

Research article

Integrating Pilates exercise into an exercise program for 65+ year-old women to reduce falls

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Abstract

The purpose of this study was to determine if Pilates exercise could improve dynamic balance, flexibility, reaction time and muscle strength in order to reduce the number of falls among older women. 60 female volunteers over the age of 65 from a residential home in Ankara participated in this study. Participants joined a 12-week series of 1-hour Pilates sessions three times per week. Dynamic balance, flexibility, reaction time and muscle strength were measured before and after the program. The number of falls before and during the 12-week period was also recorded. Dynamic balance, flexibility, reaction time and muscle strength improved ($p < 0.05$) in the exercise group when compared to the non-exercise group. In conclusion, Pilates exercises are effective in improving dynamic balance, flexibility, reaction time, and muscle strength as well as decreasing the propensity to fall in older women.

Key words: Pilates, elderly women, balance, reaction time, muscle strength.

Introduction

During the past century, the number and proportion of older adults among the world population has increased due to socio-economic developments and better medical services (Lord et al., 1991). Although the majority of the population in Turkey is young, with the general increase in life expectancy, the older adult population is growing rapidly as it is in other European countries. In particular, in Turkey the percentage of individuals over the age of 60 increased from 5.9 % to 8.2 % from 1950 to 2000. Furthermore, it has predicted that the elderly will become a majority of the population with the next 30 years (NISBO magazine, 2003).

Although this general increase in lifespan can be considered a positive development, there are a number of serious health problems that can develop in the elderly. In particular, studies investigating physiological and physical changes in the elderly indicate that a decrease in bone mineral density (Riggs et al., 1982) as well as in the capacity of muscular (Hortobagyi et al., 1995) and cardiovascular (Cheitlin, 2008) systems causes difficulties in their daily lives. In addition, of major concern is the considerable increase in the risk of falls among the older adult population. Osteoporotic fractures, occurring as a result of falls, are considered one prominent factor that noticeably reduces quality of life amongst older adults. In this regard, researchers, all around the world (Ozmen and

Gokce-Kutsal, 2006) have looked for preventive strategies to eliminate deficiencies in physical functioning and risk factors of falling in the elderly.

Research has shown that (Stathi and Simey, 2007) most of the older adult population, especially those who are physically inactive, are functioning either at their sub-maximum or maximum physical capacity in order to achieve the requirements of many daily activities. Thus, deteriorations in physical capacity such as balance deficiencies, lower limb muscle weakness and slowed reaction time have been identified as independent risk factors and may have the potential to lead to dependency and an increased risk of falling (Lord, Sherrington and Menz, 2001; Lord and Sturnieks, 2005; Tinetti et al., 1994). Regular exercise participation, at this point, appears to be essential and is considered an appropriate, healthy and cost effective way of both improving and sustaining physical aspects of health in the elderly. In this regard, a number of different exercise trials, including both aerobic and resistance activities have been employed by many researchers to improve physical functioning and reduce the risk of falling in the elderly (Lord, 1991; Provience et al., 1995; Tromp, 1998).

Pilates, originally developed by Joseph Pilates after World War I, is described by practitioners as “*a unique method of physical fitness that uses a combination of muscle strengthening, lengthening and breathing to develop trunk muscles and restore muscle balance*” (Bernardo, 2007; Cozen, 2000; Kloubec, 2010; Latey, 2001; Smith and Smith, 2005). Contrary to traditional resistance exercises based on training the muscles in an isolated manner, Pilates exercises have a holistic approach, requiring activation and coordination of several muscle groups at a time (Pilates, 2001). Although recent studies (Caldwell et al., 2009; Johnson et al., 2007) reported that Pilates exercises are suitable for all ages, all body types and fitness abilities due to the modifiable nature of the movements, (Kaesler et al., 2007; Kloubec, 2010; Segal et al., 2004; Sekendiz et al., 2007), experimental attempts and control conditions are still limited and do not enable researchers to draw clear conclusions regarding the effectiveness of Pilates exercises on improving physical functioning among older adults. For example, in one of their comprehensive reviews Smith and Smith (2005) proposed that Pilates exercises might reduce the risk of falling as a result of improvements in balance, muscle strength and coordination. However, most of the experimental studies examining the effects of

