Review Article

RBAFS Revista Brasileira de Atividade Física & Saúde
SOCIEDADE BRASILEIRA DE ATIVIDADE FÍSICA & SAÚDE

rbafs.org.br

The effect of Pilates practice on balance in elderly: a systematic review

Efeito da prática do Pilates sobre o equilíbrio de idosos: uma revisão sistemática

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DOI

10.12820/rbafs.23e0019

ABSTRACT

The aging is accompanied by a gradual decline in balance and increases risk of falls. Pilates has been used for balance training. The purpose of this research was to systematize studies regarding the effects of Pilates exercise interventions on static and dynamic balance of elderly people. A survey was conducted in three indexed databases: Medline/Pubmed, Scopus and Science Direct, using the descriptors "balance" or "equilibrium" with the term "Pilates". Fifteen articles were selected and used in this systematic review. Based on the results, we observed that the practice of Pilates with a minimum frequency of two sessions per week for an hour lasting for a period of at least five weeks or three times per week for 12 sessions or more showed improvement on static and dynamic balance of elderly.

Keywords: Physical activity; Balance; Elderly; Exercise movement techniques.

RESUMO

O envelhecimento é acompanhado por um declínio gradual no equilíbrio e aumento do risco de quedas. Pilates tem sido utilizado para o treinamento do equilíbrio. O objetivo desta pesquisa foi sistematizar estudos que evidenciem os efeitos da intervenção com exercícios de Pilates sobre o equilíbrio estático e dinâmico de idosos. Uma pesquisa foi realizada em três bases de dados indexadas: Medline/Pubmed; Scopus e Science Direct, a partir da associação dos descritores "balance" ou "equilibrium" com o termo "Pilates". Quinze artigos selecionados e analisados foram utilizados para compor esta revisão sistemática. A partir dos resultados foi possível verificar que a prática de Pilates realizada com frequência mínima de duas sessões semanais, por uma hora por dia, em período igual ou superior a cinco semanas resultou em melhorias no equilíbrio estático e dinâmico de idosos.

Palavras-chave: *Atividade física; Equilíbrio postural; Idosos; Técnicas de exercício e de movimento.*

Introduction

Increased life expectancy has generated growing interest in understanding health problems related to aging. It has been well established that aging is accompanied by a gradual decline in balance due changes in proprioceptive system[1], which can increase risk of falls. Falls in elderly remain a major source of morbidity, mortality, reduced functionality and independence[2].

Balance is defined as a person's ability to control their body position within the limits of the base of support[3]. Balance can be categorized in Static balance (quiet erect standing) and Dynamic balance (the capacity to maintain or regain a stable position of the body during movements or in response to a perturbation)[4]. Maintaining balance is crucial for the successful performance of most movements practiced in daily life or movements involving high complexity and requiring self-proper body control[5,6]. Postural control is resultant of the synergy of small muscle contractions, which maintain the center of gravity within the limits of stability and orientation of the body in order to adapt to gestures and techniques according to the demand of the activity[7,8]. Postural control depends on the interaction of the sensory system (visual, vestibular and somatosensory) with the central nervous system and with the neuromuscular system. The central nervous system receives sensory information about the body position and responds by activating a specific musculature[9].

The deep muscles of the trunk or core muscles have been identified as great aids to maintain balance[10-12]. Core consists of 29 muscles separated into two systems: global, which are superficial muscles that perform movements dynamically; and local, which are the deep muscles (in-

cluding multifidus and transversus abdominis) responsible for stabilizing the trunk during the performance of activities. The better the activation of core muscles, the better the individual's ability to maintain balance[13, 14].

The practice of Pilates has been widely used to activate the muscles of the core. The method focuses on toning the deep core stabilizer muscles using control and conscious movements that allows the practitioner to improve fitness, muscle tone, posture, flexibility and balance[11,12,15]. Exercises can be performed on mat using the body weight, or with specific apparatus, such as the Reformer, Cadillac, Chair and Barrel, which were developed by the creator, Joseph Pilates (1880-1967). Other accessories as elastics, ball and rollers are also used during mat or apparatus classes to enable different kinds of exercises in order to improve strength, stretching and postural realignment[11, 16].

