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Effects of Pilates on fall risk factors in community-dwelling elderly women: A randomized, controlled trial.

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Abstract
Objective: the main objective was to analyze the effects that an exercise programme based on the Pilates method would have on balance confidence, fear of falling, and postural control among women ≥60 years old. Methods: a total of 110 women (69.15 ± 8.94 years) participated in this randomized, controlled trial that took place in Jaén (Spain). The participants were randomly assigned to either a control group (n = 55), which received no intervention, or to a Pilates group (n = 55), which carried out an exercise programme based on the Pilates method in 60-minute sessions for 12 weeks. The Falls Efficacy Scale-International and the activity-specific balance confidence scale were respectively used to assess fear of falling and balance confidence in performing activities of daily living. Postural control was evaluated using a stabilometric platform. Results: Regarding balance confidence, the Pilates group showed higher values compared to the control group (77.52 ± 18.27 vs 72.35 ± 16.39, Cohen’s d = 0.030). Women in the Pilates group showed lower fear of falling, compared to those of the control group (22.07 ± 5.73 vs 27.9 ± 6.95, Cohen’s d = 0.041). Finally, concerning static balance, participants of the Pilates group experienced statistically significant improvements on the velocity and anteroposterior movements of the centre of pressure with eyes open and closed respectively (Cohen’s d = 0.44 and 0.35 respectively). Conclusion: A 12-week Pilates training programme has beneficial effects on balance confidence, fear of falling and postural stability, in elderly women.

Keywords: Menopause, falls, postural balance, fear of falling, Pilates

Highlights
• Falls are considered a major public health problem.
• The fear of falling, balance confidence and postural control are three important fall risk factors.
• A 12-week Pilates training programme has benefits of the fear of falling and balance confidence in elderly women.
• Postural control improved in elderly women after 12 weeks of Pilates exercises.

Introduction
Falls are considered the most common geriatric syndrome (Iwamoto et al., 2009). Falls and their associated comorbidities are linked to increased morbidity and disability (Muir, Gopaul, & Odasso, 2012), as well as to substantial economical and medical costs (Florence et al., 2018; Gannon, O’Shea, & Hudson, 2008).

Several modifiable and non-modifiable fall risk factors have been described (Hita-Contreras, Martínez-Amat, Cruz-Díaz, & Pérez-López, 2015).

Balance confidence and FoF are two important psychological factors linked to balance impairment and falling. Low balance confidence can lead to limitations in daily-life activities and to restrictions in physical activity, which in turn can result in falls, increased FoF, and loss of independence, thus causing a vicious circle that makes individuals increasingly isolated and dependent (Murphy, Williams, & Gill, 2002; Scheffer, Schuurmans, Van Dijk, Van Der Hooft, & De Rooji, 2008). Therefore, balance confidence and FoF must be taken into account when developing...
fall intervention strategies for the elderly (Landers, Oscar, Sasaoka, & Vaughn, 2016).

Postural instability is associated with the risk of falling, and stabilometry has been proven to predict falls in several groups of older adults (Hita-Contreras et al., 2013; Pajala et al., 2008). Among the existing strategies for the prevention of falls, exercise-only interventions appear to be the best possible approach at the moment, with comparable results to a multicomponent intervention (Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). In recent years, new types of exercise training programmes have been suggested to positively contribute to the prevention of falls (Lomas-Vega, Obreoyo-Gaitán, Molina-Ortega, & Del-Pino-Casado, 2017; Ma, Liu, Sun, Zhu, & Wu, 2016). One on the latest training trends is the Pilates method. This is a set of mind–body exercises focused on enhancing physical capacities such as flexibility, strength, and coordination, devised around six basic principles: centreing, concentration, precision, control, breathing, and flow. Pilates exercises are recommended for all people since they can be easily adapted to fit the needs of a wide variety of practitioners (Wells, Kolt, & Bialocerkowski, 2012). As a matter of fact, it has been specifically proposed as a suitable exercise for older adults (Bergamin et al., 2015).

