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Effects of a Pilates exercise program on muscle strength, postural control and body composition: results from a pilot study in a group of post-menopausal women

M. Bergamin · S. Gobbo · V. Bullo · T. Zanotto · B. Vendramin · F. Duregon · L. Cugusi · V. Camozzi · M. Zaccaria · D. Neunhaeuserer · A. Ermolao

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Abstract Participation in exercise programs is heartily recommended for older adults since the level of physical fitness directly influences functional independence. The aim of this present study was to investigate the effects of supervised Pilates exercise training on the physical function, hypothesizing that a period of Pilates exercise training (PET) can increase overall muscle strength, body composition, and balance, during single and dual-task conditions, in a group of post-menopausal women. Twenty-five subjects, aged 59 to 66 years old, were recruited. Eligible participants were assessed prior and after 3 months of PET performed twice per week. Muscular strength was evaluated with handgrip strength (HGS) test, 30-s chair sit-to-stand test (30CST), and abdominal strength (AST) test. Postural control and dual-task performance were measured through a stabilometric platform while dynamic balance with 8 ft up and go test. Finally, body composition was assessed by means of dual-energy X-ray absorptiometry. Statistically significant improvements were detected on HGS (+8.22 %), 30CST (+23.41 %), 8 ft up and go test (−5.95 %), AST (+30.81 %), medio-lateral oscillations in open eyes and dual-task condition (−22.03 % and −10.37 %). Pilates was effective in increasing upper body, lower body, and abdominal muscle strength. No changes on body composition were detected. Results on this investigation indicated also that 12-week of mat Pilates is not sufficient to determine a clinical meaningful improvement on static balance in single and dual-task conditions.

Keywords Pilates · Strength · Balance · Dual-task · Women

M. Bergamin (✉) · S. Gobbo · V. Bullo · T. Zanotto · B. Vendramin · F. Duregon · M. Zaccaria · D. Neunhaeuserer · A. Ermolao
Sport and Exercise Medicine Division, Department of Medicine, University of Padova (IT), Via Giustiniani, 2, 35128 Padova, Italy
e-mail: marco.bergamin@unipd.it

V. Camozzi
Endocrinology Division, Department of Medicine, University of Padova (IT), Via Giustiniani, 2, 35128 Padova, Italy

L. Cugusi
Department of Medical Sciences "M. Aresu", University of Cagliari, Cagliari, Italy

Introduction

Worldwide, the number of people over 60 years is growing faster than any other age group and it is expected to grow from 688 million in 2006 to almost 2 billion by 2050 (WHO 2007). This general upturn in life expectancy compels that more efforts have to be spent on prevention and treatment for multiple chronic health conditions, disability, and mental health in the elderly population.

Ageing alone entails a normal decline of physical efficiency as well as the overall physical fitness and body composition. These changes involve muscular strength (Yassierli et al. 2007) and peak power output (Runge et al. 2004), which appears to be related to loss of muscle mass due to an age-related factor as well as neuromuscular changes (Kim and Sapienza 2005). These contributors are all related with fall risk, that is one of the major public health issue associated with substantial healthcare costs and risk for disability, hospitalization, nursing home admission, and mortality among older adults (Patel et al. 2014). On the other side, the increase of physical activity, as well as tailored interventions focused on endurance, resistance, flexibility, and balance exercises are heartily recommended for this population, given that the level of physical fitness directly influences functional independence in the elderly (Garatachea and Lucia 2013).

Dual-task performance is increasingly growing the attention of clinicians and researchers, since it is an experimental condition that reproduces frequent situations of the everyday living (e.g., walking and talking simultaneously), especially when the motor task involves static or dynamic balance (Bergamin et al. 2014). Apparently, this performance is highly developable in subjects with different chronic conditions (Zanotto et al. 2014) than healthy elderly (Gobbo et al. 2014); nevertheless, it appears that only few studies investigated appropriate physical activity interventions to improve dual tasking. Besides, it has to be considered a non-secondary aspect; exercise interventions and testing procedures were extensively different between the few trials reported by the literature (Wollesen and Voelcker-Rehage 2013).

