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Home-Based Pilates Exercise Regimen Can Alter the Balance and Trunk Mobility of Non-Exercising Middle-Aged Women: A Pilot Study

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ABSTRACT

Background: Technological inventions are promoting a sedentary lifestyle. With aging limited physical activities result in postural instability, falls, and mobility reduction, for which the two physical fitness components - balance and flexibility play indispensable roles. Among many exercise protocols, Pilates is one of the most beneficial regimens for developing core muscle strength, balance, flexibility, and aerobic capacity in middle-aged women. **Purpose:** The purpose of the current pilot study was to examine the influence of a nine-week home-based Pilates exercise (HBPE) program on the balance and trunk mobility of middle-aged women. **Methodology:** This pilot study adopted a quasi-experimental design with 40 non-exercising middle-aged women (age 40–60 years) who were purposively enrolled in a Pilates exercise group (PEG, n=20; mean age= 52.05±5.93 years) and a Control group (CNG, n= 20; mean age= 51.90±5.88 years). The PEG was exposed to three weekly sessions of 50–60 minutes for nine weeks of Pilates exercises, while the CNG used to perform only their daily usual activities. One-leg stand test, Timed up and go test, and Sit-and-reach test had been administered twice before and after the intervention of the HBPE program to evaluate their static balance, dynamic balance, and trunk flexibility respectively. **Result:** Nine weeks of the HBPE program significantly influenced the static balance ($t= -4.901$, $p=0.001$, $\Delta\% = 9.82$), dynamic balance ($t= 2.582$, $p=0.018$, $\Delta\% = -1.02$), and trunk flexibility ($t= -8.000$, $p=0.001$, $\Delta\% = 2.51$) among the participants of PEG, while CNG showed no significant changes in those dependent variables. **Conclusion:** The current pilot study concludes that nine weeks of the HBPE program can significantly improve the balance and trunk flexibility of non-exercising middle-aged women and thereby can increase postural stability and trunk mobility.

Key words: Aging, Sedentary lifestyle, Exercise, Postural balance, Mobility

INTRODUCTION

The evolutionary process, along with the advancement of medical science, resulted in an increased life span for humans. The global population of the elderly is anticipated to nearly triple by 2050 (Bandyopadhyay et al., 2023; Kulik et al., 2014). This prognosis has prompted many medical, health professionals, and fitness trainers to devote closer attention to health, wellness, and safety of the elderly. Age-related decline in various organs, systems, and physical abilities starts at the age of 30 and continues until death. Aging is accompanied by a decline in different physical capabilities (Bandyopadhyay, 2020), with common alterations in physiological functioning (Bandyopadhyay et al., 2022). The changes in physiological functioning include diminished kinesthesia, and proprioception, particularly a decline in the number of cutaneous receptors in the lower extremity, decreased muscle mass and strength mostly related to core muscles, decreased cognitive capacities, and increased vibration sensory threshold (Długosz-Boś et al., 2021). Furthermore, cerebral conductivity decreases, resulting in prolonged reaction times, and loss of sensory and motor neurons leading to decreased integration of sensory and motor responses (Michalska et al., 2021). All such alterations in physical functioning frequently result in gait instability and reduced balance ability, limiting the social autonomy of senior people and, in some situations, causing falls. In many cases, joint degenerative disorders appear, affecting body posture and perhaps resulting in postural instability (Presta et al., 2023).

Many research investigations have been conducted in an attempt to assist older people in remaining independent and in good health for as long as possible. The signs of aging have become more visible since middle age. In this perspective, middle age may be considered as the right time to prepare oneself to be physically fit and active so that one can enjoy a healthy, graceful, and independent old age. Among the determinants, balance, and flexibility are the two key difficulties that may affect the daily lives of the elderly

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population. The primary function involved in controlling balance is to maintain the body's stability during static and dynamic positions by producing proper responses to govern body alignment (Ivanenko & Gurfinkel, 2018). Input from sensory organs such as the eyes, vestibular systems, and proprioceptors is responsible for such responses. But aging results in drastic anatomical and physiological changes in sensory organs, which may lead to balance disorders and falls, and thus the older population becomes more dependent (Liu et al., 2014). Women experience more falls than men do, and as a result, they are hospitalized more frequently (Gale et al., 2016).

Flexibility is an individual's ability to execute movement around the joint with the greatest possible amplitude (Bains et al., 2016). While the anatomical structure of the joint determines the types of movements that may be executed, muscle flexibility is indispensable for successful mobility. Further, chronological age, gender, fitness, fatigue, and temperature are the factors that influence flexibility. With advancing age, the increase in rigidity of tendons and ligaments, tightening of the cross-links, reduction in elastin content, deterioration in cartilage and fluid within the joint, and dysfunction of muscles all result in joint stiffness and mobility reduction (Kostrominova & Brooks, 2013).

Many studies demonstrate that moderate physical activity improves psychomotor coordination, muscle strength, and visual perception, which improves balance, minimizes the risk of falling, and increases joint mobility (Bandyopadhyay, 2020; Sadeghi & Shojaedin, 2021; Sherrington & Tiedemann, 2015). Despite the advantages of exercise, older people are less likely to start and continue exercising. So, it's important to offer adult exercise programs that are comparable to other exercise programs in terms of safety, and effectiveness. According to current WHO standards, weekly physical activity of 150–300 minutes is recommended for health benefits (Bull et al., 2020). To develop interest and motivate adults to maintain exercise adherence, they need to be provided with a variety of physical training options, as there is no universal exercise program that fits all (Palazzo et al., 2016). Further, motivating middle-aged women to regularly participate in an exercise program should be planned as safe, enjoyable, interesting, convenient, and at the same time within their capacity.