Recent reviews have suggested that Pilates exercises are effective to prevent falls in several populations. However, randomized, controlled trials are scarce, particularly concerning psychological fall risk factors such as balance confidence and FoF (Hita-Contreras, Martínez-Amat, Cruz-Díaz, & Pérez-López, 2016; Moreno-Segura, Igual-Camacho, Ballester-Gil, Blasco-Igual, & Blasco, 2018).

In accordance with the above considerations, the main objective of our study was to analyze the effects that an exercise programme based on the Pilates method would have on women aged 60 years and older concerning their postural control, FoF, and balance confidence when performing daily activities. We hypothesized that a 12-week Pilates exercise programme would have positive effects and reduce the risk of falling by increasing balance confidence, decreasing the fear of falling, and improving postural control.

Methods

Study design

The present randomized, controlled trial involved an experimental design that analyzed the effects of a 12-week Pilates intervention on the postural balance, FoF, and balance confidence of elderly women. The study is part of a research project registered at clinicaltrials.gov as NCT03201107 (https://clinicaltrials.gov/ct2/show/NCT03201107). This project analyzed the effects of a Pilates-based training programme on different physical and psychological health indicators of community-dwelling postmenopausal women aged 60 years and older, so there may be some overlap with respect to participants and general methodology. This paper followed the CONSORT statement for the reporting of randomized, controlled trials. Enrolment took place in July 2017 and the intervention took place from September 2017 through December 2017. All participants signed an informed consent form before the beginning of the study, which was approved by the Human Ethics Committee of the University of Jaén and conducted in accordance with the Declaration of Helsinki, good clinical practices, and applicable laws and regulations.

Participants

Women who were: (i) aged 60 years and over and with at least 12 months since their final menstrual period (Soules et al., 2001); (ii) not involved in a Pilates exercise programme in the last year; and (iii) physically independent enough to perform basic daily activities (Barthel index) (Mahoney & Barthel, 1965) were included in the study. We excluded women who: (i) suffered from any kind of systemic condition which prevented them from exercising; (ii) were under medication which might affect their body composition; (iii) said that they would be absent for more than two weeks during the interventional period; or (iv) were already taking part in a different training programme. Participants were recruited after contacting two associations of postmenopausal women in Jaén (Spain). From a total of 113 patients who were initially contacted and screened for inclusion in the study, 110 met the inclusion criteria and were accepted.

Sample size calculation

The sample size was calculated using Ene 3.0 (GlaxoSmithKline, SA, Madrid, Spain). The required sample was determined taking as a reference the data reported by Josephs, Pratt, Calk-Meadows, Thurmond, and Wagner (2016). To obtain a statistically significant difference using ABC scores as the dependent variable, with a power of 0.80, a significance level of 95%, and considering an estimated drop out of 22.58%, 52 subjects per group were required.

Randomization

After obtaining informed consent participants were randomly allocated, using a computer-generated
random numbers table, to either a Pilates group (PG) or a control group (CG) in a 1:1 ratio. Participants, investigators, and physiotherapists were blinded to group assignment. Allocations were performed in sealed, opaque, and consecutively numbered envelopes kept in a locked location, which were then opened by an independent administrator.

**Intervention**

The PG performed exercises as per described in Appendix 1. The intervention involved a 12-week programme of twice-weekly 60-minute sessions of Pilates exercises, for a total of 24 sessions. Each session comprised three phases: warm-up (10 min), main exercises (35 min), and cool-down (15 min). The first session served the purpose of letting participants familiarize themselves with Pilates, the correct execution of movements, breathing, and a brief explanation of its basic principles. The following sessions included strengthening and stretching exercises for the main body segments, with ten repetitions of each exercise. The last sessions involved equipment such as resistance bands, rings, and balls. The goal of these exercises was to improve flexibility as well as increase stamina and muscle tone. The supervisors adjusted the difficulty and intensity of each exercise according to the subjects’ capacity, to ensure that they were performed against the greatest possible resistance while maintaining good form. The intensity of exercises was modified according to the progress of participants, although the effort level never exceeded the basic-intermediate. Participants allocated to the control group simply maintained their day-to-day lifestyles, received a series of guidelines aimed at fostering physical activity (http://www.juntadeandalucia.es/salud/servicios/contenidos/andaluciaessalud/docs/130/Guia_Recomendaciones_AF.pdf) and were asked not to engage in any other exercise training programme. Participants were periodically contacted by telephone during the intervention period and were questioned about their physical activity habits.

