-60	15-30
Movements	4	4	4	4	3	3	3	3
RPE*	10	10	10	11	11	11	12	12
Intensity** (% HR max)	50-55	50-55	55-60	55-60	60-65	60-65	65-70	65-70
Total time (m)	60	60	60	60	60	60	60	60
Warm-up (m)	10	10	10	10	10	10	10	10
Cool-down (m)	5	5	5	5	5	5	5	5

RPE: Rate of perceived exertion; %HR max: Percent of maximum heart rate.

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Notes: RPE is a subjective measure of how hard a subject is working during exercise. A scale of 1 to 10 is typically used, with 1 being very easy and 10 showing maximal effort. %HR max is a way of expressing exercise intensity as a percentage of a subject's maximum heart rate.

movement were performed during the first two weeks of the sessions, the intensity of which was adjusted by the participants based on their level of physical condition. Increased intensity of work during the training period (increased repetition and reduced rest). Repetitions progressed gradually over a two-week interval, resulting in ten repetitions in the last two weeks (seventh and eighth weeks). The intensity of exercise was measured by rating of perceived exertion and heart rate. The rating of perceived exertion was in the primary stage of training in the first 10 sessions and reached 12 in the eighth session (Table 1) [30].

Data analysis

The data were analyzed using the SPSS software, version 20. The normality of the data was evaluated by the Shapiro-Wilk test and the equality of variances among the groups was evaluated by the Levene test. The paired t-test and analysis of covariance were used for within and between changes, respectively. The significance level of P<0.05 was considered as the decision rule to determine the significance of the differences.

Results

Table 2 presents the characteristics of the participants in both the experimental and control groups. The findings presented in Table 3 demonstrate significant reductions in weight (P=0.01), body mass index (P=0.01), waist circumference (P=0.01), and hip circumference (P=0.01) within the experimental group after the training period. Conversely, these changes were not significant in the control group (P>0.05). Following the training intervention, the experimental group exhibited a 2.01% decrease in body weight, a 1.94% decrease in body mass index, a 3.86% decrease in waist circum-

Table 2. The characteristics of the subjects

Groups	Mean±SD			
	Variations			
	Age (Y)	Height (cm)	Weight (kg)	Body Mass Index (kg/m²)
Training	64.46±5.63	163.23±8.32	61.38±14.36	23.08±5.17
Control	68.53±7.95	167.23±9.13	67.89±10.71	24.36±3.72

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Table 3. Changes in body composition of elderly men in different groups

Variables	Groups	Stages				Variations				
		Mean±SD		t	P*	95% Confidence Interval of the Difference		Changes (%)	F	P**
		Pre-test	Post-test			Lower	Upper			
Weight (kg)	Training	61.38±14.36	60.17±13.58	3.99	0.02†	0.54	1.86	-2.01	2.51	0.12
	Control	67.89±10.71	67.73±10.52	0.307	0.76	-1	1.34	-0.23		
Body mass index (kg/m²)	Training	23.08±5.17	22.64±4.99	4.261	0.01†	0.21	0.66	-1.94	0.91	0.34
	Control	24.36±3.72	24.3±3.78	0.262	0.79	-0.38	0.48	-0.24		
Waist (cm)	Training	83.92±13.78	80.8±13.53	6.87	0.01†	2.12	4.1	-3.86	3.95	0.05
	Control	90.3±11.55	90.61±11.52	-0.428	0.67	-1.87	1.26	0.34		
Hip (cm)	Training	91.23±8.51	87.23±8.66	6.45	0.01†	2.64	5.35	-4.58	1.36	0.25
	Control	92.61±9.63	91.61±10.38	1.237	0.24	-0.76	2.76	-1.09		
Waist-to-hip ratio	Training	0.91±0.07	0.92±0.08	-1.04	0.31	-0.21	0	1.08	2.65	0.11
	Control	0.97±0.12	0.99±0.13	-1.63	0.12	-0.03	0	2.02		

SD: Standard deviation.

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†Significant level at P<0.05, *Significance value (P) within the group, **Significance value (P) between groups.