Experiment results have consistently demonstrated that Pilates has a positive effect on healthy subjects' balance. Indeed, Cruz-Ferreira[17] conducted a systematic review and found evidences to support the use of Pilates to improve dynamic balance. However, there is some contradiction about the intervention methods, the frequency, time and the methods of evaluating balance and lack of consistent information regarding Pilates prescription for elderly people, who can be benefit with balance improvements and diminish risk of falls. In fact, it has not been established yet how much and what types of range of motion exercises are the most effective for elderly people[18]. Thus, this literature review aims to systematize studies focusing on the effects of an intervention with Pilates exercises on static and dynamic balance of elderly people.

Methods

Articles were selected on April 2017, by searching three indexed databases: Medline/PubMed; Scopus and Science Direct with the key words "balance" or "equilibrium" and the term "Pilates", which although it is not a health science descriptor, is fundamental to the development of this study.

A set of criteria were selected to compose the review and included: original articles; published in peer-reviewed journal; dated between 2006 and March 2017; written in English; conducted as randomized controlled trial, quasi-experimental studies and cross over method; evaluated the effect on subjects' balance; and studied healthy individuals with an average equal to or greater than 65 years.

The research initially generated a total of 762 articles. Of these, 488 studies were within the period of interest (2006 - March 2017). After checking for repeated studies and verifying the terms in the title and abstract, 59 eligible articles were further screened. Two review authors independently applied inclusion criteria for the studies after reading abstracts and selecting potential studies. The assessors critically analyzed and discussed the selection of article and disagreements were resolved with a third reviewer when needed.

The articles were primarily selected by analysis according to the abstract, then by reading the full article, focusing on criteria and objectives of the study. At the end of the evaluation, fifteen relevant articles were included in this systematic review. The following data were extracted independently by two reviewers: author, years of publication, subjects, study design, Pilates method of intervention, balance variables studied and key results.

Methodology quality assessment was evaluated according to a protocol developed for the present study based on Bento et al.[2]. The 11 criteria judged important for this review were as follows: control group; random allocation of the subjects; initial similarity between groups; blind evaluation; intervention with Pilates method; supervised program; minimal frequency of training of twice a week; minimal duration of the program of eight weeks; static balance evaluation, dynamic balance evaluation; reliable instruments for assessment. Higher scores denoted better article quality.

Data were systematized by the comparison established between Pilates intervention and control group (inactive) or initial condition and post-intervention condition for studies with a single group. The results of the static and dynamic balance were used to report the differences. Strength of scientific evidence was measured by "best evidence synthesis", which determines strength by the number and quality of studies and consistency of results[17].

Results

Flowchart of the article selection process is showed in Figure 1. Fifteen articles were considered relevant and were used in this systematic review. All of the selected studies conducted Pilates intervention with a minimum of 40 minutes sessions and evaluated the effects of this exercise on balance of elderly people. The average age of the participants was 70.35 ± 2.85 years. Although this is quite high, participants were in general healthy and physically independent.

Score for methodological quality assessment protocol ranged from 5 to 10 (mean 8), indicating moderate quality of studies. The quality criteria satisfied by all researches

were related to "supervised program" and "reliable instruments for assessment". While the criteria least checked corresponded to "similarity between groups" (2 articles) and "blind evaluation" (6 articles). Score for methodological quality assessment protocol is presented in Table 1.