**Outcomes**

All measurements were recorded before training (pre-intervention) and just after the intervention period (post-intervention).

**Balance confidence (primary outcome).** The Activities-specific Balance Confidence scale (ABC; Powell & Myers, 1995) assesses the level of confidence in performing a specific task without losing balance or becoming unsteady, and also measures functional balance. It consists of 16 items that range from 0 to 100%, and the total score of the ABC is obtained by summing the ratings (0–160) and then dividing by 16. Higher scores reveal greater degrees of self-confidence. In this study we used the Spanish version of the ABC scale (Montilla-Ibáñez et al., 2017).

**Fear of falling.** The Falls Efficacy Scale-International (FES-I) is a 16-item questionnaire developed to evaluate FoF (Yardley et al., 2005). This is a reliable instrument for the study of older populations which assesses physical, social, and functional aspects related with concerns about falling. Its total score ranges from 16 (complete absence of concern) to 64 (extreme concern). For the purposes of this study we used the Spanish version of the FES-I, which has been validated for a postmenopausal population (Lomas-Vega, Hita-Contreras, Mendoza, & Martínez-Amat, 2012).

**Stabilometric analysis.** An EPS pressure platform (Bologna, Italy) was used to assess stabilometric parameters. Calculations of center of pressure (CoP) movements were performed with the EPS-System-Footchecker 3.1 software. The Romberg test was performed under both eyes-open (EO) and eyes-closed (EC) conditions. The patients stood barefoot and as still as possible, with arms on the sides, feet separated at a 30° angle, and heels placed 2 cm apart (Baydal-Bermouei et al., 2004). Each session lasted 30 s, with a one-minute interval between tests and a sampling frequency of 40 Hz. The stabilometry test measured the following parameters related to the participants’ CoP under both EO and EC: mediolateral (X) and anteroposterior (Y) mean displacements of the CoP (mm), and velocity of CoP movement (v, in mm/s). Several studies have demonstrated the reliability of this test (Bauer, Groger, Rupprecht, Tibesku, & Gassmann, 2010; Hita-Contreras et al., 2013).

**Statistical analysis**

Statistical analyses were performed using SPSS statistical software, version 17.0 (SPSS, Inc., Chicago, IL, USA). Mean values, standard deviations, number of cases, and the percentage of the total for each variable of interest were calculated. The differences between both groups were examined using Student’s t test for independent samples and the statistical Chi-square test. A mixed analysis of variance (ANOVA) was employed to assess differences between and within groups. In this analysis, intervention (PG vs CG) was the between-group factor and measurement time (pre-intervention vs post-intervention) was the within-group factor. Dependent variables were FoF, balance confidence, and stabilometric parameters under both EO and EC.
conditions. We performed separate analyses for each dependent variable and examined a possible interaction between treatment and measurement time. A p-value below 0.05 was considered statistically significant. Intergroup effect sizes were calculated using Cohen’s $d$ and categorized as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) according to benchmarks suggested by Cohen (1988).

**Results**

A total of 110 women (68.18 ± 8.35 years) were allocated to either the PG ($n = 55$) or the CG ($n = 55$). Three participants from the CG did not attend the measurement session after the intervention. A flow diagram of the participants is presented in Figure 1. All sessions were supervised by a qualified and experienced professional. No injuries or adverse effects were observed during the intervention. A minimum attendance to 79.17% of the training sessions was required to be included in the analysis. Participants who missed more than three consecutive exercise sessions were considered drop-outs. There were no statistically significant differences in the baseline comparisons between groups regarding descriptive and clinical variables (Table I). Adherence to the Pilates programme was satisfactory, with all participants completing ≥91.6% of the sessions.