In the light of that, there is an evident need to examine specific types of physical activity interventions that could improve static and dynamic balance during dual-task condition. Pilates exercise training could be a suitable type of exercise for older adults owing to its effects on functional capacity and quality of life. Exercise prescription could incorporate Pilates for the subjects which present impaired balance conditions since Pilates has showed to be effective in increasing static and dynamic balance and in prevention of falls (Bullo et al. 2015). This form of exercise was born after the First World War by Joseph Pilates (1880–1967) for the training and rehabilitation of athletes and dancers. This type of exercise is characterized by a holistic approach requiring the activation and coordination of several muscle groups simultaneously (Latey 2001) and following a different approach to the traditional resistance exercises where muscle groups are often trained segmentally (Irez et al. 2011). Most recent literature described Pilates as an effective activity able to increase body balance due to the stimulation on motor control, in particular for the abdominal region (Granacher et al. 2013) with a concurrent high-concentration demand on breathing, muscle contraction, and posture (Patti et al. 2015).

To the best of the authors' knowledge, literature lacks investigation about benefits of Pilates on several domains, in particular about the potential changes on body composition and dual-task performance. In the clinical setting, dual-task performance is of growing importance for geriatricians when the motor task encompasses postural balance on upright position, since its impairment is unavoidably associated with increased fall risk (Muir et al. 2010). Starting from these perspectives, the aim of this present study was to investigate the effects of supervised Pilates exercise training on the physical function and the body composition, hypothesizing that a period of Pilates might determine improvements on these variables, especially on muscle strength and balance, not only during single but also during dual-task conditions, in a group of post-menopausal women.

Materials and methods

Participants

Twenty-five post-menopausal women, aged 59 to 66 years old, were recruited from a senior citizens center of northern Italy. The inclusion criteria were age ≥59 years old, and no exercise contraindications detected from a full physical examination, including cardiovascular, pulmonary, musculoskeletal, and abdominal evaluation. Further, subjects should not have attended a structured physical activity or exercise program in the prior 6 months. Exclusion criteria were uncorrected visual impairment, neurological disorders (e.g., Parkinson's disease, stroke), orthopedic surgery to the lower limbs, medication that could influence posture and/or gait, cognitive impairments, and a history of vertigo or falls in the previous month. The study complied with the current laws of Italy for research on human participants and was approved by the University Hospital ethical committee.

Procedure

Before testing, each subject provided written informed consent and completed a medical history questionnaire. To quantify the daily amount of physical activity (Table 1), a global physical activity questionnaire

Table 1 Baseline characteristics of study participants (mean ± standard deviation)

	Characteristics at baseline
Age (year)	63.00 ± 2.29
Height (cm)	160.48 ± 6.78
Weight (kg)	65.92 ± 10.90
BMI (kg m^{-2})	25.61 ± 4.04
Weekly amount of physical activity (min $week^{-1}$)	89.63 ± 41.96
Time since onset of menopause (year)	12.04 ± 4.26
Surgical menopause (*N*, %)	0, 0 %

BMI body mass index, *min* minute

(GPAQ) was administered (Cleland et al. 2014). Subsequently, they underwent the mini-mental state examination (MMSE) (Folstein et al. 1975; Tombaugh and McIntyre 1992) for the evaluation of cognitive impairments. All participants were assessed for physical functioning and body composition prior (T_0) and after (T_1) an exercise intervention of Pilates. Height and weight were measured respectively to the nearest centimeter using a stadiometer (Ayrton Corporation, Model S100, Prior Lake, MN) and to the nearest 0.1 kg using an electronic scale (Home Health Care Digital Scale, Model MC-660, C-7300 v1.1). Body composition was assessed by means of dual-energy X-ray absorptiometry (DXA; QDR 4500 W, software version 12.6; Hologic, Bedford, MA, USA) and was performed on all subjects. A standardized procedure for patient positioning and software utilization was used as suggested by the manufacturer; besides, the accuracy of fat mass (FM) and fat-free mass (FFM) estimates has been examined in a previous validation study. Appendicular skeletal muscle mass was also calculated following the method of Baumgartner and colleagues (Baumgartner et al. 1998). Muscular strength was evaluated with different functional tests such as the handgrip (HGS) strength test, the 30-s chair sit-to-stand (30CST) test, and an abdominal strength (AST) test. Dominant and non-dominant handgrip strength was measured with a calibrated dynamometer (Baseline, Elmsford, NY, USA). Grip handle was adjusted to accommodate the size and comfort of the participant's hand, and the elbow was flexed to 90° to guarantee the strongest grip strength measurement (Mathiowetz et al. 1985).