Among many adult exercise protocols, Pilates, which was developed more than 80 years ago, has become well-accepted in the last 20 years due to its benefits for developing postural balance, endurance, coordination, strength, and flexibility (Bullo et al., 2015; Cruz-Ferreira et al., 2011). The Pilates program includes exercises that can strengthen the small muscles in the body and thereby develop the strength of the core muscles attached to the lumber, abdomen, pelvic floor, and hip. It may contribute to strengthening the lower extremity and thus increase balance and reduce the chances of falls (Kloubec, 2011). Additionally, Pilates has the benefit of allowing exercise load to be adjusted by the body's center of balance because it is an individual body-based workout. Further, it may incorporate aerobic exercises, resistance exercises, stretching, and flexibility exercises by using various equipment viz. a resistance band, a medicine ball, a Swiss ball, etc. for increasing muscle strength, flexibility, and balance (Bullo et al., 2015; Cruz-Ferreira et al., 2011; Vieira et al., 2017), and is simple to carry out anywhere. Numerous research investigations (Kolomiitseva et al., 2022; Sekendiz et al., 2007; Su et al., 2022) concerning Pilates have been conducted recently due to its rising popularity and was found as a potential workout program for developing physical efficiency among the older population. Fernández-Rodríguez et al. (2021) conducted a systematic review of 39 studies based on the influence of Pilates exercise on the risk of falls and physical performance components in the elderly, and they concluded that the Pilates program can be considered as a potential, effective, and safe program for developing strength, flexibility, and balance. Pilates has gained much acceptance worldwide because of its simplicity and space effectiveness, but in India, it is not well known by adults; instead, they practice yogic postures to keep themselves fit. But executing any yogic posture requires a greater range of motion around the joint, which middle-aged and older people may face difficulties with. In that context, Pilates is a light- to medium-intensity workout that they can undertake with ease and comfort and thereby feel motivated to participate in. Keeping in view the findings of the previous studies, the research hypothesis adopted for the current pilot study was that Pilates exercises would bring about changes in balance and trunk flexibility in middle-aged women. In this perspective, a pilot study was conducted on the home-based Pilates exercise (HBPE) program to introduce this new regimen of exercise protocol and observe its effect on balance and trunk mobility in middle-aged women.

METHODS

Study Design

The current pilot study used a quasi-experimental design. It was conducted through pre-test, and post-test from November to January 2022-23. Before conducting a pre-test on dependent variables a thorough medical check-up was done for all participants by a registered medical practitioner. As per their health status and feasibility to participate throughout the nine weeks of the HBPE program based on personal interviews, they were purposively divided into an exercise group and a control group. During the interview, a few participants reported that they would not be able to take part in the exercise program due to their household chores and family responsibilities, but they showed their interest in remaining as control participants. The details of the study were provided in written form, as well as verbally explained to all the participants. The pre-test on balance (static and dynamic) and trunk flexibility were conducted two days prior to the commencement of the HBPE program. The post-intervention tests on static and dynamic balance and trunk flexibility were taken two days after the completion of nine weeks of the HBPE program that followed the same method and were conducted in an almost similar environment. The nine-week HBPE program was implemented in the exercise group, whereas the control group did not participate in such a program and was asked to maintain their usual daily routine. The Faculty Council, Department of Physical Education, University of Kalyani, India, approved the current pilot study (Ref No.- PE-34/2023/65). Figure 1 depicts the current study design.

Participants and Determination of Sample Size

Initially, the help of a questionnaire consisting of seven questions on basic information such as age, occupation, willingness, and physical activity status (two questions with options 'yes' or 'no', Q1. "Are you involved in any kind of exercise program at present?"; Q2. "Were you involved in any kind of exercise program in recent past?"), and medical history (two questions with options 'yes' or 'no', Q1. "Currently, are you suffering from any chronic disease such as diabetes, high blood pressure, cardiac problem, spinal injury?"; Q2. "Do you have any health problem where exercise is not recommended?"), a total number of 65 adult women were reached in Begampur, a semi-urban place in West Bengal, India. Based on the following inclusion criteria, forty (n=40) of them were chosen: i) willing to participate; ii) women between 40 and 60 years old; iii) ability to perform light to moderate physical activity independently; iv) not having any history of acute disease (cardiovascular ailment, hypertension, spinal cord injury, hyperglycemia); v) not engaging in regular physical activity; and vi) being found medically fit. They were purposively divided into two groups: the Pilates exercise group (PEG, n=20) and the Control group (CNG, n=20). Figure 1 presents the procedure for selecting participants. In the present study, G*Power 3.1.9.7 software was used for determining the sample size (Faul et al., 2009). Based on the previous studies, a priori power analysis was employed to calculate the sample size with an estimated effect size of 0.65, $\alpha = 0.05$, power = 0.80 (Fleming et al., 2020; Su et al., 2022), and the minimum sample size n= 17 for each group, df = 16, and critical t value = 1.7458. Predicting a 12–15% attrition rate, 20 subjects in each group were included (Bandyopadhyay & Das, 2022).

Tools used for Assessing Dependent Variables

In the current investigation, static and dynamic balance and trunk flexibility were dependent variables, whereas the nine-week HBPE program was the only independent variable. The dependent variables were measured through reliable and valid tests. One leg stand test (Amaro-Gahete et al., 2017; Barranco-Ruiz & Villa-González, 2020) was used to measure static balance; Timed Up and Go test (Długosz-Boś et al., 2021; Vieira et al., 2017) was used to examine dynamic balance; and Sit-and-reach test (Akhavan Rad et al., 2019; Mayorga-Vega et al., 2014; Su et al., 2022) was used to assess trunk mobility.