**Balance confidence**

Regarding ABC, the PG scored higher than the CG ($77.52 ± 18.27$ vs $72.35 ± 16.39$). The Group × Time interaction yielded statistically significant differences: $F(1, 105) = 64.31$, $p < 0.001$, $\eta^2 = 0.38$, but not Time: $F(1, 105) = 0.92$, $p = 0.341$, $\eta^2 = 0.01$; nor Group: $F(1, 105) = 0.00$, $p = 0.999$, $\eta^2 = 0.00$ (Figure 2). A detailed analysis showed statistically significant differences only between the pre- and post-intervention measurements for the PG, $t(54) = −5.47$, $p < 0.001$ (Cohen’s $d = 0.30$).

**Fear of falling**

As for FoF (FES-I), women in the CG showed higher scores, and thus greater FoF, than those in the PG ($27.9 ± 6.95$ vs $22.07 ± 5.73$). Statistically significant changes were observed in the Time variable: $F(1, 105) = 5.35$, $p = 0.023$, $\eta^2 = 0.05$; and in the Group × Time interaction: $F(1, 105) = 127.19$, $p < 0.001$, $\eta^2 = 0.55$; but no statistically significant effects were appreciated in the Group variable: $F(1, 105) = 3.72$, $p = 0.056$, $\eta^2 = 0.03$ (Figure 2). The detailed analysis of interaction showed statistically significant differences between both groups in post-intervention measurements, $t(105) = 4.75$, $p < 0.001$, with a large size effect (Cohen’s $d = 0.92$). In addition, statistically significant interactions appeared between pre- and post-intervention measurements for the PG, $t(54) = 6.27$, $p < 0.001$ (Cohen’s $d = 0.41$).

**Postural control**

Under the eyes-open condition, no statistically significant changes were appreciated neither in XEO

*Figure 1. CONSORT flowchart of patient selection and allocation.*
nor in YEO parameters (Table II). However, statistically significant changes appeared in vEO concerning Group × Time: A detailed analysis of interaction revealed statistically significant differences between both groups in post-intervention measurements, \( t(105) = 2.2, p = 0.012 \), with a small size effect (Cohen’s \( d = 0.03 \)). In addition, statistically significant differences were observed between the pre- and post-intervention measurements for the PG, \( t(54) = 2.45, p < 0.018 \) (Cohen’s \( d = 0.44 \)).

Under the eyes-closed condition, stabilometric analysis showed no statistically significant differences concerning vEC and XEC, but we found statistically significant differences regarding YEC in the Group × Time interaction (Table II). In the detailed analysis of interaction, statistically significant differences appeared between both groups in post-intervention measurements \( t(105) = 2.099, p = 0.038 \) (Cohen’s \( d = 0.41 \)). In addition, statistically significant differences were revealed between pre- and post-intervention measurements for the PG, \( t(54) = 2.71, p < 0.009 \) (Cohen’s \( d = 0.35 \)).

### Discussion

This study was performed to analyze the effects of a 12-week Pilates intervention on balance confidence when performing activities of daily living, FoF, and postural balance in women aged 60 years and older. The key findings of the present study show that FoF, balance confidence, and postural stability significantly improved after Pilates exercises. These results have important clinical implications for this target population, since increased FoF and the loss of balance confidence are strongly associated with reduced physical activity, which in turn spirals down into increased fall risk and social withdrawal.

Psychological factors such as balance confidence and FoF are two important fall risk factors and they

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**Table I. Baseline characteristics of the study group.**

