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Effectiveness of 4 - Weeks Pilates Training Programme on Balance and Risk of Fall in Older Adults with Assisted Living Facility

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Abstract: ***Background: Pilates, a type of exercise, targets to improve core stability, strength, flexibility, muscle control, posture and breathing. By improving strength, balance, and gait through the practice of Pilates, the attitude of avoiding activities, due to fear of falls, can be prevented in older age groups. Objective: To study the effect of 4 - weeks Pilates training programme on balance and risk of fall in older adults with assisted living facility. Method: 30 participants were selected as per the inclusion and exclusion criteria. Subjects were assessed by the Timed Up and Go Test (TUG) and Berg Balance Scale (BBS) prior to commencement of training. A 60 minutes Pilates session was carried out thrice a week for 4 weeks. At the end of 4 weeks the subjects were re - assessed by the Timed Up and GO test and the Berg Balance Scale. The data collected was statistically analyzed. Results: The Timed Up and Go test and the Berg Balance Scale show statistically significant improvements, with p - values <0.001 in both measurements. Conclusion: This study concludes that Pilates intervention for older adults residing in assisted living facilities can improve their static and dynamic balance thus reducing the risk of fall.***

Keywords: Pilates, Balance, Risk of Fall, Assisted Living Facility, Old Age Homes

1. Introduction

Pilates training method was discovered by Joseph H. Pilates in the early 20th century. Pilates improves general body flexibility and health focusing on enhancing the core strength, posture, and coordination of breathing with movement [1, 2] Pilates training method is based on 8 principles, which includes - control, breathing, flowing movement, precision, stability, centering, range of motion, and opposition [3] It is a combination of exercises which focuses on lumbo - pelvic stabilization and activation of the deep muscle of the trunk, with a full connection between the mind and the body. [1] Pilates can be practiced on - floor / simple mats/ adding implements as unstable surfaces, springs pulley machines and thera balls. [1] The main principle of Pilates is centering, which refers to lumbo - pelvic stabilization and motor control during the execution of several tasks. Deep core muscles, especially the transversus abdominis and multifidus muscles become activated during the practice of Pilates. No age limit has been recommended for the practice of Pilates; in fact it has been specifically proposed as a suitable exercise for older adults. [1, 4] It improves several physical capacities such as strength, agility, and coordination, as well as psychological status and quality of life. [1]

Pilates is a widely accepted means of exercise in rehabilitation for people of varying ages. Its goal is to connect the mind and body so that the body can bring into play the greatest mechanical advantage to achieve optimal balance, strength and health. Pilates focuses on increasing strength and flexibility through controlled movements of the body. Pilates comprises of synergistic movement patterns. These include isometric, eccentric, and concentric muscle contractions. These movement patterns are easily integrated into day to day functions. Pilates underlines lumbo - pelvic stability, movement precision and segmental mobility of the spine, coordination and balance. Exercise improves postural alignment, breathing, coordination, balance, and appropriate use of core and postural muscles, including abdominal, pelvic, spinal and gluteal muscles. Many exercises as are performed in a standing position have the potential to improve standing balance—an important modifiable risk factor for falls.

Balance is the maintenance of a state of equilibrium when a body is at rest or is moving. When the line of gravity through the CoM falls outside the BoS, human beings are able to take corrective action to achieve favourable realignment. Thus, balance is regarded more as an activity, instead of as a mere state. The incidence of balance difficulties increases with age and may be a leading cause of falls in older adults. The aging process involves changes in body structures and function that can lead to decreased strength and flexibility as well as a decline in coordination and balance. Loss of balance is common among older adults and its prevalence ranges between 20 - 50%. In basic terms, loss of balance occurs when the centre of mass (CoM) falls out of alignment with the base of support (BoS). In human bipedal stance and gait, about two thirds of the body mass and height are above a relatively smaller BoS, thus being inherently low in stability. The BoS is reduced by half when standing on one leg, adding to the potential instability. Hence, it is predictable that an elaborate biological substrate

for maintaining or regaining balance evolved. As humans perform their daily activities, there occurs a lot of body movements and are often exposed to destabilizing environmental forces. As, the relationship between the CoM and BoS is spontaneously changing, it requires that balance is considered in a dynamic context.