30CST was used to measure lower body strength. The general procedure of this field tests has been largely described and validated elsewhere (Rikli and Jones 1999). The 30CST consists of standing up and sitting down from a chair as many times as possible within 30 s. A standard armless chair (with a seat height of 45 cm) was used. Initially, subjects were seated on the chair. They were instructed to look straightforward and to rise after the "1, 2, 3, go" command with their arms folded across their chest. All trials were performed using the same chair. The AST was opted to assess abdominal muscle strength and consisted of calculating the number of crunches performed in 30 s on an abdominal pad (Domyos, Monza, Italy). For this test, subjects were asked to lay down on the pad, with knees flexed at 90° and the hands set on the pad frame. They were instructed to rise after the "1, 2, 3, go" command with their chest up approximately to 30° from the floor. Each test was performed three times, and the mean value was included in the statistical analysis. Dynamic balance was evaluated with 8 ft up and go test (8-UGT). 8-UGT measures the time it takes to get out of a chair, walk 2.44 m to and around a cone, and return seated to the chair.

Static balance was measured by means of a stabilometric platform (RGMD, Genoa, Italy). It was fixed on flat floor, 3 m apart from walls or objects that could be used as a support by the subjects while being tested. In front of it, a blackboard was placed to the distance of 3 m. The evaluation of static balance was performed in three conditions: eyes open, eyes closed, and dual-task condition. In all tests, subjects were required to stand erect with feet together and the arms at sides (Lanska and Goetz 2000) as still as possible. During the Romberg test with eyes open, the subject has to fixed a reference point located on the blackboard for 30 s. During the Romberg test with eyes closed, the subject has to stay on the platform for 30 s with closed eyes. In dual-task condition, participants had to stand as still as possible in Romberg position, with eyes open, counting backwards aloud, starting from a randomly selected number, in steps of one, as fast and as accurately as possible for the entire duration of the test (Bergamin et al. 2014; Yardley et al. 1999). All participants performed randomly the three balance tests three times.

Pilates exercise intervention

Participants underwent a twice-a-week 60 min of Pilates exercise intervention for 12 weeks. The

Pilates exercise program included a starting 10 min warm-up with very low-intensity exercises, including breathing and joint mobility exercises carried out in upright position. The central part of the protocol had a duration of 40 min and included only floor exercises such as one leg circle, single leg kick, double leg kick, side kick, one leg stretch, single leg heel, single leg toes, side lying hip abduction, side lying hip adduction, roll up, rolling back, leg rises on all fours, pelvic curl, and the hundred. The last exercise, the "hundred", is a classic Pilates mat exercise that expected to maintain a standard position with feet off from the floor, knees bent at a 90° angle, arms long and just above the abdominal floor, head and shoulders curled off from the floor. At the same time, subjects had to use abdominal muscles to support the head and move arms up and down at side energetically keeping time to the 4-count breath in and the 6-count breath out. Two sets per 10 repetitions were executed for each exercise in order to standardize the volume of the intervention. Finally, subjects performed a 10-min cool down consisting of stretching exercises. All sessions were supervised by an exercise specialist, with a teaching certification in Pilates methodology of training.

Statistics

Statistical analyses were carried out using SPSS (version 18.0 for Windows; IBM, Armonk, NY, USA). Results are expressed as means ± standard deviation or percentage. The Kolmogorov–Smirnov test was carried out to check if data were normally distributed, and Levene's test was performed to analyze the homogeneity of variance. Student's *t* test for dependent samples was used to evaluate each variable within groups before versus after exercise intervention. Significance limits were set at $P < 0.05$. Additionally, the effect size (ES) of each outcome measures was calculated following the formula: ES = (mean pre value − mean post value)/SD pre value. The ES is a measure of the effectiveness of a treatment, and it helps to determine whether a statistically significant difference is a difference of practical concern. Interpretation was performed according to guideline by Cohen (1988) where an ES value of 0.20 indicates a small effect, ES of 0.50 indicates medium effect, and, finally, ES higher than 0.80 indicates a large effect.

Results

Among subjects, one had type 2 diabetes, ten were smokers and five are still smokers, thirteen had hypertension, ten had hypercholesterolemia; eleven were taking vitamin D, four calcium, eleven medications for blood pressure and five for hypercholesterolemia. Due to health conditions, two subjects did not complete the Pilates program and all measurements pre- and post-intervention, determining an 8 % dropout ratio. The average adherence in the 24 sessions was 92.03 %.

Paired *t* test detected statistical significance improvements on handgrip strength test ($p = 0.011$, +8.22 %), 30-s chair-stand test ($p < 0.001$, +23.41 %), 8 ft up and go test ($p = 0.025$, −5.95 %), abdominal strength test ($p = 0.008$, +30.81 %), appendicular mass ($p = 0.003$, + 1.65 %), medio-lateral oscillations in open eyes and dual-task condition ($p < 0.001$, −22.03 %; $p = 0.027$, −10.37 %, respectively), and sway path in closed eyes condition ($p = 0.006$, +10.52 %).