<table>
<thead>
<tr>
<th></th>
<th>All participants (n = 107)</th>
<th>Control group (n = 52)</th>
<th>Experimental group (n = 55)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>68.18 (8.35)</td>
<td>66.79 (10.14)</td>
<td>69.98 (7.83)</td>
<td>0.070</td>
</tr>
<tr>
<td>Years since menopause</td>
<td>20.40 (9.34)</td>
<td>17.38 (10.43)</td>
<td>20.47 (7.75)</td>
<td>0.084</td>
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<tr>
<td>History of falls</td>
<td>No</td>
<td>65 (60.75%)</td>
<td>35 (67.31%)</td>
<td>0.235</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>42 (39.25%)</td>
<td>30 (54.55%)</td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>No</td>
<td>100 (93.46%)</td>
<td>47 (90.38%)</td>
<td>0.196</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>7 (6.54%)</td>
<td>5 (9.62%)</td>
<td></td>
</tr>
<tr>
<td><strong>Clinical characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABC</td>
<td>74.24 (18.73)</td>
<td>76.90 (16.53)</td>
<td>71.74 (20.43)</td>
<td>0.155</td>
</tr>
<tr>
<td>FES-I</td>
<td>24.30 (6.87)</td>
<td>23.77 (6.36)</td>
<td>24.80 (7.34)</td>
<td>0.441</td>
</tr>
<tr>
<td>vEO</td>
<td>16.15 (4.77)</td>
<td>16.76 (5.50)</td>
<td>15.51 (3.80)</td>
<td>0.172</td>
</tr>
<tr>
<td>XEO</td>
<td>9.62 (8.95)</td>
<td>9.78 (9.53)</td>
<td>9.45 (8.38)</td>
<td>0.852</td>
</tr>
<tr>
<td>YEO</td>
<td>18.55 (10.83)</td>
<td>18.43 (10.59)</td>
<td>18.69 (11.19)</td>
<td>0.903</td>
</tr>
<tr>
<td>vEC</td>
<td>15.71 (4.41)</td>
<td>16.04 (4.42)</td>
<td>15.35 (4.42)</td>
<td>0.421</td>
</tr>
<tr>
<td>XEC</td>
<td>9.85 (8.22)</td>
<td>10.10 (8.85)</td>
<td>9.58 (7.58)</td>
<td>0.745</td>
</tr>
<tr>
<td>YEC</td>
<td>18.44 (10.93)</td>
<td>18.63 (10.45)</td>
<td>18.23 (11.51)</td>
<td>0.849</td>
</tr>
</tbody>
</table>

Notes: Values expressed as mean and standard deviations and frequencies and percentages for continuous and categorical variables. X: mediolateral displacements of the centre of pressure; Y: anteroposterior displacements of the centre of pressure; v: velocity of the centre of pressure displacements (mm/s²); EO: eyes open; EC: eyes closed.

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**Figure 2.** Between-group and within-group comparison of balance confidence and the fear of falling. ABC: Activities-specific balance confidence. FES-I: Falls efficacy scale-international. \( *P < 0.05; **P < 0.01; ***P < 0.001. \)
have been shown to be essential when developing fall intervention strategies for the elderly (Landers et al., 2016). However, there are few RCTs focused on the effects that Pilates may have on these factors. When considering the success of a fall prevention programme, the importance of adhering to the intervention has already been demonstrated (Shumway-Cook et al., 2007). In the present study all women in the PG attended at least 79.17% of the sessions and none missed more than three consecutive sessions, which is in accordance with existing training guidelines (McArdle, Katch, & Katch, 1991). Therefore, all subjects successfully completed the Pilates programme.

As far as balance confidence is concerned, the ABC scale has shown excellent internal consistency (Cronbach’s alpha = 0.916) and substantial test-retest reliability (intraclass correlation coefficient = 0.86) (Montilla-Ibáñez et al., 2017). Increases in the ABC scale score have been reported after a programme of elastic band exercises and physical therapy treatment for the elderly (Kwak, Kim, & Lee, 2016), As for Pilates exercises, Josephs et al. (2016), found statistically significant improvements in balance confidence after 12 weeks of Pilates in comparison with resistance exercises, but their small sample size (n = 24) and the lack of a third control group that received no intervention could limit the interpretation of these results. The findings of the present RCT are consistent with those previously described, since we observed a statistically significant improvement in the ABC total score after the intervention with a medium-size effect (Cohen’s d = 0.30). Balance confidence is associated with actual balance ability and with falls (Hatch, Gill-Body, & Portney, 2003; Scheffer et al., 2008). A balance confidence score of 67 has been reported to be a reliable predictor of future falls, with a specificity and sensitivity of 87.5% and 84%, respectively (Lajoie & Gallagher, 2004). These findings may be important for the prevention of falls and fall-related injuries because, although participants in the PG showed a slightly superior baseline mean value (71.74), their improvement in the ABC scale score after the Pilates exercises (7.78%) puts them considerably far from that cut-off score.