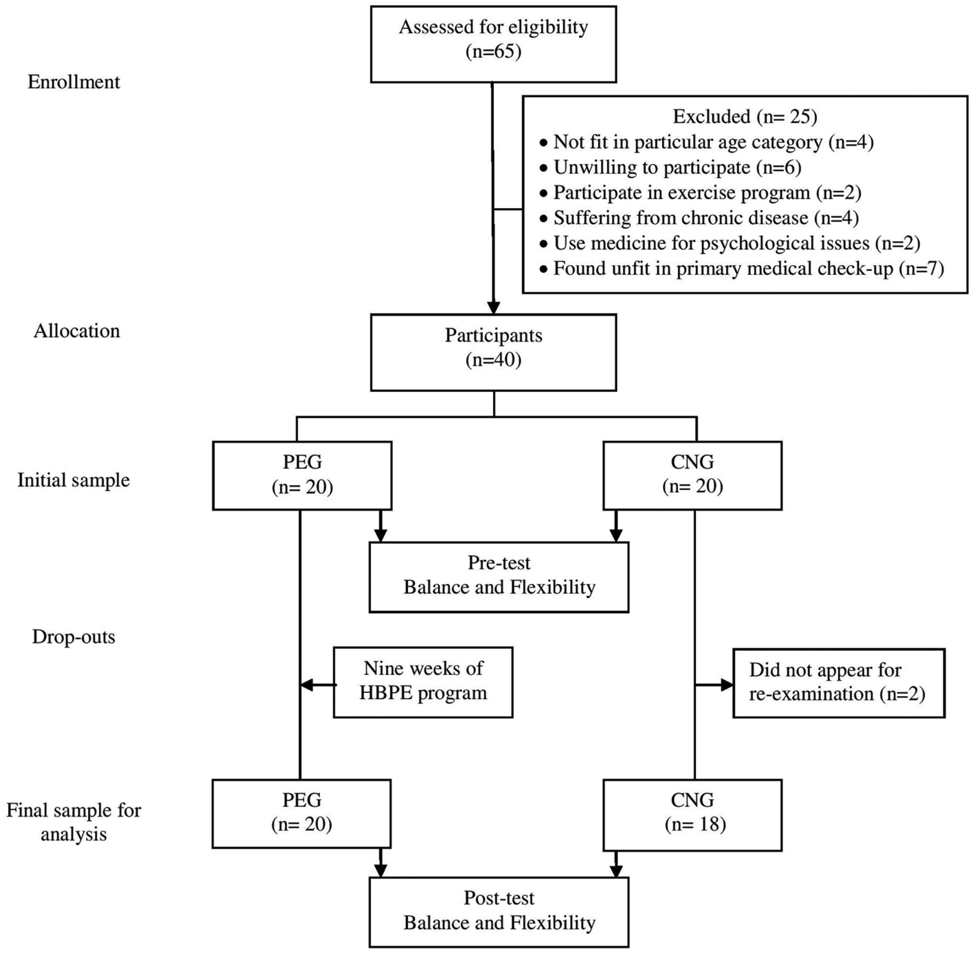

Figure 1. Study design

One-leg stand test

One-leg stand test (Amaro-Gahete et al., 2017; Barranco-Ruiz & Villa-González, 2020) was employed for measuring the static balance in which the ability to maintain balance while the person was standing on one leg was assessed. The subject can choose a preferred leg to stand on and should place the heel of the opposite leg at the knee on the supporting leg, and with the thigh of the opposite leg rotated outwards. The participant's arms remained relaxed with eyes open. The maximum time for maintaining the correct standing position was recorded in seconds (0–60s) by a stopwatch (Casio, Japan) and among two trials the best result was considered as a score.

Timed up and go (TUG) test

The dynamic balance of the subjects was assessed by the Timed up and go (TUG) test (Długosz-Boś et al., 2021; Vieira et al., 2017), where the participants were instructed to rise from a chair, then walk three meters, then turn 180 degrees to return to sitting in the chair at their comfortable pace. The minimum time taken by an individual to complete the test in three trials was counted as score, which was recorded by using a stopwatch (Casio, Japan).

Sit-and-reach test

The Sit-and-reach test (Akhavan Rad et al., 2019; Mayorga-Vega et al., 2014; Su et al., 2022) was employed by using the Baseline Sit and Reach Trunk Flexibility testing box (Baseline, USA) for measuring trunk flexibility that corresponds with trunk mobility. The participants were directed to sit on the ground with the soles of their feet kept leaning against the flexbox without bending their knees and their hands stretched gently forward as far as possible. They were instructed to hold the position for two seconds. Two attempts were allowed, and the furthest position they reached with their hands was the test score.

Exercise Intervention

The HBPE program was offered to the Pilates exercise group for 3 days in a week of 50–60 minute sessions for nine consecutive weeks as per WHO 2020 guidelines (Bull et al., 2020). These nine weeks were divided into one week of orientation, followed by Part-I (PI) for the next four weeks and Part-II (PII) for the last four weeks. The intervention program consisted of three parts: (i) Warming-up of 10 minutes; (ii) Main part of the exercise program of 30–40 minutes; and (iii) Cooling-down of 10 minutes. The main part of the HBPE intervention program was planned with various types of Pilates exercises for different regions of the body, and they were performed in different body positions (i.e., sitting, lying, kneeling, and standing postures) by using mats. The types of Pilates exercises and their load dynamics (repetitions and sets) were determined based on exercise protocols used in previous studies (Długosz-Boś et al., 2021; Kolomiitseva et al., 2022; Su et al., 2022). The number of repetitions for a particular exercise for each participant was determined following the Borg exertion scale (Williams, 2017), in PI light to moderate (2-3 Borg CR10), and in PII moderate to somewhat severe (4-6 Borg CR10) (Bandyopadhyay & Das, 2022). The sequence of exercises was followed from neck to ankle. During the HBPE program, the participants were asked to attend three supervisory orientation sessions in the first week to get familiar with the new regimen of exercises, followed by four weeks of Home-based Pilates exercise program 3 times per week in PI, where they were instructed to practice the same at their own house as per their convenience. Again, the participants were asked to participate in two supervisory sessions on the sixth week to get acquainted with the exercises to be performed in the next four weeks of the HBPE (PII) program. During orientation, each exercise was explained properly with several times of demonstrations along with the particular breathing pattern, i.e., exhaling while flexion and inhaling while extension (Vieira et al., 2017) followed by practice with the investigators, and the detail of the Borg exertion scale was also explained, which they followed to monitor their repetition and holding time on the basis of their feelings and perceptions. Though the Pilates exercises are not very common in India, it has many similarities with Indian-rooted yogic postures, so three sessions of orientation were enough to become familiar with the particular exercises. They were provided with particular charts (Chart 1 for PI and Chart 2 for PII) mentioning the details of the exercises to be performed. A total number of 17 exercises were given in both PI and PII. The details of the intervention protocol are presented in Table 1. To avoid monotony and increase difficulty a few exercises were changed for particular body regions in PII. After each home-based session, each participant used to report to the investigators regarding their performance and execution. The PEG participants were also instructed to communicate with the investigators during their sessions through a video call if they feel so. The time frame of the intervention program is depicted in Figure 2.

