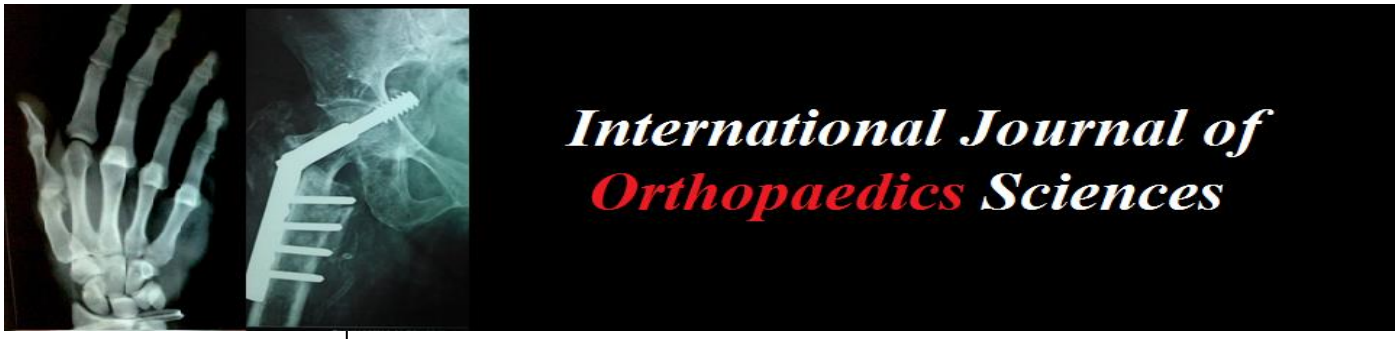

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Effect of pilates on the balance of older adults at high risk of falling: A narrative review

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Abstract
Falling is a very common phenomenon, with huge social and economic ramifications. It poses a serious risk to older adults, who are more prone to falls than younger patients and face more serious complications. Pilates is one of the most popular forms of exercise in the modern western world and some of its benefits include improving balance and posture, as well as strengthening the core. The objective of our review is to summarize recent findings on the benefits of Pilates for balance in older people who are at high risk of falling. Method: The following keywords were used to perform a search in English for the PubMed and Google Scholar databases: "Pilates and older adults and balance" for clinical studies published in the last decade. Results: Six clinical studies were included in this review involving a total of 273 older people at high risk of falling. Most studies have concluded that the Pilates method has a positive effect on balance, while one study found that it is not effective in improving balance in older adults. Discussion - Conclusions: The Pilates method can improve balance, mobility, and overall quality of life in older adults, as it reduces their risk of falling.

Keywords: Pilates, older adults, balance, fall

Introduction
Falls are one of the most common and serious problems faced by older adults [1]. Shumway-Cook *et al.* [2] defined a fall as "an unplanned, unexpected contact with a support surface such as the floor, a chair, or a wall". After a fall, anxiety and fear can have a strong psychological impact that can further increase the risk of falling and have a devastating impact on quality of life [3]. The etiology of falls in older adults is multifaceted and includes extrinsic factors such as poor lighting and inappropriate footwear, as well as intrinsic factors such as medication use, cognitive decline, and vision impairment [4]. Other factors that may also contribute to a higher risk of falling consist of musculoskeletal disorders, including reduced active range of motion of the hip and ankle joint [4, 5].

Falling is the second leading cause of accidental death worldwide. Each year, approximately 680,000 people die from falls, the majority of whom are older adults. In the United States, almost three million older people visit the emergency room due to a fall and every 19 minutes an older adult dies from a fall or its complications [6]. In Greece, about 30,000 falls in older adults at home were recorded in the period 1996-2003 and in at least half of the cases a serious injury or fracture was caused [5].

Pilates has gained popularity recently and seems to be a practical way to improve balance and quality of life while strengthening trunk muscles. The resistance used in exercises performed on the floor with this method is either provided by the performer's own body weight or by the resistance of springs attached to the equipment. Joseph Hubertus Pilates, a German, is credited with its invention [7]. However, knowledge is limited on the impact of Pilate on the muscles in the lower limbs. A study has identified positive effects of Pilates in postural stability of older adults, albeit with controversial results [8, 9].