Pilates are restricted within the study of young adults (Sekendiz et al., 2007) and middle-aged individuals (Johnson et al., 2007), which calls for the necessity of experimental research for the elderly. Moreover, previous studies are heavily concentrated on the separate specific aspects of physical functioning in which the main focus is either investigating the changes in balance (Hall, 1998; Kaesler et al., 2007) or muscle strength (Smith and Smith, 2005). Examining the role of Pilates exercises, therefore, on multiple aspects of physical functioning, such as balance, muscle strength and reaction time simultaneously, may extend our understanding of the effects of Pilates in the elderly. The importance of these physical fitness parameters on reducing the risk of falling in elderly populations was clearly documented by a recent review (Hsiao-Weckler, 2008) that suggested that lower extremity flexibility, reaction time, and strength should be studied and considered when developing exercise-based fall intervention programs for older adults. Finally, tracking the changes in the number of falls along with the changes in physical fitness parameters from a longitudinal perspective would enable us to determine the efficacy of Pilates exercises as a preventive intervention method in reducing the risk of falling in the elderly (Kloubec, 2010).

Thus, the main purpose of this study was to determine if Pilates exercises could improve dynamic balance, flexibility, and reaction time and muscle strength in older women. In addition, the number of falls was also investigated as a result of Pilates exercises. Based on the previous research results (Bernardo, 2007; Caldwell et al., 2009; Cozen, 2000; Johnson et al., 2007) demonstrating the efficacy of Pilates interventions on improving young adults' physical fitness parameters, it was hypothesized that compared to the control group, Pilates exercises would significantly improve dynamic balance, flexibility, muscle strength and reaction time and decrease the number of falls in the exercise group.

Methods

Participants

Subjects were recruited from female volunteers living in a residential house. Sixty subjects were randomized into control ($n = 30$) and experimental ($n = 30$) groups. Eligibility criteria were that the participants had to be healthy, over 65 years of age, and have been relatively sedentary (undertaking no leisure time physical activity or less than 30 minutes of physical activity per day) for at least a year. Volunteers were informed of possible significant risks, which mainly included muscular soreness. The control group was comprised of a similar sample of healthy subjects living in a similar residential house. All participants signed an informed consent form approved by the Ataturk Hospital human subjects committee prior to participation in the study. Exclusion criteria included any significant general health problem or orthopaedic problem that would keep them from fully participating in the intervention protocol and/or the inability to attend at least 80% of the training sessions.

The control group received no Pilates training during the 12-week period and was instructed to refrain from beginning a new exercise program or changing their cur-

rent activity levels during this time period.

Measurements

The prospective, treatment-controlled, study design involved pre and post measurement tests relating to the 12-week period of Pilates exercise. The dependent variables, balance, reaction time, flexibility and muscle strength, the number of falls as well as body height and weight were measured in all subjects. The Pilates group participated in a 12-week Pilates exercise class held 3 days per week. Each exercise session lasted about 60 minutes and was led by a certified Pilates instructor. Modifications of exercises were consistent with those detailed in the Stott Pilates Comprehensive Mat work Manual (Pilates, 2001). Modified Pilates-based exercise was divided into three parts. The first part (4 weeks duration), consisted of mat exercises (Pilates, 2001), in the second part, Thera-Band elastic resistance exercises were added, and in the third part, the participants performed Pilates ball exercises for beginners (Latey, 2001).

All measurements were taken in the residential house, a week before start of the intervention period and at the end of the intervention period. Subjects were contacted by two research team members who were blinded to their group assignments. All measurements were completed on the same day, not involving a Pilates session for the post-intervention assessment. Falls were defined as unintentional movements to the floor or ground (Tinetti, 1995). The number of falls was asked during the baseline measurement of the current study and after the study. Falls during follow-up were obtained with a set of monthly falls calendars, which subjects were asked to fill in each day and return to the physiotherapist at the end of each month. Subjects were asked to write (F) on the calendar if they had a fall on that day and (N) if they did not fall. Subjects who had not returned a calendar within 10 days of the end of the month were reminded by the physiotherapist and asked about their falls for the previous month. Instruments for testing were calibrated and used by the same researcher to control possible inter-tester variation. Prior to the testing, a standardized 5-minute warm-up was completed.

