Acute and Chronic Effects of Exercise

A randomized controlled trial on the effects of Pilates on bone mineral density and fat distribution in older women

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Abstract - Aim The purpose of this randomized clinical trial was to examine the long-term effects of Pilates exercises on body composition (i.e., bone mineral density and body fat distribution) of sedentary older women. **Methods:** A single-blinded, randomized controlled trial with concealed allocation and per-protocol analysis was undertaken. The experimental group received Pilates exercises over six months and the control group received no intervention. Outcomes related to body composition were collected within a laboratory setting at baseline (Month 0) and after intervention (Month 6), by blinded measurers. **Results:** Twenty women with mean age of 64 years (SD 3) and mean body mass index of 29 kg/m^2 (SD 3) completed the study protocol. According to the T-score classification, 65% of the included participants had normal bone mineral density, 25% had osteopenia and 10% had osteoporosis in the lumbar spine. After six months of Pilates exercises, there were no between-group differences in any outcome measures. **Conclusion:** This randomized clinical trial demonstrated that six months of Pilates exercises did not improve bone mineral density and did not change the body fat distribution of sedentary older women. The sample was mostly comprised of women with no bone mineral density impairment, and, therefore, larger randomized trials should examine the long-term effects of Pilates in a population of older women with osteoporosis.

Keywords: body composition, older, pilates, rehabilitation, strength.

Introduction

Despite obesity, cardiovascular diseases, and infection outbreaks, most of the projected gains in life expectancy will occur in older ages, especially in women, furthering the ageing trends in the industrialised world[1]. Age-related impairments in bone mineral density contribute to disabilities, falls and mortality[2], which places greater strain on the healthcare system. With aging, the balance between bone formation by osteoblasts and bone resorption by osteoclasts shifts in a negative direction, favouring greater bone resorption, less bone formation, osteoporosis, and fractures[3]. In addition, changes on fat mass and fat-free mass composition associated with aging, such as greater fat mass or body fat percentage, have demonstrated strong correlation with cardiovascular diseases[4]. Therefore, interventions aiming at improving body composition of older adults may reduce age-related disabilities and improve longevity.

Pilates is a mind-body approach that focuses on improving strength, core stability, flexibility, muscle control, posture and breathing, which has the potential to minimize or revert age-related impairments[5]. Mat or equipment Pilates exercises are designed to change the relative level of physical stress in the neuromusculoskeletal system by combining movement with other forces generated both inside the body (e.g., isometric muscle contractions) and outside of the body (e.g., gravity), which may cause adaptive responses in the biological tissues[6,7]. Pilates exercises have proved to be effective for reducing pain in people with low back pain[8] and for improving balance and fitness of older adults[9,10], but their effects on body composition of older adults remain uncertain[11].

The purpose of this randomized clinical trial was to examine the long-term effects of Pilates exercises on body composition (i.e., bone mineral density and body fat distribution) of sedentary older women. The specific research questions were:

1) Do six months of Pilates exercises improve bone mineral density of the lumbar spine and femur of sedentary older women, compared with no intervention?
2) Are any benefits carried over to improvements on body fat distribution (i.e., weight, body mass index, fat

mass, fat-free mass, body total fat distribution, android and gynoid fat distribution)?

Methods

Design

A single-blinded, randomized controlled trial with concealed allocation and per-protocol analysis was undertaken. Women, aged between 60 and 69 years, were recruited from the general community of a metropolitan city in Brazil, by means of social media advertisements. A research assistant, who was not involved with the recruitment, compiled a computer-generated, random allocation sequence. The allocation sequence was kept in opaque, sequentially numbered, and sealed envelopes, which were held off-site by an independent researcher. After the baseline measurements, the envelope was opened, and group allocation was revealed. The experimental group received Pilates exercises over six months and the control group received no intervention. Outcomes related to body composition were collected within a laboratory setting at baseline (Month 0) and after intervention (Month 6), by blinded measurers. Effects on quality of life have been published elsewhere[12]. The study reporting followed the CONSORT statement guidelines[13]. The trial was prospectively registered (ReBEC: RBR-22 bpsb) and approved by the Institutional Research Ethical Committee (#929.768) and all participants provided written consent.