Statistical Analysis

The IBM SPSS 23 version was used for statistical analysis. The normality and homogeneity of the data were checked by the Kolmogorov-Smirnov test and Levene's test, respectively. The normality test results showed that the data were normally distributed. Descriptive statistics (mean and standard deviation) were calculated from the pre-and post-test data for all the variables. The baseline differences between the groups were examined using the Independent t-test. To find out the effects of nine weeks of the HBPE program, the pre-test and post-test means of dependent variables for both groups were compared using Paired sample t-test. The significance level was set at $p<0.05$. The percentage of change ($\Delta\%$) in dependent variables was calculated using Microsoft Excel 2010 software.

RESULTS

For the present investigation, 40 middle-aged women were chosen, and as per their convenience, they were divided

Table 1. Intervention protocol

Section with Duration	Body Position	Exercise with sequence	Body Region	Reps/Holding Time	Ex planned for PI & PII
Warming-up (10 min)	-	Walking on toe, alternative knee up with foot flexion, arm stretching, arm raise up, and waist bending forward and backward	-	-	PI & PII
Main part (30-40 min)	Standing	Neck flexion	N	5 reps	PI
		Shoulder Shrugs	S, N	8-10 reps	PI
		Shoulder Rolls	S, N	5 reps for each side	PII
		Arms circles	S	5 reps for each side	PII
		Wall Push-ups	S	8-10 reps	PI & PII
		Hip flexion and extension	H, Th	5 reps for each leg	PI & PII
		Squats	H, Th	8-10 reps	PII
	Sitting	Spine twist- double pause	W	8-10 reps	PI
		Spine Stretch	Sp, Ab, Th	8-10 reps	PI & PII
		Mermaid	H, W, Th	5 reps for each side	PI & PII
		The Saw	H, W, Sp, Th	5 reps for each side	PII
		Half-roll back	Sp, Ab	5-8 reps	PI & PII
	Lying	Ab Preparation	H, Sp, Ab, Th	20-30 sec	PI
		Shoulder Bridge- spine curls	H, Sp, Ab, Th	10 reps	PI & PII
		Breaststroke preparation	S, H, Sp, Ab,	20-30 sec	PI
		Side-lying hip abduction	H, Th	5 reps for each side	PI
		Side kicking series: up-down	H, Ab, Th	5 reps for each side	PI
		Side kicking series: front-back	H, Ab, Th	5-8 reps	PI
		Corkscrew	H, W	5 reps for each side	PII
		Roll-up	Sp, Ab	5-8 reps	PII
		Hundred	Sp, Ab	10 reps (10 counts)	PII
		Single leg stretching	Sp, Ab, Th	5 reps for each leg	PI & PII
		Single leg kick	Sp, Th	5-8 reps for each leg	PI & PII
		Double leg kick	H, Ab, Th	5-8 reps	PI & PII
Cooling-down (10 min)	-	Relaxation exercises, stretching exercises	-	-	PI & PII

reps=repetitions, N=neck, S=shoulder, H=hip, W=waist, Th=thigh, Sp=spine, Ab=Abdomen, Ex=exercise, PI=part-I, PII=part-II, sec=seconds, min=minutes

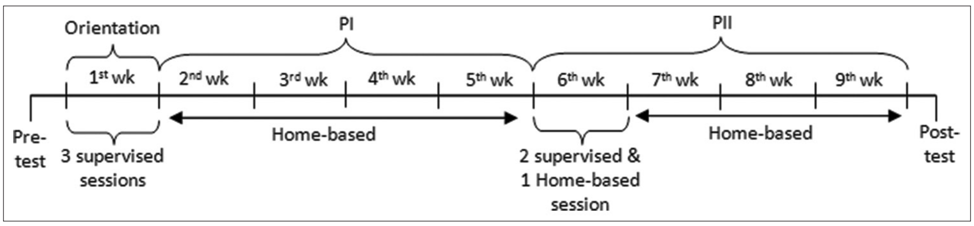

Figure 2. Time frame of the HBPE program

into PEG (n=20, with a mean age of 52.05±5.93 years, and a mean BMI of 25.30±2.03 kg/m^2), and CNG (n=20, with a mean age of 51.90±5.88 years, and a mean BMI of 25.50±1.37 kg/m^2). The participants' general characteristics are depicted in Table 2. The baseline characteristics of the groups were compared using an Independent t-test, which is depicted in Table 3, and it reveals that the groups did not differ significantly, so the groups were more or less homogeneous. The participants in the PEG group had at least 90% attendance. Throughout the intervention period, none of the participants reported any adverse events. Two participants from CNG did not appear in the post-test and their pre-test data were excluded in the pre-post-test comparison.