Dynamic balance was assessed using the MED-SP300 (Medical Sports Performance 300, Tumer Eng., Ankara) dynamic stability measurement platform. This device was evaluated using measurements obtained from the MED-SP 300 level of "easy". It uses a circular platform that is free to move in the anterior-posterior and medial-lateral axes simultaneously, which permits Rank Value (an overall) Stability Index (RVSI) to be obtained. Moreover, it has $\pm 15^\circ$ measuring ability in all directions. Measurements were conducted in 30-second trials during which the participants maintained an upright standing position on the unstable surface of the MED-SP300. In our measurements, a safe cage was used to prevent any accidents. This dynamic balance measurement platform is portable, cheap, and suitable for measuring dynamic balance (Cug et al., 2007; Babayigit-Irez et al., 2006). *Reaction time* was measured with a device (New Test-2000, Co, and Finland) using light and sound stimuli. The subjects were asked to press a button with their index finger as quickly as possible when they observed the light stimu-

lus on the light panel, placed in front of them, or heard the sound stimulus.

Muscle Strength was measured as hip flexion, hip abduction, and hip adduction by using a Muscle Manual Tester (Lafayette Company, Model 01160 Nicholas Manual Muscle Tester MMT). The average of three trials in which a maximum effort was supplied following some practice trials gave the most reliable results. At least 15-seconds were allowed between trials (Andrews et al., 1996; Bohannon, 1986; Kendall et al., 1971; Roy et al., 2004).

Flexibility was measured by the “sit-and-reach” test (Clark et al., 1989). After a warm-up, the participants sat on the floor with their legs straight out in front of them, heels touching the side of a box. Their fingertips were positioned on the 0 cm edge of the box that was marked in centimeters towards the opposite edge. They were then asked to bend forward with arms outstretched towards their toes. The farthest test score of three trials was recorded. The sit-and-reach test was conducted to measure flexibility of the hamstrings and lower back.

Pilates equipment

In Pilates exercise, different equipment is used to achieve different aims. We used Thera-Band elastic resistance bands, as well as Pilates or exercise balls. The Thera-Band resistance exercises strengthen the chest and arms, while helping with abdominal strength as well. The Thera-Band elastic resistance bands are portable, inexpensive and can be used in the seated, standing, supine or prone positions. Elastic resistance is usually provided in a color-coded progression from light to heavy resistance, yellow, red, green, blue, black and silver, tan and gold respectively. Elastic bands can accommodate exercisers of varying ages and abilities (Page and Ellenbecker, 2003). We used blue, red and green colored exercise bands. We assigned the type of resistance bands for each participant based on their muscle strength measurements.

Statistical analyses

All data were analyzed using SPSS Version 17. All tests were assessed by mixed design repeated measure MANOVA's with Group as a between subject factor. They were then conducted separately for physiological measures. The main significant and interaction effects were examined by follow-up univariate analysis performed to identify group differences.

Results

Exercise and control groups' age, height, weight and BMI means are given in Table 1. The Pilates exercise group completed 36 training sessions (92% participation rate).

To test initial differences between groups for balance, reaction time, muscle strength and number of falls, multivariate ANOVAs were conducted. The analyses revealed no significant differences in any of the physiological measurements of dynamic balance, flexibility, muscular strength or reaction time, (Wilks' Lambda=.84, $F(1, 58) = 1.66$, $p > 0.05$) amongst the groups.

A 2x2 (exercise/control x pre/post) mixed design repeated measure MANOVA was conducted to examine

the effects of Pilates exercise on dynamic balance, flexibility, muscle strength, reaction time and number of falls parameters of elderly women. Results revealed a significant multivariate main effect for Time (Pillai's Trace = 0.94, $F(6, 53) = 61.13$, $p < 0.05$, $\eta^2 = 0.94$, power = 0.99), a Time x Group interaction (Pillai's Trace = 0.87, $F(6, 53) = 26.01$, $p < 0.05$, $\eta^2 = 0.87$, power= 0.99) and main effect for Group (Pillai's Trace = 0.60, $F(6, 53) = 13.457$, $p < 0.05$, $\eta^2 = 0.60$, power= 0.99).