Participants and therapist

Participants were eligible if they were: women, aged between 60 and 69 years old, sedentary and non-smokers. Participants were classified as sedentary when they informed no regular exercises during the past 12 months, had been working predominantly in a sitting position and reported passive leisure activities. They were excluded if they had red flags preventing physical exercises, such as vertebral fracture or cancer[14], unstable cardiovascular conditions, neurological diseases associated with risk of falls or did not attend at least 90% of the training sessions. The experimental intervention was delivered by a physiotherapist, who had over ten years of clinical and research experiences in rehabilitation. A total of 24 participants was allocated to the experimental (n = 12) or control (n = 12) groups.

Intervention

The experimental group received 30-min sessions of Pilates exercises, twice a week, over six months. The sessions included both mat and equipment Pilates (e.g., Cadillac, Reformer, Chair)[15] focusing on the lower limbs and core muscles, according to the recommendations provided by the Physical Mind Institute[16]. The experimental intervention was performed in a rehabilitation centre and included a single series of 12-20 repetitions of the following exercises: bicycle, Eve's Lunge, Footwork, Footwork Heel Lowers and Lift, Front Balance Lunges, Jump Board Variations, Leg Springs Supine Variations, Pelvic Lift, Side Splits, Swan, The Hundred, Walking. The progression of the exercises followed three cycles: Cycle 1 - eight weeks of adaptation, which involved physical, chemical, or metabolic stimulation to prepare the connective and muscular tissues and avoid lesions. The participants performed a single series of 12 repetitions of each exercise using the mild resistance (i.e., the initial springs of Pilates equipment); Cycle 2 - nine weeks of increased resistance and intensity of the exercises. The participants performed a single series of 12 repetitions of each exercise using the moderate resistance (i.e., the intermediate springs of Pilates equipment); and Cycle 3 - eight weeks of maintenance of resistances. The participants performed a single series of 20 repetitions of each exercise using the moderate resistance (i.e., the intermediate springs of Pilates equipment). One minute rest was always allowed between types of exercises[16]. The control group received no intervention, and participants were instructed to maintain their habitual daily activities throughout the research period. There were no other additional interventions delivered to either the experimental or control groups.

Outcome measures

The primary outcome was bone mineral density of the lumbar spine (L1-L4) and femur (i.e., proximal femur and total femur), measured by densitometry (DPX NT, General Electric, Fairfield, Connecticut-USA), and reported in g/cm^2. The anatomical sites were defined according to the International Society of Clinical Densitometry. The diagnosis was based on the T-score thresholds defined by the World Health Organization, as: normal (T-score $\geq$ -1 SD), osteopenia (T-score between -1 e -2.4 SD) or osteoporosis (T-score $\leq$ -2.5 SD).

Secondary outcomes were body weight (kg), body mass index (kg/m^2), fat mass (kg), fat-free mass (kg), body total fat distribution (%), android fat distribution (%), and gynoid fat distribution (%), measured by densitometry.

Sample size

Sample size was estimated based on t-tests for comparison of means originated from continuous outcomes (i.e., mineral bone density), calculated to reliably detect between-group differences considering 80% power, two-tailed significance level of 0.05, proportional distribution between-groups and a standardized magnitude of effect 1 (E/C), using *EPI BIOESTAT*[17]. The least number of participants estimated was 12 individuals, per group. A target of 24 participants, in total, was set.

Data analysis

Data analysis was conducted based upon a per-protocol basis by an independent researcher, who was blinded to group allocation. Data collection returned seven outcomes: bone mineral density of the lumbar spine (g/cm^2), bone mineral density of the proximal femur (g/cm^2), bone mineral density of the total femur (g/cm^2), weight (kg), body mass index (kg/m^2), fat mass (kg), fat-free mass (kg), body total fat distribution (%), android fat distribution (%), gynoid fat distribution (%). Two-way analysis of variance with repeated measures at the two time-points for all outcomes were analysed, to determine the statistical significance of the between-group differences and reported as mean between-group differences and 95% confidence intervals [CI]). All analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (23.0 version).