Table 4. Changes in physical fitness factors of elderly men in different groups

Variables	Groups	Stages				Variations				
		Mean±SD		t	P*	95% Confidence Interval of the Difference		Changes (%)	F	P**
		Pre-test	Post-test			Lower	Upper			
Flexibility (cm)	Training	-6.03±0.6	0.34±0.09	-35.79	0.01†	-6.75	-5.98	1873.52	780.9	0.01†
	Control	-6.54±0.79	-6.15±0.83	-1.8	0.09	-0.86	0.08	-6.34		
Cardiovascular fitness (cm)	Training	237.07±89.09	253.84±88.85	-5.07	0.01†	-23.97	-9.56	6.6	2.95	0.09
	Control	215.61±48.07	205.76±47.52	1.11	0.28	-9.4	29.09	-4.78		
Dynamic balance (s)	Training	9.8±2.65	9.03±2.31	3.58	0.01†	0.3	1.24	-8.52	2.59	0.12
	Control	10.62±3.27	10.88±3.45	-1.29	0.21	-0.7	0.17	2.38		
Upper limb strength (number in 30 s)	Training	15.84±7.35	19.15±7.13	-7.7	0.01†	-4.24	-2.37	17.28	6.43	0.01†
	Control	13.84±3.46	13.3±4.25	0.8	0.43	-0.91	1.98	-4.06		
Dynamic leg strength (number in 30 s)	Training	14.76±3.19	18.3±2.42	-7.05	0.01†	-4.63	-2.44	19.34	14.78	0.01†
	Control	14.15±3.02	14.84±2.15	-1.81	0.09	-1.52	0.14	4.64		
Lower limb muscle endurance (number of steps)	Training	28.69±2.09	32.46±2.75	-8.55	0.01†	-4.72	-2.8	11.61	29.56	0.01†
	Control	26.92±3.12	25.84±3.41	1.31	0.21	-0.70	2.86	-4.17		

SD: Standard deviation.

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†Significant level at P<0.05, *Significance value (P) within the group,** Significance value (P) between groups.

Table 5. Changes in postural abnormalities of elderly men in different groups

Variables	Groups	Stages				Variations				
		Mean±SD		t	P*	95% Confidence Interval of the Difference		Changes (%)	F	P**
		Pre-test	Post-test			Lower	Upper			
Forward head	Training	32.23±1.48	31.53±1.33	2.92	0.01†	0.17	1.2	-2.22	0.2	0.65
	Control	31.46±0.96	31.33±1	0.93	0.36	0.14	-0.17	-0.41		
Scoliosis (mm)	Training	40.5±1.06	40.09±1.06	3.08	0.01†	0.13	0.11	-1.02	0.63	0.43
	Control	40.33±0.95	40.41±0.97	-0.45	0.65	0.16	-0.44	0.19		
Kyphosis (o)	Training	45.76±3.94	43.69±3.79	5.41	0.01†	0.38	1.24	-4.73	2.2	0.15
	Control	46.76±4.86	46.38±5.33	0.51	0.61	0.74	-1.24	-0.81		
Lordosis (o)	Training	43.15±3.07	40.69±3.61	5.89	0.01†	0.41	1.55	-6.04	3.04	0.09
	Control	42.92±3.88	43±3.1	-0.16	0.87	0.45	-1.07	0.18		
Genu Varum (cm)	Training	6.04±0.74	5.96±0.74	0.63	0.53	0.12	-0.18	-1.34	6.77	0.01†
	Control	6.72±0.61	6.62±0.51	1.24	0.23	0.08	-0.07	-1.51		

SD: Standard deviation.

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†Significant level at P<0.05,*Significance value (P) within the group, **Significance value (P) between groups.

ference, along a 4.58% decrease in hip circumference. There was no significant difference between the experimental and control groups in terms of body composition variables, such as body weight, body mass index, waist circumference, hip circumference, and waist-to-hip ratio (P>0.05). The results provided in Table 4 indicate a significant improvement in flexibility (P=0.01), cardiorespiratory function (P=0.01), upper limb strength (P=0.01), leg dynamic strength (P=0.01), and endurance of lower limb muscles (P=0.01).