Fall occurs as a result of failure to regain balance after destabilization. Falls in older adults can lead to disability, mortality, and health care utilization. According to global report on falls prevention by the World Health Organization (WHO), people aged 65 years and above fall about 28%–35% in each year and this proportion increases as age and frailty level increase. The prevalence of falls in India, above the age of 60 years, reported to range 14%–53%. [3] Falls are a multifactorial problem with many intrinsic and extrinsic risk factors that have been identified Extrinsic risk factors may include unsafe foot wear or environmental tripping hazards whereas, decreased postural stability, impaired mobility and balance may be the intrinsic factors. Additionally, a fear of fall develops in many who though not injured experience falls. This fear limits theirmobility and reduces physical fitness, which in turn increases their actual risk of falling.

2. Literature Survey

Previous researches and studies done were referred by using the key word Pilates, older adults, balance and falls. The databases searched were PubMed and Google Scholar. Articles included were randomized and non - randomized trials, quasi experimental trials, case studies and systemic reviews. Books on Pilates were also referred.

3. Materials and methods

The study was an intervention study conducted in old age homes where a sample size of 30 older adults was collected using a convenient sampling method. The study utilized chairs measuring tape and stopwatch for the TUG test and a Berg Balance Scale. The Pilates program was conducted using chairs and as a group session.

Inclusion criteria: 1. Older adults (age - 60 or above) willing to participate.2. Impaired balance as defined by TUG Test (>13.5 seconds) and Berg Balance Scale (<40 seconds) or fall in the past.3. No history of hospitalization in past 3 months.4. Ability to follow instructions given in English, Hindi or Marathi.

Exclusion criteria: 1. Participation in Pilates / any exercise program during or over the last year.2. Wheelchair bound/ Subjects who are completely dependent on walking aid.3. Obese older adults.4. Significant Cardio (recent MI, unstable angina, post CABG) respiratory (Dyspnoea even at rest) problems.5. Vestibular problems /vertigo or progressive neurological conditions.6. Urinary incontinence.7. Presence of any implants/Fracture in past 4months/ any surgery.8. Inability to raise arms to 90 degrees of shoulder elevation.

Outcome measures: Two were used to assess the participants before and after the training program.1. Timed Up and Go (TUG) test: It shows high reliability (0.99) and validity (o.75) [5] to determine the risk of falls and measure the progress of balance, sit to stand and walking. Appropriate for older people who are frailer / who use walking aids. Performed as - 1. Patient is seated in an armchair.2. Measuring the time it took the subject to stand up from an armchair at the therapist command, walk a distance of 3 m with their normal pace with an assistive device they regularly use, turn, walk back to the chair and sit down. A TUG >13.5 seconds indicates moderate to high fall risk.2. Berg Balance Scale (BBS): A score of 45 /< indicates a greater risk for falls. Person's static and dynamic balance abilities & validated scale - widely used to determine the state of balance of the older adults. It is 14 - item functional test –common actions - necessary for performing activities of daily living. Tasks include - Sitting to standing, Standing unsupported, Sitting unsupported, Standing to sitting, Transfers, Standing with eyes closed, Standing with feet together, Reaching forward with outstretched arm, Turning 360 degrees, Retrieving object from floor, Turning to look behind, Standing with one foot in front, Standing on one foot, Placing alternate foot on stool. Scoring is done on a 5 - point (0–4) ordinal scale as per the patient's ability to complete the requested action. Score - 0 if task could not be completed and score of 4 indicated independence. Reliability and validity of the Berg balance scale to assess balance have been documented, in both nursing home and community - dwelling older adults. It is an effective indicator of falls within community – dwelling adults. It has high reliability (0.98) and validity (0.91) [5]

Procedure: A basic assessment was done to exclude the individuals. Screening on the basis of the inclusion and exclusion criteria was done. Prior to the study its purpose and the procedure was explained to the subjects. Subjects were assessed by the TUG Test and Berg balance scale prior to commencement of training. A 60 minutes Pilates session was carried out thrice a week for 4 weeks. First 10 minutes involved a warm - up period (focus on breathing and core stability.) Remaining 25 minutes including active exercises on a chair was done (focused on strengthening the extremities, core and improving flexibility of spinal segments.). Next 15 minutes of standing exercises (focused on lower extremity stability and strength.) Session was completed with a cool down regime (focused on breathing and balance.) For non - training days, 15 - 20 min of home program was taught to the participants and they were asked to note down the days they performed it. At the end of 4 weeks the subjects were re - assessed by the Tug test and the BBS. The data collected was statistically analysed. The intervention protocol was referred from a study by (Rachel W. Pata et. al, 2013), but the resistance exercised were excluded as resistance exercises couldn't be started in the duration of the study.