Result

Flow of participants through the trial

Forty older women were screened by telephone between February 2015 and May 2015. Out of them, 14 were ineligible due to smoking or physical activity habits and 2 refused to participate. Thus, 24 women were physically screened, eligible and invited to participate. After six months, the data from four participants, who withdrew from the study (3 from the experimental group), were missing. The reasons for withdrawing were unavailability to attend sessions due to work or climate changes (n = 3) and home moving (n = 1). Figure 1 shows the flow of the participants through the trial.

The sample was, therefore, comprised of 20 women with mean age of 64 years (SD 3) and mean body mass index of 29 kg/m^2 (SD 3). Most of the participants were

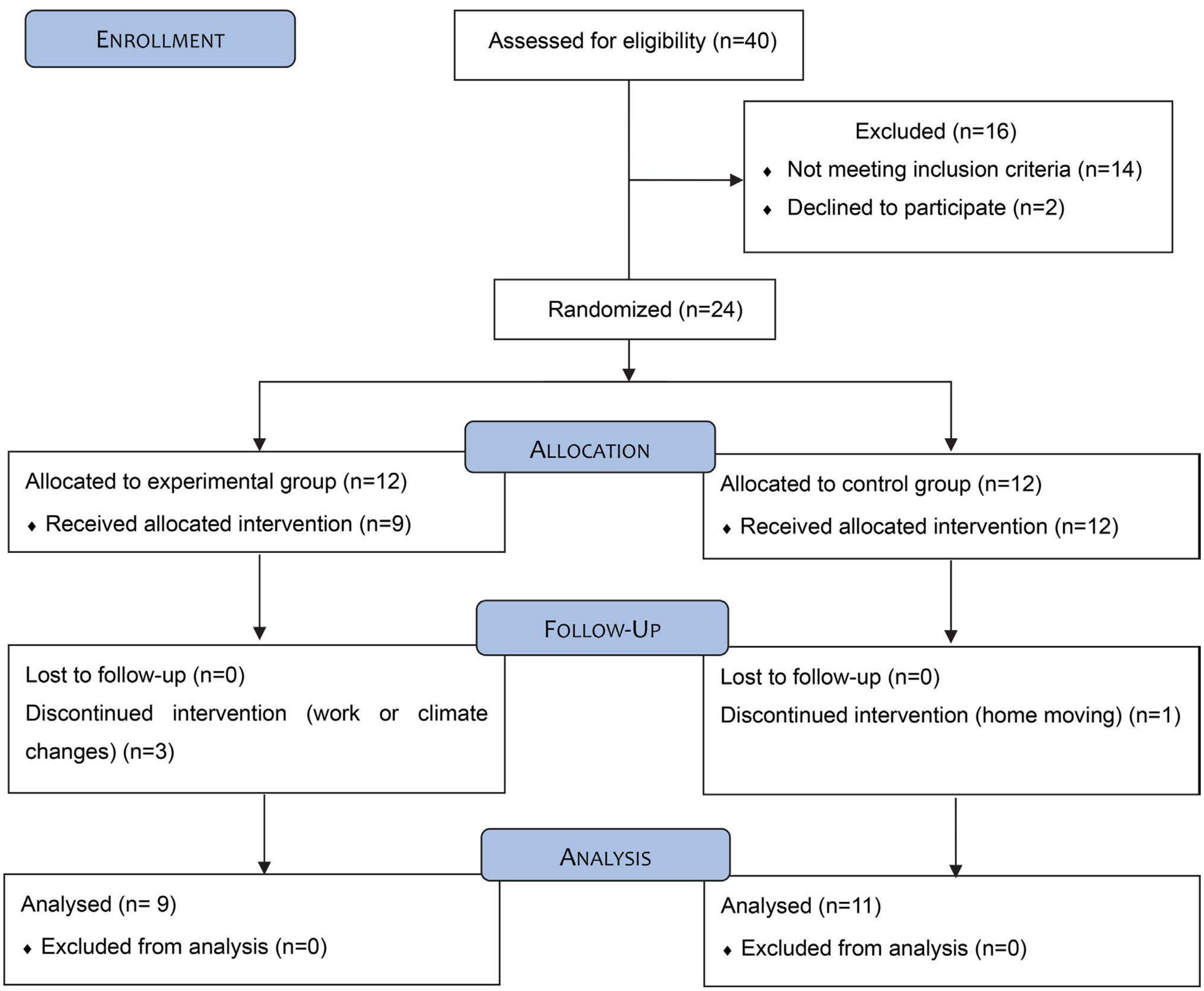

Figure 1 - Flow of participants.

married (n = 13; 65%), retired (n = 13; 65%) and had a monthly income ranging from U$ 180 to U$ 540. According to the T-score classification, 65% of the included participants had normal bone mineral density, 25% had osteopenia and 10% had osteoporosis in the lumbar spine. As shown in Tables 1 and 2, the groups were similar regarding their baseline characteristics. At the beginning of each intervention, all participants were requested to inform any side effects related to the interventions. There were no reports of side effects.

After six months of Pilates exercises, there were no between-group differences in any outcome measures. The group means (SD) and between-group differences (95% CI) are provided in Table 2.

Discussion

This randomized clinical trial demonstrated that a six-month period of Pilates exercise is feasible for sedentary older women but did not improve the bone mineral density of the lumbar spine and femur and did not modify the body fat distribution.