However, the amount of dynamic balance decreased significantly (P=0.01). Cardiorespiratory function (6.60%), upper limb strength (17.28%), leg dynamism strength (19.34%), and endurance of lower limb muscles (11.61%) were significantly improved after the training intervention. The changes of inter-group averages in the records of physical fitness indicators of elderly men include flexibility (F=780.90, P=0.001), upper limb strength (F=6.43, P=0.001), leg dynamic strength (there was a significant difference between the experimental and control groups [F=14.78, P=0.001] and lower limb muscle endurance [F=29.56, P=0.001]).

Based on the results of Table 5, the changes in group averages in the forward head (P=0.01), scoliosis (P=0.01), kyphosis (P=0.01), lordosis (P=0.01), found a significant decrease; however, there was no significant change in the amount of genu varum. Forward head (2.22%), scoliosis (1.02%), kyphosis (4.73%), and lordosis (6.04%) were significantly improved after the training intervention. The averages of genu varum differ significantly between the two experimental and control groups (F=6.77, P=0.001). This indicates a significant difference in the variable.

Discussion

Specific Pilates exercises had a significant effect on diverse aspects of physical fitness in inactive elderly males. These exercises enhanced flexibility, cardiorespiratory performance, upper limb strength, lower limb dynamic strength, and lower limb muscle endurance. Nevertheless, there was a marked decline in dynamic balance. These findings are consistent with the investigation carried out by Pouyafar et al. [31] but are in disagreement with the outcomes reported by Vasconcelos et al. [32]. Pouyafar et al. (2021) reported eight weeks of whole-body vibration exercises in two groups of high and low intensity, respectively, with a frequency of 25-40 Hz and a range of 3 mm, and rope pulling on the physical performance of elderly men. They concluded that the flexibility of the lower body, the strength of upper limb muscles, static hand strength, dynamic leg strength, muscle endurance performance of lower limbs, cardiorespiratory performance, dynamic balance performance, and body fat percentage were significantly improved in the experimental groups [31]. In contrast, Vasconcelos et al. (2016) examined the effects of an advanced resistance exercise program with a high-speed multivitamin on the physical performance of older women with obesity, reporting that the advanced resistance exercise program with a higher-speed multivitamin did not have an effective effect on improving the physical function of older obese women [32]. Aerobic exercises improve endurance capacity by increasing oxidative enzymes, muscle glucose, and glycogen content increasing the pulse volume and decreasing heart rate, and resistance exercise also improves endurance through increasing time to reach fatigue [33]. Hence, it is probable that the enhanced strength observed in the trials of this study resulted in an increase in exercise capacity and improved resistance of the respiratory and cardiovascular systems [34]. The first factor in motor emotional hypersensitivity to maintain balance is the myotatic reflex is carried out by muscle spindles [35]. Pilates exercises increase the sensitivity of muscle spindles and by improving the neuromuscular function, they increase the speed of mechanical and physiological responses causing co-activation of α and gamma motor neurons and ultimately facilitating muscle contraction. Increasing the sensitivity of muscle spindles and improving neuromuscular control after Pilates exercises is reported as one of the reasons for improving balance after these exercises [35, 36]. Based on the findings of this study and previous research, Pilates exercises possess the capacity to enhance the physical well-being of older adults. These exercises contribute to maintaining a delicate equilibrium between the factors that stimulate and impede muscle growth [37].

It is essential to acknowledge that elderly individuals experience their movement limitations stemming from physiological and physical conditions. Hence, the inclusion of exercises that take into account these limitations, along with adherence to a tailored exercise regimen, can prove advantageous for this particular population. In summary, this kind of exercise intervention holds great potential in assisting with the rehabilitation and sports programs for the elderly [38]. The findings of the current research indicate the effectiveness of Pilates exercises in reducing forward head, scoliosis, kyphosis, and lordosis. However, there was no significant change observed in genu varum. These results are consistent with a study conducted by Emery et al. [16] while contradicting the findings of Ershadi et al. [39]. Emery et al. [16] investigated the impact of 12 weeks of Pilates exercises (2 sessions per week, 60 min each) on arm-trunk position and flexibility in 19 participants. They concluded that the exercises significantly improved back kyphosis, enhanced neck strength, and upper chest flexibility, and could potentially aid in the prevention of neck and shoulder disorders. Conversely, Ershadi et al. [39] reported that eight weeks of Pilates exercises resulted in an improved forward head angle in the experimental group compared to the control group, but no significant difference was observed in kyphosis and lordosis angles between the two groups.