No statistically significant differences were detected in lean body mass trunk ($p = 0.959$), sway path, sway area, and anterior-posterior oscillations in open eyes and dual-task conditions ($p = 0.057$, $p = 0.065$, $p = 0.598$, $p = 0.521$, $p = 0.284$, $p = 0.067$, respectively) and sway area, anterior-posterior and medio-lateral oscillations in closed eyes condition ($p = 0.099$, $p = 0.333$, and $p = 0.841$, respectively). Tables 2 and 3 show the pre-post differences observed from T_0 to T_1 in physical function and body composition.

Table 2 Effects of the Pilates exercise program on physical performance, appendicular muscle mass, and abdominal, upper, and lower body strength (mean ± standard deviation)

Outcome variables	Pre	Post	Effect size
HGS (kg)	22.63 ± 3.18	24.49 ± 3.60*	0.58
30CST (number)	15.88 ± 3.02	19.60 ± 4.00*	1.23
8-UGT (s)	5.99 ± 0.78	5.63 ± 0.83*	0.46
AST (number of repetitions)	24.34 ± 9.06	30.65 ± 6.73*	0.55
Lean body mass trunk (kg)	20.48 ± 2.53	20.47 ± 2.31	0.01
Appendicular mass (kg m^{-1})	6.16 ± 0.61	6.27 ± 0.65*	0.17

HGS handgrip strength test, *30CST* 30-s chair-stand test, *8-UGT* 8 ft up and go test, *AST* abdominal strength test

*$p < 0.05$ indicates a statistical significant difference between pre- and post-Pilates exercise intervention

Table 3 Effects of the Pilates exercise program on static balance and dual-task performance (mean ± standard deviation)

	Variables	Sway path (mm/s)	Sway area (mm/s)	AP oscillations (mm)	ML oscillations (mm)
Romberg OE	Pre	13.79 ± 4.15	28.76 ± 3.91	22.34 ± 5.91	27.33 ± 8.20
	Post	12.75 ± 3.61	25.08 ± 11.69	21.7 ± 5.4	21.52 ± 7.51*
	Effect size	0.25	0.29	0.13	0.72
Romberg CE	Pre	18.14 ± 6.01	39.30 ± 23.34	25.65 ± 7.19	28.30 ± 8.77
	Post	19.66 ± 6.38	43.07 ± 22.69	26.54 ± 7.64	26.96 ± 9.02
	Effect size	0.31	0.24	0.19	0.03
Dual task	Pre	15.54 ± 4.36	28.30 ± 15.22	22.80 ± 9.14	24.34 ± 7.14
	Post	14.82 ± 4.12	25.45 ± 11.67	19.96 ± 5.62	21.66 ± 6.05*
	Effect size	0.11	0.15	0.29	0.34

OE open eyes, *CE* closed eyes, *AP* anterior posterior, *ML* medio-lateral

*$p < 0.05$ indicates a statistical significant difference between pre and post Pilates exercise intervention

Discussion

The present study aims to observe the effects of a 12-week Pilates exercise intervention; our initial hypothesis was that a program of Pilates training might enhance some parameters of physical efficiency, such as general strength and balance; additionally, we postulated that this type of training might modify body composition in a group of healthy asymptomatic post-menopausal women. Current literature lacks of intervention studies, which examined the potential changes in body composition with gold standard methodology such as DXA; moreover, another interesting point concerns the possible modifications of the postural control during dual-task conditions consequent a Pilates intervention program, which have not been examined yet.

Overall, results of this investigation demonstrated that Pilates exercise training could be an effective method to improve upper-limb (HGS), lower-limb (30CST), and abdominal strength (AST). This conclusion was also supported by effect sizes that indicated from medium to large effects in these parameters. Furthermore, also dynamic balance (8-UGT) has been found significantly improved, but the magnitude of change, together with a low effect size, was not clinically meaningful. On the other side, data from static balance and dual-task performance were difficult to be interpreted; despite some parameters that showed statistically significant improvements, small effect sizes were generally appraised. The only outcomes that showed remarkable reductions were medio-lateral sways in both Romberg open eye and during dual-task conditions. In particular, the first parameter showed a medium to high ES, with a noteworthy clinical improvement (−22 %).