Table 1. Characteristic of the exercise and the control groups. Data are means (\pm SD).

	Pilates (n = 30)	Control (n = 30)
Age	72.8 (6.7)	78.0 (5.7)
Height (m)	156.1 (6.4)	156.5 (5.2)
Weight (kg)	67.2(9.5)	67.8 (10.9)
BMI (kg·m ⁻²)	27.5 (5.6)	27.6 (5.4)

Dynamic balance

Results of the mixed design repeated MANOVA test revealed significant correlative effects for group and measurements. Follow-up ANOVAs indicated a significant main effect of time for dynamic balance ($F(1, 58) = 81.89$, $p < 0.05$, $\eta^2 = 0.67$, power = 0.99), an interaction of time X group effects for dynamic balance ($F(1, 58) = 348.69$, $p < 0.05$, $\eta^2 = 0.50$, power = 0.99) and main effect of group for dynamic balance ($F(1, 58) = 19.63$, $p < 0.05$, $\eta^2 = 0.25$, power= 0.99). The Pilates exercise group showed significant improvement regarding dynamic balance ($t(df=29) = 11.63$, $p < 0.05$) compared to the control group.

Flexibility (Sit-and-Reach)

Results of the mixed design repeated MANOVA indicated significant interaction effects for group and measurements. Follow-up ANOVA's indicated a significant main effect of time for flexibility ($F(1, 58) = 5.81$, $p < 0.05$, $\eta^2 = 0.09$, power = 0.66) and an interaction of time X group effects ($F(1, 58) = 12.06$, $p < 0.05$, $\eta^2 = 0.17$, power = 0.93) and main effect of group ($F(1, 58) = 17.44$, $p < 0.05$, $\eta^2 = 0.23$, power = 0.99). The Pilates exercise group showed more improvement regarding flexibility than did the control group (Table 2).

Muscle strength

There was a significant difference between the pre- and post-measures of muscle strength for the exercise group after 12 weeks of Pilates exercise. Pilates exercise had positive effects to increase muscle strength. Results of the “mixed design repeated MANOVA” indicated a significant interaction effect for group and measurements. Follow up ANOVA results revealed that there were significant time interactions for muscle strength ($F(1, 58) = 24.47$, $p < 0.05$, $\eta^2 = 0.66$, power = 0.99) and time X group effects interactions ($F(1, 58) = 25.62$, $p < 0.05$, $\eta^2 = 0.32$, power = 0.99) for group effects ($F(1, 58) = 24.27$, $p < 0.05$, $\eta^2 = 0.29$, power = 0.99) (Table 2).

Reaction time

Results of the mixed design repeated MANOVA indicated a significant difference (Table 2). Follow up ANOVA results revealed that there were significant main

Table 2. Comparison of dynamic balance, flexibility, reaction time, muscle strength and number of falls between control and exercise groups. Data are means (\pm SD).

Variables	Groups			
	Exercise		Control	
	Pre- test	Post- test	Pre- test	Post- test
Dynamic Balance (angle)	10.98 (1.50)	8.99 (1.50) *	11.40 (1.81)	11.23 (2.10)
Sit and reach (cm)	12.75 (4.40)	15.88 (5.10) *	10.80 (3.84)	10.40 (3.60)
Muscle Strength (kg)	23.34 (5.70)	32.71 (7.00) *	20.98 (8.90)	20.72 (8.60)
Reaction Time				
Simple RT (ms)	.34 (.09)	.26 (.05) *	.38 (.09)	.39 (.08)
Choice RT (ms)	.69 (.20)	.55 (.10) *	.72 (.16)	.73 (.10)
# of falls	1.87 (1.4)	.37 (.50) *	1.63 (1.21)	1.30 (.40)

* $p < 0.05$

effects of time for simple reaction time ($F_{(1, 58)} = 63.83$, $p < 0.05$, $\eta^2 = 0.52$, power = 0.97), and choice reaction time ($F_{(1, 58)} = 79.31$, $p < 0.05$, $\eta^2 = 0.58$, power = 0.94) and there was an interaction of time X group for simple reaction time ($F_{(1, 58)} = 38.367$, $p < 0.05$, $\eta^2 = 0.40$, power = 0.97) and choice reaction time ($F_{(1, 58)} = 23.65$, $p < 0.01$, $\eta^2 = 0.29$, power = 0.72) (Table 2). The Pilates exercise group showed more improvement regarding both simple and choice reaction time than did the control group.