Table 2. General characteristics of participants

Group	Age (years) (M±SD)	Height (cm) (M±SD)	Weight (kg) (M±SD)	BMI (kg/m^2) (M±SD)
PEG	52.05±5.93	156.15±3.38	61.75±5.01	25.30±2.03
CNG	51.90±5.88	155.10±2.86	61.45±4.02	25.50±1.37

PEG=Pilates exercise group, CNG=Control group, cm=Centimetre, kg=Kilogram, M=Mean, SD=standard deviation, kg/m^2=Kilogram/Meter^2

Table 3. Baseline differences, and comparison between pre-and post-test means of PEG and CNG

Variables (unit)	Period	PEG (n=20)	CNG (n=18)	Baseline differences, (df=38)
SB (sec)	Pre	24.95±10.30	24.06±11.03	t (-0.030), *P*=0.997
	Post	27.40±9.93	24.11±9.88	-
	Paired t-test	t (-4.901), *P*=0.001*	t (-0.060), *P*=0.953	-
	Δ%	9.82	-	-
DB (sec)	Pre	8.83±2.35	8.88±2.37	t (0.050), *P*=0.961
	Post	8.74±2.33	9.02±2.38	-
	Paired t-test	t (2.582), *P*=0.018*	t (-1.801), *P*=0.089	-
	Δ%	-1.02	-	-
Trunk Flexibility (cm)	Pre	7.97±2.40	8.07±2.34	t (-0.108), *P*=0.914
	Post	8.17±2.39	8.01±2.37	-
	Paired t-test	t (-8.000), *P*=0.001*	t (1.890), *P*=0.076	-
	Δ%	2.51	-	-

PEG=Pilates exercise group, CNG=Control group, SB=static balance, DB=dynamic balance, df=degree of freedom, Δ%= percentage of change, *P*=level of significance, * = Significant at 0.05 level, sec=second, cm=centimetre, n=number of participants

Paired sample t-test reveals that the PEG significantly improved their SB (pre vs. post; 24.95±10.30 sec vs. 27.40±9.93 sec; t = -4.901, p=0.001), DB (pre vs. post; 8.83±2.35 sec vs. 8.74±2.33 sec, t = 2.582, p=0.018), and trunk flexibility (pre vs. post; 7.97±2.40 cm vs 8.17±2.39 cm, t = -8.000, p=0.001) following 9 weeks of HBPE program whereas CNG showed no significant changes in their SB (pre vs. post; 24.06±11.03 sec vs. 24.11±9.88 sec, t = -0.060, p=0.953), DB (pre vs post; 8.88±2.37 sec vs. 9.02±2.38 sec, t = -1.801, p=0.089), and trunk flexibility (pre vs. post; 8.07±2.34 cm vs. 8.01±2.37 cm, t = 1.890, p=0.076) respectively.

DISCUSSION

The current pilot study was conducted to examine the effects of 9 weeks of a planned HBPE program on static and dynamic balance and trunk mobility of non-exercising community dweller middle-aged women. The results showed that there was an improvement in static balance of 9.82%, dynamic balance of -1.02%, and trunk flexibility of 2.51% among the participants of the PEG, while the CNG showed no significant changes. Hence, the hypothesis that was adopted for this pilot study is accepted. The findings ensured the effectiveness of 9 weeks of the HBPE program in improving balance and trunk mobility, which was comprised of 17 exercises in each phase (PI and PII) and was planned for almost all regions of the body involving all joints, keeping in view the needs of women, particularly during this age. In accordance with our findings, Ramezani et al. (2021) found that 8 weeks of a Pilates exercise program with the frequency of 3 days per week of 60-minute sessions with 10 exercises significantly improved the balance (static and dynamic) of inactive, healthy elderly women. In another study, Sekendiz et al. (2007) found significant improvement in static balance (31%) among sedentary adult women following a 5-week of Pilates exercise program of 3 days per week of 60-minute sessions. Su et al. (2022) found significant improvement in balance (+4.2%) among community dwellers middle-aged women following 12 weeks of a Pilates program (twice per week of 60-minute sessions). Siqueira Rodrigues et al. (2010) reported that static balance improved (4.35%) significantly among elderly females following 8 weeks (twice a week of 60-minute sessions) of Pilates training. Hyun et al. (2014) confirmed that the dynamic balance improved (-21.71%) after 12 weeks of a Pilates mat exercise program with three 40-minute sessions per week. On the other hand, many investigators found no significant improvement in balance among older women following a Pilates program of 3 months with a frequency of twice a week (Długosz-Boś et al., 2021), once a week for 10 weeks (Pyskir et al., 2016), twice a week for 8 weeks (Donath et al., 2015). Balance is the ability to maintain equilibrium when all working forces are canceled out by one another to produce a stable condition. Static balance depends on the capacity to keep the center of gravity within the base of support, keeping a position devoid of postural sway while adopting a particular posture, and dynamic balance indicates the capacity of an individual to maintain postural stability while the body is in motion (Su et al., 2022). The proper reception of external sensory stimuli and the application of balancing strategies are essential components of maintaining balance (Dunsky, 2019). Maintaining postural balance requires a complex interaction between the sensory and musculoskeletal systems (Ivanenko & Gurfinkel, 2018; Michalska et al., 2021), which may be affected by the process of aging, such as the loss of sensory and motor neurons and resulting instability (Michalska et al., 2021). Previous studies reported that as we grow older, the two functions of sensory inputs, i.e., visual and vestibular, get impaired, but exercise can help older people strengthen the functions of the same (Eikema et al., 2014; Hsieh et al., 2014). With aging, the movements required for accomplishing daily tasks become less efficient because of declining balance, thus leading to restricted movements. So, the middle-aged and elderly population needs to maintain an optimum level of balance to remain active (Dunsky, 2019). Pilates is a low-intensity exercise that the elderly can manage properly with satisfaction to improve flexibility, strengthen their muscles, and increase their aerobic capacity. Therefore, it is believed that Pilates promotes balance, thereby reducing the risk of falling. Also, as people get older, the number of sarcomeres in series inside muscle fibers may decrease (Kostrominova & Brooks, 2013), which may be related to a loss of flexibility and subsequently reduce mobility. The major effect of these changes is a decline in functional ability, which may raise the risk of falling, make it harder to carry out everyday tasks, and decrease one's quality of life (Vieira et al., 2017).