In the study of Cheshomi et al. [40], by examining the effect of six weeks of resistance training with elastic along with stretching training on the upper cruciate syndrome of overhead athletes, they concluded that the thoracic kyphosis angle, forward head angle, and forward shoulder angle in the intervention group decreased significantly.

This muscle imbalance caused by repeated overhead activities leads to a forward shoulder. Kendall's point of view in improving postural disorders is based on stretching the short muscles and strengthening the weakened muscles in the involved position. Kendall seems to think that the shortness of the muscles in the upper anterior part of the chest reduces the ability of people with kyphosis to have a good posture [41]. These muscles are generally stronger than their antagonist muscles, which leads to muscle imbalance and an unfavorable body position. On the other hand, weak or stretched muscles in the posterior part of the thoracic spine can help correct and maintain proper alignment. This is important to avoid the undesired condition [42]. Studies indicate that hyper-kyphosis in the elderly can be caused by aging, compression fractures of vertebrae, postural control disorders, degenerative diseases of vertebral discs, muscle weakness, and erosion of vertebral ligaments [43]. An increase in thoracic kyphosis has many adverse consequences for health, some of the most important of which are a decrease in physical performance, pulmonary dysfunction, increased shortness of breath, problems in performing daily activities, balance disorders, falls, and a decrease in quality of life [44].

Functional exercises are sports activities that aim to replicate everyday movements, including walking up and down stairs, sitting and standing, and handling light equipment. The primary goal of these exercises is to improve physical fitness through the targeted development of key factors such as endurance, strength, flexibility, and balance [45]. A corrective functional training program has been shown to improve muscle strength and deep muscle receptors in older individuals [46]. However, conflicting results in previous research may be due to differences in participants' physiological conditions, overall health, exercise duration, type, and intensity. Considering the numerous benefits that Pilates exercises offer for older individuals, specialists, medical personnel, and physicians need to consider them to enhance the physical, cognitive, and overall quality of life for older adults. [26, 47]. By focusing on strengthening the core muscles of the body, Pilates exercises provide functional benefits such as improved balance, reduced risk of falling, increased muscle strength and endurance, and enhanced flexibility in the elderly [48, 49]. These benefits help maintain motor independence and improve the ability to perform daily activities. Given these advantages, professionals, medical staff, and physicians should consider incorporating Pilates exercises as an effective method for enhancing physical function, cognition, and overall quality of life in rehabilitation and geriatric care programs.

Conclusion

Overall, Pilates exercises were found to significantly improve flexibility, cardiorespiratory function, upper limb strength, leg dynamics, and lower extremity muscle endurance in inactive elderly men. Additionally, there was a noticeable reduction in posterior abnormalities, such as forward head, scoliosis, kyphosis, and lordosis. It is recommended that future research focuses on the longer duration of Pilates exercises, given their importance in preventing and treating various physical fitness abnormalities and indicators. Furthermore, it is advisable to utilize reputable medical devices such as body composition analysis, radiography, or spinal cord rat devices to accurately measure postural abnormalities and body composition.

Study limitations

One limitation of this study was the inability to use valid medical devices, such as body composition, radiography, or spinal mouse devices, to provide measurements. Considering that this study was faced with many limitations, such as varied diets, various adaptive responses to physical activity, the small number of subjects due to the withdrawal of some of them from participating in the present research, and individual differences, as a result, the side of caution should be observed more. However, the study had sufficient statistical power to identify differences. It is recommended to conduct further randomized controlled trials to gain a better understanding of the effects of these interventions over a longer period and in different age groups.

Ethical Considerations

Compliance with ethical guidelines

Informed consent was obtained from the participants following the Declaration of Helsinki. This study was approved by the local Ethics Committee of Hakim Sabzevari University, Sabzevar, Iran (Code: IR.HSU.REC.1401.011).

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Authors' contributions

Conceptualization and methodology: Keyvan Hejazi and Azizeh Toghdori; Data collection, data analysis, and the original draft preparation: Keyvan Hejazi; Review and editing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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