The goal of this review is to investigate the efficacy of the Pilates method in improving balance in older adults who are at a high risk of falling.

Method

Between March and April 2022, English searches were conducted on the PubMed and Google Scholar databases. Different Boolean operators were used in the search with the following keywords: Pilates AND older adults AND balance. Articles that were clinical studies published in the last decade were selected.

Results

The titles and abstracts of the articles that resulted from our search were first screened, followed by a thorough evaluation of the full texts. Ultimately, six clinical studies were determined to fit our criteria and were reviewed. The total sample was 273 older adults. The characteristics of the sources included in this review are listed below while Table 1 summarizes the characteristics of each research.

Table 1. Details of the included studies

Author Year	Number of participants	Intervention duration	Intervention	Outcome measures
Josephs *et al*. (2016) [10]	31	12 weeks	Group 1: Pilates program Group 2: Traditional exercise program	▪ Fullerton Advanced Balance Scale ▪ ABC
Pata *et al*. (2014) [11]	35	8 weeks	Pilates group	▪ TUG ▪ Forward Reach Test ▪ Turn 180 Test
Oliveira *et al*. (2015) [12]	32	12 weeks	Group 1: Pilates program Group 2: Static stratching program	▪ TUG ▪ BBS ▪ SF-36 ▪ Peak isokinetic torque of knee flexors and extensors
Bird *et al*. (2012) [13]	32	5 weeks	Group 1: Pilates program Group 2: Regular activity	▪ Four Square Step Test ▪ TUG ▪ Swing range ▪ Lower limb strength
Gabizon *et al*. (2016) [14]	88	3 months	Group1: Pilates program Group 2: No intervention	▪ Standing stability ▪ Balance measures ▪ Health status self-report
Roller *et al*., (2018) [9]	55	10 weeks	Group 1: Pilates Reformer program Group 2: No intervention	▪ SOT ▪ TUG ▪ ABC ▪ ADT ▪ SLR ▪ AROM ▪ BBS ▪ 10MWT

Literature review

The study by Josephs *et al*. [10] examined whether the Pilates method is more effective than traditional resistance and balance exercises for improving balance and reducing falls in 31 older adults at risk of falling. Participants were randomly allocated to the Pilates group (intervention) and the traditional exercises group (control). The duration of both programs was 12 weeks with two one-hour sessions per week. The results showed a significant improvement in the Fullerton Advanced Balance Scale both in the Pilates group (mean difference = 6.31, $p<.05$), as well as the control group (mean difference = 7.45, $p = .01$). Moreover, the Pilates group significantly improved in the Activities - Specific Balance Confidence Scale (ABC), (mean difference = 10.57, $p = .008$). Consequently, the Pilates method and trandtional exercise programs are equally effective in improving balance in older adults at risk of falling. However, the Pilates group improved more in balance confidence.

In the study of Pata *et al*. [11], the effect of Pilates was evaluated on reducing falls in older adults. Specifically, 35 older adults aged 61-87 participated in an eight-week exercise program based on the Pilates method. The Timed Up-and-Go (TUG), Forward Reach, and Turn 180 tests were performed before and after the intervention. Measures included the number of falls, the perceptual ability of the exercises, and the fear of falling. All tests recorded significant improvements (TUG test ($p<0.001$); Turn 180 Test ($p = 0.002$); Forward Reach Test ($p = 0.049$)). The results also showed a positive perceptual ability of the Pilates exercises and reduced fear of falling. Thus, an exercise program based on the Pilates method was proven to improve balance, mobility, and posture stability reducing the risk of falling in older adults.

Furthermore, Oliveira *et al*. [12] studied the effect of the Pilates method on stregthening lower limbs, balance, and health-related quality of life in oldr adults. Their study involved 32 participants randomly and equally allocated to the experimental group (mean age = 63.62±1.02 years), who attended two Pilates sessions per week for 12 weeks, and the control group (mean age = 64.21±0.80 years), who attended 2 static stretching sessions per week for 12 weeks. The following measures were evaluated before and after the intervention: peak isokinetic torque measurement of the knee flexors and extensors with the TUG test, the Berg Balance Scale (BBS), and the Health Survey assessment (SF-36). The results revealed notable improvements of the experimental group in almost all examined variables compared to the control group. Pilates exercises led to significant improvements in peak isokinetic torque of the knee flexors and extensors, balance, and health-related quality of life of older adults.