Figure 1: A illustrates the single leg circles and **Fig 1. B** illustrates the arm exercise performed by the participant

Exercise on chair:

1) Diaphragmatic breathing
2) Inhale/exhale and pull up pelvic floor and tighten abdominals
3) Shoulder rolls/lifts
4) Scapular protraction/retraction with arms flexed to 90
5) Arm exercises: inhale reach up arms up to ceiling, exhale back to ground.
6) Neck stretches and nodding
7) Heel and ankle pumps
8) The hundred
9) Abduction and adduction of the legs with legs hovered
10) One leg circles
11) Spine stretch forward
12) Spinal twist
13) Saw
14) Neck pull
15) Mermaid: stretching out one leg and reaching away from it.
16) Heal raises on edge of the chair, turned out, then just one leg.

A. Exercise in standing

1) Leg exercises
2) Toe raise in all positions: feet together, feet apart and Pilates position
3) Calf stretches
4) Roll forward: stretching back and hamstrings

4. Statistical analysis

All data was analysed using SPSS version 28.0.0.0 (190). The Shapiro- Wilk test was done to assess whether the data was normally distributed. The test showed that the data was not normally distributed. Hence, a nonparametric test, Wilcoxon signed rank test was used to assess the pre - test and post - test values of TUG and BBS. The significance level was 0.001. Correlation of age and BMI with TUG and BBS pre and post - test were done using Spearman's correlation test.

5. Results

From the 30 participants in the study, 20 were males and 10 were females. Age range was 62 – 85 years, with an average of 78.1 (±6.32) years with males showing an average of 77.2 (±6.74) years and females an average of 79.9 (±4.9) years. An average BMI of 21.06 (±3.7) was calculated, the male average BMI being 21.63 (±2.44) and the female average BMI being 19.93 (±5.22). All participants attended all the 12 Pilates sessions. The data recorded, shown in Table 1.

Table 1: demonstrates the demographic data of the participants

Demographic data	*Participants*
Number of males	20
Number of females	10
Age Mean (±SD) Male Female	78.1 (±6.32) 77.2 (±6.74) 79.9 (±4.9)
Height Mean (±SD) Male Female	161.06 (±8.79) 164.1 (±8.07) 155 (±6.82)
Weight Mean (±SD) Male Female	54.95 (±11.76) 58.35 (±8.52) 48.16 (±14.16)
BMI Mean (±SD) Male Female	21.06 (±3.7) 21.63 (±2.44) 19.93 (±5.22)

Figure 2: illustrates the spinal twist exercise performed by the participants.

Figure 3: shows the leg exercises performed by the participants

Table 2: demonstrates the pre and post - test average of the TUG test and the BBS and their p - value by the Wilcoxon signed rank test

Tests	Pre - test average ±SD	Post - test average ±SD	Mean Difference	P - value
TUG s	13.96 (±0.49)	13.26 (±0.64)	0.7	<0.001
Berg Balance Scale	35.73 (±2.91)	41.76 (±4.50)	6.03	<0.001

An average improvement of 0.7 seconds in TUG and an average increase of 6 scores in BBS were noted. The Wilcoxon signed rank test analysed the Timed Up and Go test and the Berg Balance Scale to show statistically significant improvements, with both having p - values <0.001, shown in Table 2.

A correlation analysis of age and BMI with the pre - test and post - test values by Spearman's test can be noted from Table 5. It shows that age has a weak positive relation with TUG pre - test and a weak negative relation with BBS pre and post - test. No relation exists with the TUG post - test. BMI has a moderate positive relation with TUG pre - test and weak positive relation with TUG post - test. BMI with BBS pre - test and post - test shows no relation.

Table 3: demonstrates the age and BMI and their correlation with the pre and post scores of TUG and BBS.

	Spearman's rho	TUG (pre) s	TUG (post) s	BBS (pre)	BBS (post)
Age	Correlation Coefficient	.155	.076	- .122	- .198
	Sig. (2 - tailed)	.413	.691	.522	.293
	N	30	30	30	30
BMI	Correlation Coefficient	.340	.266	.005	- .099
	Sig. (2 - tailed)	.066	.156	.981	.602
	N	30	30	30	30

6. Discussion

With increase in age, there occurs a decline in sensory systems which implicates in reduced ability of the older adults to adapt to changes in the environment and maintain balance. Reduced proprioception, changes in visual inputs, inappropriate antagonist muscle activation or proximal to distal sequence of muscle activation when exposed to visual perturbations and manipulations emphasizes an increased variability in gait posing a particular challenge to older adults, as it has been linked to falls (Muyinat Y. Osoba et. al, Feb 2019).