Flexibility is the optimum physiological range of motion of a particular joint and plays an important role in performing simple to complex movements that are included in daily activities (Sekendiz et al., 2007; Su et al., 2022). With aging, flexibility decreases, and depending on the joint, the reduction may range up to 50%. It is recommended by the ACSM that optimum levels of aerobic fitness, body composition, muscular strength, and flexibility should be included when considering health-related fitness (Garber et al., 2011). Trunk muscle strengthening should be considered seriously because these muscles give the person stability and mobility. They are also crucial for developing strength, muscular endurance, and a degree of flexibility in this area, which is necessary for completing activities in daily life (Huxel Bliven & Anderson, 2013). Many investigations have been conducted on the Pilates program and Nikić & Milenković, (2022) found significant improvement in flexibility (33%) following 16 weeks of the Pilates program with 3 days per week of 1-hour sessions among middle-aged women. Su et al. (2022) found significant improvement in flexibility (+3.5%) among community dwellers middle-aged women following 12 weeks of a Pilates program of twice per week of 60-minute sessions. Sekendiz et al. (2007) found significant improvement in posterior trunk flexibility among sedentary adult women following 5 weeks of Pilates exercise. In another study, Kolomiitseva et al. (2022) conducted a 12-week Pilates program (3 days per week of 1-hour sessions) and found significant improvement in trunk flexibility among healthy middle-aged women.

So, our pilot study was in the right direction, and further investigations may be conducted considering many more dependent variables. Investigations may also be conducted for both sexes based on this particular exercise protocol. Furthermore, the present protocol can be adopted by health professionals and fitness experts to provide health benefits to the middle-aged and older population.

Limitations of the Study

Because of the participants' inability to assemble at a particular place and time, the program had to be conducted home-based. Though the PEG participants had been provided with a familiarization session and a detailed chart, they were still not under the direct supervision of the investigators, which may lower the level of perfection of their exercise execution. Further, in a supervised program investigators can motivate the participants, and they also get the opportunity to learn many more things from their peers as well as from investigators regarding a healthy and active lifestyle. Moreover, for conducting a home-based program 1-2 weeks of orientation are essential to ensure that the participants can perform exercises independently and accurately. Though the PEG participants were advised to follow their normal daily activities and usual diet, the investigators had very little control over those.

Strength and Practical Implication

It is evident from the previous investigations that Pilates programs are effective in improving mobility and postural stability among the middle-aged and older population, but on the other hand, it was also noticed from the literature that no significant changes occurred in physical capacity, including flexibility and balance, among the elderly following Pilates programs. The reason may be the exercise protocol, and the session frequency plays an important role. The fundamental ideas underlying Pilates exercises focus mainly on concentrating, coordinating, and controlling body movements. But we have given much more emphasis to proper body alignment while performing exercises. Moreover, in the current Pilates program, exercises were designed for the whole body and maintained a proper sequence from neck to shoulder, then hip and waist to ankle. More exercises were given for the hip and waist to develop the muscles involved with the pelvic and abdomen regions such as gluteus, rectus abdominis, transverse abdominis, and external and internal oblique, which play a primary role in lower limb movement as well as trunk stability. In our HBPE program, only participants' body weight was used as resistance. Particularly, the protocol used for the present investigation causes a significant improvement in postural stability and trunk mobility. Moreover, our program was so meticulously designed that it can be used as a model for home-based as well as community-based programs, with little modification for medical and rehabilitation centers. As the program was home-based, no dropouts were reported, and all the participants attended almost all sessions except for very urgent issues (the adherence rate was 90%). In modern days, women are engaged in various activities, and they may not be able to participate in a program in a community setting. Moreover, middle-aged women should pay more attention to preparing themselves for graceful aging. So in that context, a home-based program was much more effective for motivating middle-aged women to participate at their convenience.

CONCLUSIONS

The current pilot study may conclude that the HBPE program can significantly improve the balance, both static and dynamic, and trunk mobility of non-exercising middle-aged women. Therefore, the Pilates program may be suggested as an effective exercise regimen for adult fitness and wellness. Further, it may be adopted as a community-based program, as well as can be used in medical and rehabilitation centers for adult and geriatric health care.

CONFLICTS OF INTEREST

The authors declared no conflict of interest.

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REFERENCES

Akhavan Rad, S., Mokhtar, N., & Kiwanuka, F. (2019). Effect of a Four Weeks Aerobic Training Intervention on Body Fat Percentage and Physical Fitness Indices among 5 to 6-year-old Obese, Overweight and Normal Weight Children: A Quasi-experimental Study. *International Journal of Kinesiology and Sports Science*, *7*(1), 12–17. https://doi.org/10.7575/aiac.ijkss.v.7n.1p.12

Amaro-Gahete, F. J., De La O, A., Jurado Fasoli, L., Castillo, M. J., & Gutierrez, A. (2017). Fitness Assessment as an Anti-Aging Marker: A Narrative Review. *Journal of Gerontology & Geriatric Research*, *06*(06), 1–7. https://doi.org/10.4172/2167-7182.1000455

Bains, B. S., Kaur, G., Sadeghi, H., Husain, A., & Singh, K. (2016). Trunk Flexibility Improvement in Response to Powered Assisted Exercise. *International Journal of Kinesiology and Sports Science*, *4*(3), 50–53. https://doi.org/10.7575/aiac.ijkss.v.4n.3p.50