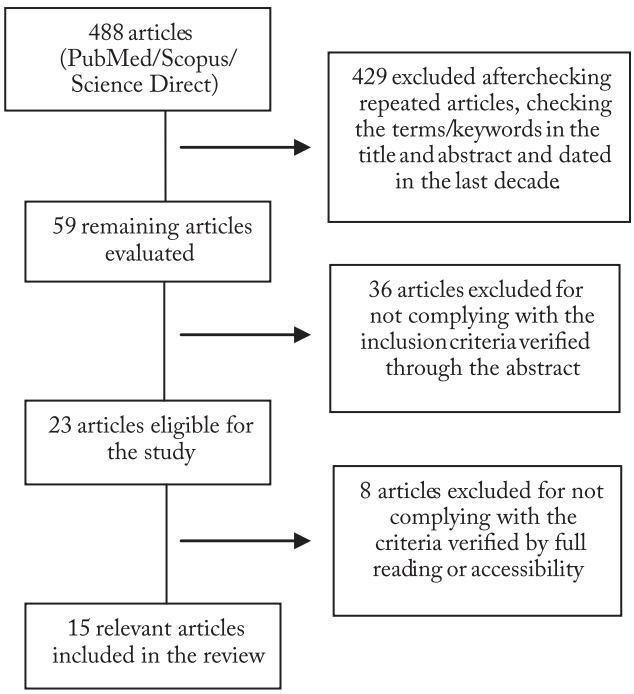

Figure 1 – Article selection process.

Regarding the methodological procedures, ten articles (66.7%) conducted a randomized controlled study[19-29], while four articles[30-33] (26.7%) conducted a quasi-experimental study evaluating the data from the same population before and after the intervention. Only one study[34] (6.7%) used a cross over method.

Moderate evidence was found for improving static and dynamic balance by "best evidence synthesis". Four articles evaluated only static balance[19,20,25,32], while three evaluate dynamic balance[22,31,33] and eight both conditions[21,23,24,27-29,30,34]. Pilates exercise demonstrated ability to improve static and dynamic balance in almost all studies. Pilates methods, frequency, variables and results can be observed in Tables 2 and 3.

Discussion

This review was conduct in order to systematize studies focusing on the effects of intervention with Pilates exercises on static and dynamic balance of elderly people. Fifteen select articles showed moderate to good methodological quality and evidence to support that exercise with apparatus or a combination of exercise on mat and with apparatus can improve both static and dynamic balance after an intervention period of twice per week or more. Mat Pilates exercises showed improvement when practiced with a minimum frequency of three times per week.

Although Newell et al.[32] Pata et al.[33] and Donath et al.[23] did not show significant results with mat and/or apparatus exercises once or twice per week, the results portray a positive trend in relation to balance. Kaesler et al.[30], Siqueira et al.[20], Barker et al.[22], Josephs et al.[28] and Sofianidis et al.[29] observed that Pilates practiced twice

Table 1 – Protocol to assessment methodology quality.

	1	2	3	4	5	6	7	8	9	10	11	Total
Barker et al.[22]	1	1	-	1	-	1	1	1	-	1	1	8
Bird et al.[34]	1	1	1	1	1	1	1	-	1	1	1	10
Siqueira et al.[20]	1	1	-	-	1	1	1	1	1	-	1	8
Donath et al.[23]	1	1	-	-	1	1	1	1	1	1	1	9
Gabizon et al.[24]	1	1	-	1	1	1	1	1	1	1	1	10
Hyun et al.[21]	-	-	-	-	1	1	1	1	1	1	1	7
Irez et al.[19]	1	1	-	-	-	1	1	1	-	1	1	7
Josephs et al.[28]	-	1	-	1	-	1	1	1	1	1	1	8
Kaesler et al.[30]	-	-	-	-	1	1	1	1	1	1	1	7
Markovic et al.[25]	-	1	-	1	1	1	1	1	1	-	1	8
Mesquita et al.[27]	1	1	1	1	1	1	1	-	1	1	1	10
Mokhtari et al.[31]	1	1	-	-	-	1	1	1	-	1	1	7
Newel et al.[32]	-	-	-	-	1	1	-	1	1	-	1	5
Pata et al.[33]	-	-	-	-	-	1	1	1	-	1	1	5
Sofianidis et al.[29]	1	1	-	-	-	1	1	1	1	1	1	8