As for FoF, it has been robustly linked to female gender (Denkinger, Lukas, Nikolaus, & Hauer, 2015), and fall risk among postmenopausal women (Hita-Contreras et al., 2013). In the present work we used the FES-I, which has excellent test-retest reliability (intraclass correlation coefficient = 0.972) and good internal consistency (Cronbach’s alpha = 0.940) (Lomas-Vega et al., 2012). Cruz-Díaz et al. (2015) reported a statistically significant improvement in FoF (FES-I) after 6 weeks of physiotherapy
intervention and Pilates in older women with low-back pain. In healthy older adults, Pata, Lord, and Lamb (2014) reported an improvement in FoF (as assessed by a Likert scale) after 8 weeks of Pilates exercises. However, that was a quasi-experimental study (without a control group) performed in 32 participants. In the present study, the positive effects of Pilates on FoF were verified and our findings showed a statistically significant decrease in the FES-I total score (Cohen’s $d = 0.41$) after the intervention. FoF is not only important for the prevention of falls, but it is also linked to activity restriction, disability, and loss of autonomy in older adults (Murphy et al., 2002), which in turn can increase FoF and the risk of falling. In light of the above, taking part in a 12-week Pilates programme may offer a way out of that vicious circle, and also provide ample benefits for the health-care system and society in general.

Regarding postural control, a systematic review with meta-analysis suggests that Pilates is effective in improving the balance of older adults, but also concludes that further high-quality studies are needed that include more balance outcomes (Barker, Bird, & Talevski, 2015). Bergamin et al. (2015) reported in a pilot study that Pilates could improve static balance (mediolateral oscillations with open eyes) in postmenopausal women aged 59–66 years old. Nevertheless, velocity, which has been considered as the most accurate measure to evaluate postural balance and a predictor independent of the incidence of falls and fractures (Hunter & Hoffman, 2001), was not assessed at that time, and the design of that (quasi-experimental) study did not allow for comparisons with a control group. In the present study, a stabilometric platform was used to objectively assess postural control. This test has shown moderate to substantial reliability for the stabilometric parameters analyzed in this study (intraclass correlation coefficients ranging from 0.495 to 0.832) (Romero-Franco et al., 2013). The stabilometric analysis showed that PG participants experienced statistically significant improvements in vEO (Cohen’s $d = 0.44$) as well as in YEC, but this latter result must be interpreted with caution because of its negligible size effect (Cohen’s $d = 0.001$). In addition, a previous study (Martínez-Amat et al., 2013) carried out a programme of proprioceptive training exercises for 12 weeks, and described statistically significant improvements in static balance, more specifically in mediolateral and anteroposterior oscillations. Since both alternatives (Pilates and proprioceptive exercises) are effective for the improvement of static balance, future research should compare the effects of these two interventions.

Among the strengths of our study we may mention its randomized, blinded, controlled trial design, the high rate of adherence to the interventions, and the use of both objective and subjective measures. However, this study also had some limitations. Firstly, only short-term effects were assessed. In addition, the present study was conducted on community-dwelling women, and its conclusions can hardly be extended to all elderly populations. Future studies should consider the mid- and long-term effects, on both men and women, of the intervention here described.

In conclusion, the present study (which involved women of 60 years and older) shows that a 12-week Pilates training programme (with twice-weekly sessions) has beneficial effects on balance confidence and FoF as assessed with the ABC and FES-I questionnaires, respectively. Improvements in postural stability were also observed, more precisely in the velocity of the CoP movement with eyes open and in the anteroposterior displacements of the CoP with eyes closed, but this latter result should be carefully interpreted due to its negligible size effect.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

**Supplemental data**

Supplemental data for this article can be accessed here (http://dx.doi.org/10.1080/17461391.2019.1595739).

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