Bandyopadhyay, N. (2020). Role of low-cost multi-component exercise programme on aging of Indian women. *Theory and Methods of Physical Education and Sports*, *04*, 62–66. https://doi.org/10.32652/tmfvs.2020.4

Bandyopadhyay, N., & Das, T. (2022). Effectiveness of Ten Weeks Community-Based Multicomponent Exercise Program on Physiological Health of Elderly Women. *International Journal of Kinesiology and Sports Science*, *10*(4), 25–33. https://doi.org/10.7575/aiac.ijkss.v.10n.4p.25

Bandyopadhyay, N., Das, T., Biswas, A., & Mondal, D. (2023). Effects of Mindfulness-Based Stress Reduction Program on Mental Health of Non-Clinical Older Adults: A Systematic Review on Randomized Controlled Trials. *International Journal of Aging Health and Movement*, *5*(2), 16-23. https://doi.org/10.7575/ijahm.v5i2.105

Bandyopadhyay, N., Das, T., Biswas, A., Mondal, S., & Koley, A. (2022). Effects of Exercise Interventions on Sleep Quality of Older Adults: A Systematic Review. *International Journal of Aging Health and Movement*, *4*(2), 1-9. https://doi.org/10.7575/ijahm.v4i2.52

Barker, A. L., Bird, M.-L., & Talevski, J. (2015). Effect of Pilates Exercise for Improving Balance in Older Adults: A Systematic Review With Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *96*(4), 715–723. https://doi.org/10.1016/j.apmr.2014.11.021

Barranco-Ruiz, Y., & Villa-González, E. (2020). Health-Related Physical Fitness Benefits in Sedentary Women Employees after an Exercise Intervention with Zumba Fitness®. *International Journal of Environmental Research and Public Health*, *17*(8), 2632. https://doi.org/10.3390/ijerph17082632

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T.,… Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Bullo, V., Bergamin, M., Gobbo, S., Sieverdes, J. C., Zaccaria, M., Neunhaeuserer, D., & Ermolao, A. (2015). The effects of Pilates exercise training on physical fitness and wellbeing in the elderly: A systematic review for future exercise prescription. *Preventive Medicine*, *75*, 1–11. https://doi.org/10.1016/j.ypmed.2015.03.002

Cruz-Ferreira, A., Fernandes, J., Laranjo, L., Bernardo, L. M., & Silva, A. (2011). A Systematic Review of the Effects of Pilates Method of Exercise in Healthy People. *Archives of Physical Medicine and Rehabilitation*, *92*(12), 2071–2081. https://doi.org/10.1016/j.apmr.2011.06.018

Długosz-Boś, M., Filar-Mierzwa, K., Stawarz, R., Ścisłowska-Czarnecka, A., Jankowicz-Szymańska, A., & Bac, A. (2021). Effect of Three Months Pilates Training on Balance and Fall Risk in Older Women. *International Journal of Environmental Research and Public Health*, *18*(7), 3663. https://doi.org/10.3390/ijerph18073663

Donath, L., Roth, R., Hürlimann, C., Zahner, L., & Faude, O. (2015). Pilates vs. Balance Training in Health Community-Dwelling Seniors: A 3-arm, Randomized Controlled Trial. *International Journal of Sports Medicine*, *37*(03), 202–210. https://doi.org/10.1055/s-0035-1559695

Dunsky, A. (2019). The Effect of Balance and Coordination Exercises on Quality of Life in Older Adults: A Mini-Review. *Frontiers in Aging Neuroscience*, *11*,318. https://doi.org/10.3389/fnagi.2019.00318

Eikema, D. J. A., Hatzitaki, V., Tzovaras, D., & Papaxanthis, C. (2014). Application of intermittent galvanic vestibular stimulation reveals age-related constraints in the multisensory reweighting of posture. *Neuroscience Letters*, *561*, 112–117. https://doi.org/10.1016/j.neulet.2013.12.048

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Fernández-Rodríguez, R., Álvarez-Bueno, C., Ferri-Morales, A., Torres-Costoso, A., Pozuelo-Carrascosa, D. P., & Martínez-Vizcaíno, V. (2021). Pilates improves physical performance and decreases risk of falls in older adults: A systematic review and meta-analysis. *Physiotherapy*, *112*, 163–177. https://doi.org/10.1016/j.physio.2021.05.008

Fleming, K. M., Coote, S. B., & Herring, M. P. (2020). An eight-week randomised controlled trial of home-based pilates for symptoms of anxiety, depression, and fatigue among people with MS with minimal-to-mild mobility disability: Study protocol. *Mental Health and Physical Activity*, *19*, 100341. https://doi.org/10.1016/j.mhpa.2020.100341

Gale, C. R., Cooper, C., & Aihie Sayer, A. (2016). Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. *Age and Ageing*, *45*(6), 789–794. https://doi.org/10.1093/ageing/afw129

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., Nieman, D. C., & Swain, D. P. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. https://doi.org/10.1249/MSS.0b013e318213fefb

Hsieh, L.-C., Lin, H.-C., & Lee, G.-S. (2014). Aging of vestibular function evaluated using correlational vestibular autorotation test. *Clinical Interventions in Aging*, *9*(1), 1463–1469. https://doi.org/10.2147/CIA.S67720

Huxel Bliven, K. C., & Anderson, B. E. (2013). Core Stability Training for Injury Prevention. *Sports Health: A Multidisciplinary Approach*, *5*(6), 514–522. https://doi.org/10.1177/1941738113481200

Hyun, J., Hwangbo, K., & Lee, C.-W. (2014). The Effects of Pilates Mat Exercise on the Balance Ability of Elderly Females. *Journal of Physical Therapy Science*, *26*(2), 291–293. https://doi.org/10.1589/jpts.26.291

Ivanenko, Y., & Gurfinkel, V. S. (2018). Human Postural Control. *Frontiers in Neuroscience*, *12*, 171. https://doi.org/10.3389/fnins.2018.00171