1 = Control Group; 2 = Random allocation of the subjects; 3 = Initial Similarity between groups; 4 = Blind evaluation; 5 = Intervention with Pilates method only; 6 = Supervised program; 7 = Minimal frequency of training of twice a week; 8 = Minimal duration of the program of eight weeks; 9 = Static balance evaluation; 10 = Dynamic balance evaluation; 11 = Reliable instruments for assessment.

Table 2 - Methodological description of included articles.

Study	Subjects (n) Mean Age ± SD (years)	Study design	Method/ Frequency
Barker et al.[22]	n = 53 PG = 22 69.25 ± 6.74 CG = 31 69.41 ± 5.76	follow-up/ randomized controlled trial	PG = 2x /week during 12 weeks -- reformer, trapeze, Wunda chair, chi ball, elastic band and foam roller and 20-minute home exercise program daily CG = 20-minute home exercise program daily
Bird et al.[34]	n = 27 67.3 ± 6.5 PG = 13 CG =12	cross over	PG = 2x /week during 5 weeks -- apparatus and on mat CG = maintained normal physical activity
Siqueira et al.[20]	n = 52 66 ± 4 PG = 27 CG = 25	randomized controlled study	PG = 2x /week during 8 weeks -- apparatus CG: no intervention
Donath et al.[23]	n = 64 PG = 17 70.8 ± 6.5 CG = 31 69.2 ± 6.1 BAL = 16 69.1 ± 5.8	randomized controlled trial	PG = 2x /week during 8 weeks – on mat CG = asked to regular daily activity schemes. BAL = traditional balance training 2x /week during 8 weeks
Gabizon et al.[24]	n = 64 PG = 17 70.3 ± 3.8 CG = 31 71.2 ± 4.6	randomized controlled trial	PG = 3x /week during 12 weeks. Mat, Thera-Band; elastic resistance bands and Swiss balls CG = not receive any intervention
Hyun et al.[21]	n = 40 PG = 20 70.0 ± 2.2 CG = 20 69.3 ± 2.6	randomized controlled study	PG = 3x /week during 12 weeks --on mat CG =3x /week during 12 weeks – on unstable support surface exercise (Standing on aero step)
Irez et al.[19]	n = 60 PG = 30 72.8 ± 6.7 CG = 30 78.0 ± 5.7	randomized controlled study	PG = 3x /week during 12 weeks -- on mat, with elastic and Swiss ball CG = no intervention
Josephs et al.[28]	n = 24 PG = 13 75.6 ± 6.72 TG = 11 74.5 ± 6.79	randomized controlled trial	PG = 2x /week during 12 weeks – with reformer, Cadillac and Chair apparatus and 15-20min home exercise program on non-program day TG = 2x /week during 12 weeks traditional strength and balance exercises and 15-20min home exercise program on non-program day
Kaesler et al.[30]	n = 8 PG = 8 66-71 CG = no existent	quasi-experimental study	PG = 2x /week during 8 weeks -- apparatus and on mat
Markovic et al.[25]	n = 34 70 ± 4 PG = 17 HG = 17	randomized controlled trial	PG = 3x /week during 8 weeks -- elastic band HG =3x /week during 8 weeks -- training performed on Huber device
Mesquita et al.[27]	n = 63 PG = 21 67.3 ± 4.9 CG = 21 71.5 ± 6.2 PNFG = 21 68.5 ± 5.4	randomized controlled trial	PG = 3x /week during 4 weeks -- on the ground CG = continued their daily activities PNFG = 3x /week during 4 weeks resistance, manual pressure, traction, stretch-approximation reflexes and visual and verbal stimulation
Mokhtari et al.[31]	n = 30 62-80 PG = 15 CG = 15	quasi-experimental study	PG = 3x /week during 12 weeks -- on mat and with elastic CG = maintained normal physical activity
Newel et al.[32]	n = 9 PG = 9 67.8 ± 5 CG = no existent	quasi-experimental study	PG = 1x /week during 8 weeks -- on mat
Pata et al.[33]	n =35 74.4 PG = 35 CG = no existent	quasi-experimental study	PG = 2x /week during 8 weeks --on mat, elastic and apparatus
Sofianidis et al.[29]	n = 36 PG = 12 70.76 ± 5.42 DG = 12 70.59 ± 5.78 CG = 12 70.37 ± 5.97	randomized controlled trial	PG = 2x /week during 12 weeks with power balls, ribbons-tires and weights DG = 2x /week during 12 weeks latin dances with and without a partner CG = instructed not to do any form of exercise