Postmenopausal osteoporosis is a disorder or negative imbalance of bone metabolism and remodelling, with bone resorption outpacing bone formation, which is quite common in sedentary women, with prevalence escalating up to 35%[18,19]. Although the sample of this study included women over 60 years of age, only 10% of the participants had diagnosis of osteoporosis, which may explain why Pilates exercises had no effect on bone mineral density. The results were similar to a randomized clinical trial[20] that showed no difference on bone mineral density of the lumbar spine (MD 0 g/cm^2; 95% CI -0.10 to 0.10) and of the femur (MD 0.02 g/cm^2; 95% CI -0.05 to 0.09), but also included only 20% of individuals with osteoporosis. These results suggest that when participants with no bone impairments are included, there is little room for improvements with Pilates exercises. On the other hand, small significant effects were demonstrated on bone mineral density of the lumbar spine (MD 0.06 g/cm^2; 95% CI 0.01 to 0.11) in a randomized trial[21] that examined effects of Pilates exercises only in women with osteoporosis. Further trials should, therefore, examine the long-term effects of Pilates exercises on bone mineral density in a specific sample of older women with diagnosis of osteoporosis. Moreover, there are characteristics of the intervention that also may have influenced the results. First, although the number of repetitions seems appropriate, the participants performed a single series, which may have not provided appropriate volume of intervention. Second, the progres-

Table 1 - Baseline characteristics of the participants.

Characteristic	Completed	
	Experimental group (n = 9)	Control group (n = 11)
Age (years), mean (SD)	64 (3)	65 (3)
Weight (kg), mean (SD)	68 (10)	73 10)
Body mass index (kg/m^2), mean (SD)	29 (3)	29 (3)

Table 2 - Mean (SD) of groups and mean (95% CI) differences between the experimental and control groups.