Number of falls

Follow-up ANOVA results indicated that there was a significant main effect of time for number of falls ($F_{(1, 58)} = 28.40$, $p < 0.05$, $\eta^2 = 0.33$, power = 0.99) and there was an interaction of time X group ($F_{(1, 58)} = 16.25$, $p < 0.01$, $\eta^2 = 0.22$, power = 0.99) and main effect of group ($F_{(1, 58)} = 8.87$, $p < 0.05$, $\eta^2 = 0.14$, power = 0.99) (Table 2). The Pilates exercise group showed a lower number of falls than the control group.

Discussion

The present study primarily examined the effects of a 12-week Pilates exercise intervention on dynamic balance, reaction time, muscle strength, and flexibility in order to decrease the number of falls in elderly women.

Attendance and adherence is clearly an important factor that influences the effectiveness of Pilates exercise. In our study, participants attended nearly all of the exercise sessions. This might particularly account for the positive effects of the intervention.

By performing the designated Pilates exercises within the training program, improvements were seen regarding all selected dependent variables. Muscular strength and flexibility of the Pilates group was significantly higher after the program. These findings supported previous findings in relevant literature (Mitchell et al., 1998). Moreover, Petrofsky et al. (2005) conducted a study to compare Pilates exercises with and without a resistance band. They found that Pilates exercises performed with a resistance band are more effective in increasing muscular strength than Pilates exercises without resistance bands. In line with this study, we used resistance bands and found a positive effect on muscle strength within the exercise group. In contrast to their study, we also added exercise ball or Pilates ball exercises to the Pilates exercise program.

Previous research indicates that regular participation in physical activity has a positive impact on muscle strength (Maughan, 2008; Daubney and Culham, 1999). In a pilot study, Donahoe-Fillmore et al. (2007) performed a study to determine the effects of a video-based Pilates mat home exercise program on core strength, muscular endurance, and posture in healthy females. They determined that Pilates home mat exercise programs have no significant effect on abdominal strength and posture but both flexor and extensor endurance appeared to improve. Eleven healthy women between the ages of 20 and 35 were drawn from a sample of two randomly separated groups, exercise group ($n = 6$) and a control group ($n = 5$). The exercise group performed a Pilates mat exercise program 3 times per week for 10 weeks. Results showed no differences in described variables. This may be related to the small number of participants. In our study, the sample size was much larger than the previously mentioned study. Moreover, in the Pilates mat video exercise group, the level of participation could not be controlled. In our study, we controlled whether or not the participants performed all of the movements in the exercise program as well as tracking and accounting for how often they missed sessions.

Sekendiz et al. (2007) examined the effects of Pilates exercise on abdominal and lower back strength, abdominal muscular endurance and posterior trunk flexibility of sedentary adult females. Participants consisted of 21 women (mean age: 30 ± 6.6 range 26–47) in the exercise group and 17 women (mean age: 30 ± 8.6 range 26–47) in the control group. Their abdominal and lower back strength, posterior trunk flexion and extension data were obtained concentrically on a Biodex isokinetic dynamometer at speeds of 60° and 120°s^{-1} . They concluded that there was a positive effect of Modern Pilates mat exercises on abdominal and lower back muscular strength, abdominal muscular endurance and posterior trunk flexibility in sedentary adult females regardless of the fact that the body weight and fat percentages did not differ significantly. These results are similar to the results of our trials in older adults.

Another study by Schroeder et al. (2002) studied the effects of Pilates exercise on flexibility. They found an acute Pilates reformer session for novice individuals appears to positively influence measures of flexibility. Their results supported our findings. Segal et al. (2004) conducted an observational repeated measures study to assess the effects of Pilates training on flexibility, body composition and health status of healthy adults. A total of

31 women with an average age of 41 years and one man of 42 years, volunteered to participate in 1-hour a week sessions of Pilates mat exercises. After six months, they found no change in the body composition of their participants. The authors concluded that Pilates exercise may improve flexibility of the trunk in healthy adults but has no effect on body composition. In line with their study, we found that Pilates exercise may improve flexibility in older adults after 12 weeks of exercise. We also could not find any effect of Pilates on Body Mass Index.