PG = Pilates Group; CG: Control Group; BAL = Balance Training Group; TG = Traditional Group; HG = Huber group; PNFG = Proprioceptive Neuromuscular Facilitation Group; DG = dancing group.

per week between 8 to 12 weeks allow improvements in balance and may prevent falls. Bird et al.[34] suggest that after the fifth week it is already possible to identify balance improvement. Mesquita et al.[27] found that when

Table 3 – Balance variables and outcomes description of included articles.

Study	Balance variables studied	Key results pos-training
Barker et al.[22]	Step test; functional reach test; lateral reach test; TUG; modified clinical test of sensory interaction on balance; dynamic gait index; FSST	Standing balance in the Pilates group
Bird et al.[34]	Static balance (FP) Dynamic balance (FSST, TUG)	FSST, TUG / body sway in medial-lateral direction
Siqueira et al.[20]	Dynamic Balance (Tinetti)	Balance
Donath et al.[23]	single limb stance [40] and perturbed kneeling, YBalance test	Static and dynamic balance in the BAL group Unclear effect of balance in the Pilates group
Gabizon et al.[24]	Static balance (FP) Dynamic balance (Berg balance score)	No difference between groups. No improvement in groups
Hyun et al.[21]	Static balance (FP) Dynamic balance (TUG)	Static and Dynamic Balance in both groups. Pilates group showed better static balance when compared to the control group in the post test
Irez et al.[19]	Static Balance (FP)	Balance of Pilates group
Josephs et al.[28]	Dynamic balance TUG FAB; ABC.	FAB in both groups ABC in Pilates group
Kaesler et al.[30]	Dynamic Balance (sway meter and maximal balance range test)	Sway meter with closed eyes and TGUGT of Pilates group
Markovic et al.[25]	Static balance (FP)	Training with Huber device was more effective to the balance than Pilates training
Mesquita et al.[27]	Stabilometry (FB) Dynamic balance TUG, Functional reach test, Berg balance score	Static balance in proprioceptive neuromuscular group Dynamic balance in both training group
Mokhtari et al.[31]	Dynamic Balance (maximal balance range test and TUG)	Balance (maximal balance range test and TUG) of Pilates group
Newel et al.[32]	Static Balance [40]	balance ($p > 0.05$)
Pata et al.[33]	Dynamic balance (maximal balance range test, TUG and turn 180º test)	TUG and turn 180º test Balance ($p > 0.05$)
Sofianidis et al.[29]	Tandem stance, one leg stance and periodic sway with and without metronome guidance	Both intervention's groups Trunk sway amplitude (Tandem stance - eyes closed) CoP displacement (one-leg stance)/ amplitude of trunk oscillation (sway task)

FP = Force Plataform. FSST = four square step test. TUG = time up and go. FAB = Fullerton Advanced Balance Scale. ABC = Activities-Specific Balance Confidence Scale.