Outcome	Month 0		Month 6		Between-group differences
	Experimental group (n = 9)	Control group (n = 11)	Experimental group (n = 9)	Control group (n = 11)	Experimental - control
BMD lumbar spine (g/cm^2), mean (SD)	1.06 (0.16)	1.15 (0.19)	1.05 (0.15)	1.17 (0.19)	-0.12 (-0.28 to 0.04)
BMD proximal femur (g/cm^2), mean (SD)	0.90 (0.11)	0.93 (0.13)	0.90 (0.12)	0.94 (0.13)	-0.04 (-0.16 to 0.08)
BMD total femur (g/cm^2), mean (SD)	0.95 (0.10)	1.01 (0.16)	0.96 (0.10)	1.00 (0.16)	-0.04 (-0.17 to 0.09)
Weight (kg), mean (SD)	67.8 (9.7)	73.3 (10.3)	67.7 (9.2)	72.2 (9.4)	-4.5 (-13.3 to 4.3)
Body mass index (kg/m^2), mean (SD)	29.5 (3.4)	29.0 (3.4)	29.3 (3.6)	29.3 (3.3)	0.0 (-3.3 to 3.3)
Fat mass (kg), mean (SD)	29.9 (6.4)	32.1 (6.8)	29.6 (6.9)	31.7 (6.2)	-2.1 (-8.3 to 4.1)
Fat-free mass (kg), mean (SD)	35.8 (3.9)	38.9 (4.2)	36.0 (3.7)	38.3 (4.1)	-2.3 (-6.0 to 1.4)
Body total fat distribution (%), mean (SD)	45.1 (4.4)	44.8 (3.7)	44.8 (5.2)	45.0 (3.3)	-0.2 (-4.2 to 3.8)
Android fat distribution (%), mean (SD)	51.1 (4.4)	51.3 (5.1)	50.0 (5.9)	51.9 (5.2)	-1.9 (-7.1 to 3.3)
Gynoid fat distribution (%), mean (SD)	50.5 (3.5)	50.0 (3.1)	49.9 (4.5)	50.3 (2.5)	-0.4 (-3.7 to 2.9)

BMD = bone mineral density.

sions followed a planned dosage of exercise across board and, therefore, were not based on individual responses to the exercises. Lastly, frequency of exercises performed twice a week could have been enhanced to at least three times a week.

After intervention, there was also no difference between the intervention and control groups in any secondary outcomes included in our randomized trial, which were related to body fat mass and fat-free mass composition. The effects of Pilates exercises on fat distribution of women have been investigated by the following randomized trials[22-24]. Our results are in accordance with one randomized trial (Fourie et al., 2013) that found no changes on fat mass (MD -1 kg; 95% CI -6 to 4) or fat-free mass (MD -2 kg; 95% CI -6 to 2) in older women after eight weeks of Pilates exercises. Two other trials[23,24] reported a small significant reduction on body fat percentage (MD -2%; 95 CI% -3 to -1) in obese younger women (mean age 30 years), with no changes on fat-free mass. These results suggest that Pilates exercises may influence fat distribution of adult obese women, but significant changes in older women seem more difficult to occur. Pilates exercises could be combined with aerobic or strength training to enhance effects on body composition of older individuals but results from systematic reviews are also unclear regarding their training effects[25,26]. Further randomized clinical trials should examine the effects of the addition of Pilates exercises to aerobic or strength training on body composition of older women.

There are both strengths and weaknesses in this study. The main strengths of the study lie in the long period of intervention of 6 months, the measurement of outcomes by a gold standard instrument, and the good retention of participants at 83%. The main weakness is that the sample, which included women with no bone mineral density alterations, may have hindered possible effects of Pilates exercises on bone mineral density. In addition, the progressions followed a planned dosage of exercise across board and, therefore, were not based on individual responses to the exercises. Lastly, analyses were based on participants who completed the protocol due to plans on the trial registry and the absence of withdrawn participants on post-intervention measurement days. Although a sample size estimation has been performed to detect between-group differences, the final sample is insufficient to draw a clear-cut conclusion regarding Pilates exercises' effects on all sedentary women.

Conclusions

In conclusion, this randomized clinical trial demonstrated that six months of Pilates exercises did not improve bone mineral density and did not change the body fat distribution of sedentary older women. The sample was mostly comprised of women with no bone mineral density impairment, and, therefore, larger randomized trials should examine the long-term effects of Pilates in a population of older women with osteoporosis.

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Internet resources

Physical Mind Institute www.physicalmindinstitute.com.
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