In another study by Bird *et al*. [13], the effect of the Pilates method on static and dynamic balance of older adults was investigated. Participants (n=32) were allocated either to the experimental group, who followed a Pilates program for five weeks, or to the control group, who had to retain their regular physical activity for the same duration. The Four Square Step

Test, the TUG test, swing range with eyes open and then closed on a firm surface and then on foam, and the strength of lower limbs were evaluated before and after the intervention. The results did not show any statistically significant differences between the two groups ($p>0.05$), except the static and dynamic balance which was improved in the Pilates group ($p<0.05$). No changes were observed in lower limb strength. Swing range was mostly affected for the Pilates group at the end of the intervention. Despite no significant differences between the two groups, participation in the Pilates program led to improved static and dynamic balance, reducing the risk of falling in older adults.

The study of Gabizon *et al*. [14] focused on the effect of a group Pilates program on balance control and health status of healthy older adults. In total, 88 participants (mean age = 71.15±4.30 years) with no indications of functional balance deficits were randomly allocated to the intervention group (n = 44) and the control group (n = 44). The intervention group attended 36 Pilates sessions for three months (three sessions per week), while the control group did not follow any program. Standing stability, performance-based measures of balance, and self-rated health status were assessed in both groups at the beginning and end of the research process. Compared to the control group, the experimental Pilates group showed no improvement in any variable. The researchers concluded that because the Pilates method does not target a specific process, it cannot improve balance control in independent older adults.

Finally, Roller *et al*. [9] used Reformer to investigate the effect of Pilates exercises on risk of falling, balance, mobility, self-efficacy, and active range of motion in people aged over 65. The sample consisted of 55 participants (mean age = 77.6 years), randomly allocated to an experimental Pilates Reformer group (n = 27) and a control group (n = 28), which received no intervention. The experimental group followed a Pilates Reformer program once per week for 10 weeks. Primary measures were the Sensory Organization Test (SOT), the TUG test, and the Activities -Specific Balance Confidence (ABC) Scale. Secondary measures were the Adaptation Test (ADT), the active range of motion of raising the lower limbs in a straight line (SLR), of hip extension and ankle dorsiflexion (AROM), the BBS and the 10-Meter Walk Test (10MWT). Gradually, the experimental Pilates group improved significantly in all parameters compared to the control group ($p\leq 0.05$). Significantly improved active range of motion in SLR, hip extension, and dorsiflexion of the ankle joint of the Pilates experimental group was found. Consequently, Pilates Reformer in people over 65 years was shown to be effective in static and dynamic balance, mobility, self-efficacy, and active range of motion of the hip and ankle joint, reducing the risk of falling.

Discussion

The results of this review show that the Pilates method can contribute to reducing falls in older adults. In several of the included studies there was evidence that Pilates improves balance, peak isokinetic torque of the knee flexors and extensors [12], active range of motion of the hip and ankle joint [9], and several other variables. The findings of our review are consistent with the conclusions of a similar systematic review [15], which also found the positive effect of the Pilates method on the balance and quality of life of older adults, reducing the risk of falling. However, in the study of Gabizon *et al*. [14], which was included in our review, it seemed that Pilates does not improve balance control in older adults. The researchers in that study argue that balance is a multi-articular skill that involves the interaction of physiological systems. Pilates specifically targets trunk muscle strength and flexibility rather than the balance control system. Therefore, it was not surprising that it did not improve balance. Finally, studies with different intervention periods, intervention times, and environments are necessary to evaluate the effects of Pilates on improving balance and, by extension, reducing falls in older people.

Conclusions

Based on the results of the studies included in our review, it would seem that the Pilates method reduces the risk of falling in older adults by improving their balance, mobility, and quality of life. The matter requires further investigation.

Conflict of Interest

Not available

Financial Support

Not available

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