Comparing our results with other investigations, strength developments are in agreement with changes described by Irez et al. (2011) and Plachy et al. (2012), showing similar fashions of improvement. Both studies were comparable for the age of participants and duration of interventions. Furthermore, in their scheme, Irez et al. (2011) included a supplementary strength stimulus, carried out through elastic resistance exercises. In regard to that, literature indicated that Pilates exercises performed with elastic bands were more effective in increasing muscular strength than those without external source of load, such as our protocol (Petrofsky et al. 2005). Thus, this probably explains our lower increase in handgrip performance and for abdominal strength. Considering the lower body strength, our results are similar to others in already published papers; in detail, Plachy and colleagues (Plachy et al. 2012) found a 43.9 % improvement in sit-to-stand test, while in another investigation with age-matched participants (Kucukcakir et al. 2013), the improvement was about 26 %. Comprehensively, the results of our investigation corroborated the already existing body of evidence. In particular, ES detected from the lower limb strength (30CST) is overlapping as reported by Bullo et al. (2015) in their meta-analysis. Pilates exercise has been already recognized as an effective method or even an alternative to increase the core muscle strength (Granacher et al. 2013). Our data showed an important development on AST (+31 %), aligned with data reported by Petrofsky and colleagues (2005) which described a 36 % improvement. Nonetheless, we found a 0.55 ES indicating a moderate effect on abdominal muscle strength. It has to be mentioned that our participants started the Pilates protocol with a baseline higher core muscle strength that could probably explain the lower development for this specific outcome.

Balance and dual-task performances were not comparatively improved like muscle strength. Improvements were found only on medio-lateral sways during Romberg test with open eyes and dual-task conditions (22 %, ES = 0.72; 10.4 %, ES = 0.34). Sway path, sway area, and anterior-posterior oscillations unvaried. On the other hand, literature provides clear results about the effectiveness of Pilates exercise in improving static and dynamic balance. Bird et al. (2012) and Bird and Fell (2014) found reductions in medio-lateral oscillations during static balance test with closed eyes on a compliant surface. Furthermore, Newell et al. (2012) showed significant improvements in the time on foot performance while Mokhtari et al. (2013) and Johnson et al. (2013) reported improvements in dynamic balance. A possible explanation of our limited effects is probably due to the sitting and supine positions that characterized our Pilates protocol with limited balance stimulation during standing position. This hypothesis can be also supported by the moderate improvement on dynamic balance (8-UGT); in fact, the 6 % improvement can be attributable to the increase on lower limbs and abdominal strength rather than the postural control. Similar to the results on static balance, dual-task performance did not show statistically significant changes, despite a low but general trend of improvement has been observed. In general, dual-task training follows the principle of performing an activity with the attention focus to another task, which can be motor, cognitive, or both. Likely Pilates, which is an activity that requires to focus its own attention on own postures and movements, does not stress mechanisms of interference such to determine increased cognitive demands necessary to induce adaptive compensation processes to sustain the overall performance (Seidler et al. 2010).

Regular participation in exercise programs can promote positive changes in body composition. The magnitude of these changes is mediated by the total volume of exercise (i.e., frequency, intensity, duration) and other factors, such as age, gender, and diet. Our lack of changes in body composition could be due to both conditions, a low total volume of exercise and no diet restrictions. Furthermore, Alandro-Gonzalvo et al. (2012) underlined that there is poor empirical evidence indicating a conclusive effect of Pilates exercises on body composition. Future investigation needs to determine if a tailored Pilates exercise alone or combined with other activities can positively affect body composition.

Our protocol is a pilot study, and the main limit that we recognize is the absence of a control group of comparison. Another limitation was the duration of the Pilates intervention. A longer exercise period could produce more positive effects in terms of postural stability and body composition. For this reason, future investigations have to consider longer periods of intervention or a greater frequency and to assign a diet regimen to their participants. Along with the dietary profile, a constant monitoring of the daily amount of physical activity would have delivered important information about daily energy expenditure; we only verified at baseline the inclusion criterion (lack of participation in structured exercise or physical activity program) through GPAQ. Future investigation should adopt technologies such as accelerometry to observe lifestyle changes affecting the body composition. Finally, an additional but general criticism arises from the intrinsic characteristics of the subjects; despite being clinically eligible to participate in the Pilates exercise program, they may have presented underlying pathologies potentially influencing the final results.

Conclusion

The aim of this study was to assess the effectiveness of 12-week Pilates exercise on muscular strength, body composition, and dynamic and static balance in a group of post-menopausal women. All test performed in this study confirmed that Pilates increased abdominal, upper, and lower limb strength. No changes on body composition were detected, probably because subjects were not involved in a diet regimen. Overall, results on this investigation indicated that 12-week of mat Pilates is not sufficient to determine a clinical meaningful improvement on static balance in single and dual-task conditions.

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