Results of the study also showed that dynamic balance increased in the Pilates group after a 12-week exercise program. In accordance with our findings, it was reported by Johnson et al. (2007) that Pilates exercise could improve dynamic balance in healthy adults. They used the "functional reach test" which is a clinical test of dynamic balance. Their results suggested that Pilates-based exercise improved dynamic balance as measured by the functional reach test in healthy adults. Similarly, we found that dynamic balance increased after Pilates exercise. In their study the participants' mean age was 27.4 and in our study participants' mean age was over 65. Kaesler et al. (2007) examined the effectiveness of a novel Pilates inspired exercise program specifically designed to improve balance in an upright position, referred to as *postural stability*, in older adults. Participants for this pilot study were 8 community-dwelling men and women ages 66–71 years. The exercise regimen was undertaken twice a week for 8 weeks. Pre and post subject assessments included postural sway (static and dynamic), the timed get-up and go test (TGUGT), sit-to-stand (timed one repetition and repetitions over 30 s) and a four stage balance test. They reported that there was a significant improvement in some components of static and dynamic postural sway, 8–27%, as well as the TGUGT, 7%, following training. They suggested future studies consider the variation of specific balance training techniques, primarily movement re-education as compared to speed and reaction time, to improve postural stability and reduce the risk of falls. In our study, participants were over 65 years old and we also measured reaction time.

One of the major findings of this study was that reaction time improved with exercise. In previous studies, the effect of exercise on reaction time has shown that reaction time can be improved by training (Laroche et al., 2007; Trombly, 2004). Although the literature has a lack of evidence about the positive effects of Pilates on reaction time, the present study found that these exercises are a very effective way to develop reaction time in older women. Kashihara and Nakahara (2005) found that vigorous exercise did improve choice reaction time and Col-lardeau et al. (2001) found that exercise improved reaction time. We also calculated reaction time by measuring both simple and choice reaction time. Yoga exercises have similarities with Pilates and yoga may affect reaction time positively (Madan et al., 1992). Previous studies on yoga have shown that regularly yoga practice can increase visual reaction time and auditory reaction (Madan, 1992; Malathi and Parulkar, 1989). Reaction time has a very important role in decreasing fall risk. In future studies, this parameter should be evaluated in more detail by using different Pilates equipment.

Wolff et al. (1999) determined the exercise effects of Tai Chi and computerized balance training in community-dwelling women at moderate risk of falls. They found that Tai Chi reduced the rate of falls during a short follow-up period of 4 months although the computerized balance-training program did not reduce falls. In our study, 3 months of Pilates exercise resulted in a decrease in the number of falls as well as an improvement in balance. There are many studies (Carter et al., 2001; Snyder 2006) that support the findings that exercise can reduce the number of falls among older adults, although prior to our study there were no studies as to whether Pilates exercises might reduce falls or not.

The results of this study represent nursing home residents in one residential house. The findings may not be applicable to the entire older adult population. In future studies, the number of residential houses involved in the study should increase in order to obtain a more diverse sampling. In this study, we chose female participants. In future studies adding male participants in an equally large sample-base could be effective in determining gender differences in the effects of Pilates exercises.

Conclusion

Pilates-based exercise was shown to improve dynamic balance, reaction time and muscle strength in the elderly. Our findings suggest that Pilates exercise may be a useful tool for people who are looking to improve these aspects of their physical health. Moreover, Pilates exercise may reduce the number of falls in elderly women by increasing these fitness parameters. From these results, we surmise that by performing Pilates exercises, even the elderly can increase their physical fitness abilities. Moreover, Pilates exercise can be integrated into exercise programs for older adults in both fitness centres and rehabilitation centres. Residential homes may recommend Pilates exercises for their residents. Physiotherapist and geriatrics specialists might also find Pilates to be a useful tool in the rehabilitative and preventative areas of their practices.

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Key points

- Pilates-based exercises improve dynamic balance, reaction time and muscle strength in the elderly.
- Pilates exercise may reduce the number of falls in elderly women by increasing these fitness parameters.

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