The TUG test and the BBS test done on the older adults in this study, demonstrate reduced static and dynamic balance and a higher fall risk pre intervention. Risks of falls have shown a higher prevalence in older adults residing in assisted facilities. Recurrent falls lead to further restriction in daily activities and increased health care costs. (WHO global report on falls prevention in older age). Physical activity in older adults with sufficient participation especially those in assisted living have shown to benefit in functional and mental performance (Vanroy et al. BMC Geriatrics (2019)).

The major finding of this study is that a 4 weeks Pilates training programme had significant effect on balance and risk of falls in older adults in assisted living facilities. These improvements could be seen in both the outcome measures. The results suggest that performing a Pilates programme in an assisted living facility thrice weekly over four weeks may improve balance leading to reduced risk of falls. Pilates exercises are initiated with core stabilization which includes utilizing and thus strengthening the abdominal, gluteal and paraspinal muscles and then proceeds through a controlled range of motion of the limbs accompanied by changes in body positions. In addition to the transversus abdominis and multifidus, the pelvic floor muscles and the diaphragm also contract, maintaining the intra - abdominal pressure at a critical level, allowing the greatest spinal support (June Kloubec, Apr - Jun, 2011). These along with the postural stability augmented by the exercises, enhances the dynamic stability and mobility thus, improving the TUG and BBS scores post Pilates exercise.

Pilates strengthen the core and overall muscles providing proximal stability and distal mobility (Emery et al.2010; Kloubec 2010). During the Pilates programme, the participants performed the exercises by engaging their core muscles and then integrating the distal movements.

Pilates improves posture and enhance postural balance, thus further improving balance and stability (Alves de Araujo et al.2012; Emery et al.2010; Natour et al.2015; Campos de Oliveira, Goncalves de Oliveria and Pires - Oliveria 2015). Maintenance of balance during mobility reduces the risk of falls.

This study further supports other Pilates based intervention studies on balance and falls in older adults (Rachel W Pata et al., 2014 Jul; Marie - Louise Bird et al., 2014; Anna L Barker et al., 2016 Oct; Moreno - Segura N et al., July 2017; Margaret Roller et al., September 2017). This study showed a significant improvement in the TUG test. A study by Rachel W Pata et al. demonstrated similar results in TUG test. A systematic review and meta - analysis conducted by Moreno - Segura N et al. showed a moderately significant improvement in the TUG assessment for dynamic balance and mobility post Pilates exercises. A statistically significant decrease in the TUG score over time during the intervention was noted by Margaret Roller et al. These results

demonstrate that a Pilates training may improve mobility and stability owing to reduced fall risks.

A significant positive change was seen in the Berg Balance Scale score post the Pilates intervention of this study. Overall state of balance analysed by Moreno - Segura N et al. using the Berg Balance Scale suggested a significant effect favouring the Pilates performing participants. The Pilates group in the study by Margaret Roller et al. demonstrate a significant improvement in the Berg Balance scores. These show that there may be an improvement in the static and dynamic balance in older adults after Pilates training. A study by Marie - Louise Bird et al. provided evidence of long term maintenance of static and dynamic balance post short term and continuing a Pilates intervention.

In the studies conducted by (Barker et al. and Roller et al.) utilized Pilates equipment such as reformer, trapeze, whereas (Bird et al. and Moreno - Segura N et al.) showed the use of reformer as well as matwork. Utilization of the equipment would be expensive and performance on them or the mat might be difficult to some older adults.

This study was conducted at the old age homes in the form of a group exercises. This might have a psychologically positive impact over the participants, as performing in a group may have motivated them towards better and routine performance and thus, boosted their confidence.

A limitation of the study was the sample size which was small due to the study being conducted during the covid pandemic.

7. Conclusion

This study concludes that Pilates intervention for older adults residing in assisted living facilities can improve their static and dynamic balance thus reducing the risk of falls. An improvement in both the outcome measures was noted in this study. A decrease in the time recorded in the post intervention TUG scores implied that, there are reduced risk of falls due to improvement in proprioception, strength, endurance and appropriate activation of the muscles promoting better adaptation to the changes in the environment and hence, an increase in stability and dynamic mobility. Consequently, this is indicated by an increase in the Berg Balance Scale scores.

Older adults living in assisted facilities can improve their balance and consequently reduce their risk of falls by performing a 4 weeks Pilates training programme. Improved balance and reduced falls may increase their self - esteem, independence, quality of life and participation. Reduced falls lead to reduced health care costs. Group participation boosts their confidence towards further participation in other activities

8. Future Scope

Further studies can include the intervention on a larger sample size. A longer duration intervention can be done to study the long term effects of Pilates training. Psychological implications of performing Pilates exercises in old age homes can be studied to provide further insights on the effects of Pilates exercises.

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