Kloubec, J. (2011). Pilates: How does it work and who needs it? *Muscles, Ligaments and Tendons Journal*, *1*(2), 61–66. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3666467

Kolomiitseva, O., Prikhodko, A., Bodrenkova, I., Hrynchenko, I., Vashchenko, I., & Honchar, R. (2022). Effect of Pilates training on respiration, joints mobility, and muscle strength in healthy middle-aged women with sedentary occupations. *Acta Gymnica*, *52*(Article e2022.008), 1–8. https://doi.org/10.5507/ag.2022.008

Kostrominova, T. Y., & Brooks, S. V. (2013). Age-related changes in structure and extracellular matrix protein expression levels in rat tendons. *Age (Dordrecht, Netherlands)*, *35*(6), 2203–2214. https://doi.org/10.1007/s11357-013-9514-2

Kulik, C. T., Ryan, S., Harper, S., & George, G. (2014). Aging Populations and Management. *Academy of Management Journal*, *57*(4), 929–935. https://doi.org/10.5465/amj.2014.4004

Liu, Y., Chan, J. S. Y., & Yan, J. H. (2014). Neuropsychological mechanisms of falls in older adults. *Frontiers in Aging Neuroscience*, *6*(Article 64), 1–8. https://doi.org/10.3389/fnagi.2014.00064

Mayorga-Vega, D., Merino-Marban, R., & Viciana, J. (2014). Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: A Meta-Analysis. *Journal of Sports Science & Medicine*, *13*(1), 1–14.

Michalska, J., Kamieniarz, A., Sobota, G., Stania, M., Juras, G., & Słomka, K. J. (2021). Age-related changes in postural control in older women: Transitional tasks in step initiation. *BMC Geriatrics*, *21*(1), 17. https://doi.org/10.1186/s12877-020-01985-y

Nikić, N., & Milenković, D. (2022). The Impact of the Pilates Program on the Mobility of Middle-Aged Women. *Sports Science and Health*, *23*(1), 42–47. https://doi.org/10.7251/SSH2201042N

Palazzo, C., Klinger, E., Dorner, V., Kadri, A., Thierry, O., Boumenir, Y., Martin, W., Poiraudeau, S., & Ville, I. (2016). Barriers to home-based exercise program adherence with chronic low back pain: Patient expectations regarding new technologies. *Annals of Physical and Rehabilitation Medicine*, *59*(2), 107–113. https://doi.org/10.1016/j.rehab.2016.01.009

Presta, V., Galuppo, L., Condello, G., Rodà, F., Mirandola, P., Vitale, M., Vaccarezza, M., & Gobbi, G. (2023). Receiver Operating Characteristic Analysis of Posture and Gait Parameters to Prevent Frailty Condition and Fall Risk in the Elderly. *Applied Sciences*, *13*(6), 3387. https://doi.org/10.3390/app13063387

Pyskir, M., Pyskir, J., Ratuszek-Sadowska, D., Sebastian, J., Bosek, M., Hagner-Derengowska, M., & Hagner, W. (2016). Stabilność posturalna starszych kobiet przed i po dziesięciu tygodniach ćwiczeń metodą Pilates= Postural stability of elderly women before and after ten weeks of Pilates exercises. *Journal of Education, Health and Sport*, *6*(12), 243–258. http://dx. doi. org/10.5281/zenodo. 198452

Ramezani, S., Biniaz, S. A., Yaghoubi, M., & Asadollahi, N. (2021). The Effect of Selected Pilates Exercises on Balance, Blood Pressure, and Body Composition of Inactive Healthy Elderly Women. *Journal of Vessels and Circulation*, *2*(1), 17–26. https://doi.org/10.32598/JVC.2.1.76.2

Sadeghi, H., & Shojaedin, S. S. (2021). The Effect of Virtual Reality on Postural Stability and Fall Risk Assessment of Older Women. *Women's Health Bulletin*, *8*(1), 37-43. https://doi.org/10.30476/whb.2021.89163.1092

Sekendiz, B., Altun, Ö., Korkusuz, F., & Akın, S. (2007). Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. *Journal of*

Bodywork and Movement Therapies, *11*(4), 318–326. https://doi.org/10.1016/j.jbmt.2006.12.002

Sherrington, C., & Tiedemann, A. (2015). Physiotherapy in the prevention of falls in older people. *Journal of Physiotherapy*, *61*(2), 54–60. https://doi.org/10.1016/j.jphys.2015.02.011

Siqueira Rodrigues, B. G. de, Ali Cader, S., Bento Torres, N. V. O., Oliveira, E. M. de, & Martin Dantas, E. H. (2010). Pilates method in personal autonomy, static balance and quality of life of elderly females. *Journal of Bodywork and Movement Therapies*, *14*(2), 195–202. https://doi.org/10.1016/j.jbmt.2009.12.005

Su, C.-H., Peng, H.-Y., Tien, C.-W., & Huang, W.-C. (2022). Effects of a 12-Week Pilates Program on Functional Physical Fitness and Basal Metabolic Rate in Community-Dwelling Middle-Aged Women: A Quasi-Experimental Study. *International Journal of Environmental Research and Public Health*, *19*(23), 16157. https://doi.org/10.3390/ijerph192316157

Vieira, N. D., Testa, D., Ruas, P. C., Salvini, T. de F., Catai, A. M., & Melo, R. C. (2017). The effects of 12 weeks Pilates-inspired exercise training on functional performance in older women: A randomized clinical trial. *Journal of Bodywork and Movement Therapies*, *21*(2), 251–258. https://doi.org/10.1016/j.jbmt.2016.06.010

Williams, N. (2017). The Borg Rating of Perceived Exertion (RPE) scale. *Occupational Medicine*, *67*(5), 404–405. https://doi.org/10.1093/occmed/kqx063