Pilates is practiced with a higher weekly frequency, i.e. three times a week, 12 sessions were sufficient to promote changes in balance. Hyun et al.[21] and Mokhtari et al.[31] also found balance improvement after 12 weeks of Pilates practice three times per week. Curiously, Gabizon et al.[24] did not find improvement on balance with Pilates intervention three times a week in 36 sessions. Maybe the exercises performed were not balance challenging enough for the population studied. In addition, Markovic et al.[25] observed that practice with Huber device can be more effective to training balance than Pilates.

Different methods of practicing Pilates showed positive results. For example, practice using elastic or springs as resistance has shown to provide greater positive effect on increasing force[19]. On the other hand, mat exercises can be performed in any place with a lower cost. Other interventions analyzed also showed improvement similar or greater in balance, i.e., traditional balance[23] and strength training[28], proprioceptive neuromuscular facilitation[27], training performed on Huber device[25] and latin dances[29]. Regardless the type of exercises, the frequency of session must be considered, once exercise with apparatus or combined exercises (apparatus and mat) had shown no effect at a lower frequency (once a week for example). These results can be justified by the fact that with a lower frequency participants were not able to adapt and retain the benefits that Pilates exercise may cause.

Although these studies did not assess the mechanisms responsible for the effect of Pilates training, Pata et al.[33] suggest that the increase in balance can be a con-

sequence of the strengthening of core muscle which allows for greater distal mobility and a better control of body alignment. This idea is supported by Kibler[35] who claim that the correct activation of the core enable an anticipatory postural adjustments which creates a stable base of support for performing activities. While Mokhtari et al.[31] state that muscle activation and proprioceptive stimulus performed during intervention may cause a displacement of the center of the ankle joint, thus improving balance. Similarly, Siqueira et al.[20] claim that increases in strength might improve the speed of muscle activation response and proprioception. As a consequence, it is possible to verify an improvement in balance and autonomy of the participants.

Considering that the average age of the population of the related studies is above 65 years, minor imbalance is important so that individuals can perform activities of daily life more easily, reducing the risk of falling and increasing independency in performing the movements. Other benefits related to the practice of Pilates, which are important for the health of the elderly, are improvements in functionality[20,30], velocity and step length[32]. Thus, the practice of Pilates is recommended for preserving functional abilities that change with aging. Despite the moderate to good score for methodological quality and strength of the scientific evidence, this literature review has the limitation that none of the articles evaluated the mechanism responsible for the effect of practicing Pilates on balance. Thus, only speculations can be used to explain the changes between the variables tested.

Articles demonstrated moderate methodological quality and science evidence. Pilates training demonstrated in general positive results on balance, functionality, gait speed and stride length of elderly. Core muscle strengthening, activation of proprioception, improvement in strength and speed of muscle activation response, might be possible explanations for the benefits founded. Improving balance is important for maintaining a better ability to perform activities of daily life, decrease the risk of falling and increase independence in performing simple and complex movements[5,6].

Current literature suggests that Pilates training should be performed at least twice per week in sessions with apparatus or a combination of mat and apparatus exercise and three times per week on mat only to balance improvements. The duration of the session must be at least of 40 minutes, for a period equal or greater than five weeks when practiced twice per week or from 12 sessions, when practiced three times per week with challenge and task specific, in order to be significantly effective in improving balance of the elderly.

Conflict of Interest

The authors declare no conflict of interest

Authors' Contribution

Goedert A, conceptualized the study, conducted the initial search and wrote the first draft of the manuscript. Santos KB, supplied the acquisition of data, analysis and interpretation. Bento PCB, was responsible for the article critically for important intellectual content. Rodacki ALF, provided the revised the article critically for important intellectual content and gave final approval of the version to be submitted.

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Recebido: 29/11/2017
Aprovado: 07/08/2018

Quote this article as:

Goedert A, Santos KB, Bento PCB, Rodacki ALF. The effect of pilates practice on balance in elderly: a systematic review. Rev Bras Ati Fis Saúde. 2018;23:e0019. DOI: 10.12820/rbafs.23e0019