SOCIEDADE BRASILEIRA DE REUMATOLOGIA

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Review article

The effects of the Pilates method in the elderly: a systematic review

*Patrícia Becker Engers, Airton José Rombaldi, Elisa Gouvêa Portella, Marcelo Cozzensa da Silva**

Postgraduate Program in Physical Education, Universidade Federal de Pelotas, Pelotas, RS, Brazil

ARTICLE INFO

Article history:
Received 21 June 2015
Accepted 18 November 2015
Available online 1 June 2016

Keywords:
Elderly
Aging
Motor activity
Review

ABSTRACT

Several studies show the benefits of including muscle strength and aerobic physical activity in the routine of elderly people. Among the various possibilities of physical activity, the Pilates method has become a popular modality in recent years, through a system of exercises enabling to work the whole body and that corrects posture and realigns the muscles, developing the body stability needed for a healthier life. The aim of this study was to review the current evidence on the effects of the practice of the Pilates method in the elderly. A systematic literature review was conducted in the following electronic databases: Pubmed, Scielo, Lilacs/Bireme, Scopus, Pedro and Isi of Knowledge, from descriptors *pilates*, *elderly*, *old adults*, *aging*. In the selection of studies the following inclusion criteria were used: original articles in English, Portuguese and Spanish languages. All selection and evaluation processes of the articles were performed by peers and the quality was verified by the Downs and Black scale. Twenty-one studies were included. The year of publication ranged from 2003 to 2014 and the size of the sample varied from 8 to 311 elderly subjects, aged at least 60 years old. The intervention period was from 4 weeks to 12 months of Pilates exercise practice. It was concluded that despite the studies pointing to physical and motor benefits of the Pilates method in the elderly, we cannot state whether or not the method is effective, in view of the poor methodological quality of the studies included in this review.

Efeitos da prática do método Pilates em idosos: uma revisão sistemática

Palavras-chave:
Idoso
Envelhecimento
Atividade motora
Revisão

RESUMO

Diversos estudos apontam os benefícios da inclusão de atividades físicas de resistência muscular e aeróbicas na rotina dos idosos. Dentre as diversas possibilidades da atividade física, o método Pilates se tornou uma modalidade popular nos últimos anos, por meio de um sistema de exercícios que possibilita trabalhar o corpo todo, corrige a postura, realinha a musculatura e desenvolve a estabilidade corporal necessária para uma vida mais saudável.

* *Corresponding author.*
E-mail: cozzensa@terra.com.br (M.C. Silva).

http://dx.doi.org/10.1016/j.rbre.2016.05.005

O objetivo do presente estudo foi revisar as evidências atuais sobre os efeitos da prática do método Pilates em idosos. A revisão sistemática da literatura foi feita nas bases de dados eletrônicas Pubmed, Scielo, Lilacs/Bireme, Scopus, Pedro e Isi of Knowledge a partir dos descritores *pilates*, *elderly*, *old adults* e *aging*. A seleção teve como critérios de inclusão artigos originais nas línguas inglês, português e espanhol. Todos os processos de seleção e avaliação de artigos foram feitos por pares e a qualidade foi verificada pela escala de Downs and Black. Foram incluídos 21 estudos. O ano de publicação variou de 2003 a 2014 e a amostra de oito a 311 idosos, com idade mínima de 60 anos. O período de intervenção apresentou variação de quatro semanas a 12 meses de exercícios do método Pilates. Concluiu-se que apesar de os estudos apontarem para benefícios físicos e motores do método Pilates em idosos, não podemos afirmar que o método é ou não efetivo, tendo em vista a baixa qualidade metodológica dos estudos que compõem a revisão.

Introduction

According to the census of 2010,[1] Brazil moves toward an increasingly aged demographic profile, with an increase in the number of elderly subjects.[2] Due to medical advances, among other things, the Brazilian life expectancy has become increasingly higher, and for 2050, the Brazilian Bureau of Statistics projected a life expectancy of 81 years.[1]

Aging is an involuntary and inevitable process that causes progressive structural and functional loss in the body, such as deterioration of functional capacity, muscle mass and strength loss (mainly due to sarcopenia), loss of bone mass and of hormone production, and delays in reaction time, which are risk factors that lead to a loss of autonomy and increased risk of falling.[3–6]

Live an independent and autonomous life, with the ability to carry out their basic tasks of daily life, is a key aspect for maintaining quality of life for the elderly.[7] However, a condition for allowing autonomy of the elderly is to maintain their physical fitness. Physical activity seems to be a strategy for maintaining autonomy, improving functional capacity, decreasing the risk of falls and, consequently, improving quality of life.[6,8]

According to the United States Centers for Disease Control and Prevention (CDC), elderly individuals should perform muscular strength (twice a week or more, with involvement of most muscle groups) and aerobic activities (at least 150 min of moderate intensity activity or 75 min of vigorous intensity activity, or a combination of these per week) in order to reduce the risk of mortality from all causes, coronary heart disease, stroke, hypertension, and type 2 diabetes.[9] Among the various possibilities of physical activity, the Pilates method has become a popular modality in recent years. Such a method has emerged as a popular way of improving the strength and overall conditioning for people of all ages and currently has been used as an adjuvant method in rehabilitation of injuries.[10] According to several authors, this method entails benefits such as increased bone mineral density, positive changes in body composition, and improvement in muscular strength and endurance, coordination, balance and flexibility.[11–13]

In view of the benefits described above and considering that the practice of this method is individualized, thereby reducing the risk of possible injury, Pilates has been quite indicated for the elderly. However, there are few studies published on systematic reviews, and particularly studies assessing the methodological quality of research in order to check the evidence for the decision-making process about the use of the method in physical activity programs aimed to the health of the elderly. In this sense, the aim of this study is to assess the effects of the Pilates method in the parameters of physical fitness and physiological and cognitive function in the elderly.

Methods

A systematic literature review was conducted in electronic databases, using the following inclusion criteria: original articles, Portuguese, English or Spanish language, and no restriction as to the year of publication. Review articles, case studies, theses and dissertations were considered as exclusion criteria.

The electronic search was conducted in the following databases: Pubmed, Scielo, Lilacs/Bireme, Scopus, Pedro and Isi of Knowledge. The descriptors used (Pilates, elderly, old adults, aging) were inserted into the Descriptors in Health Sciences (DeCS), in English and their equivalents in Portuguese language. The descriptors were used with the following combinations: “Pilates and elderly”, “Pilates and old adults” and “Pilates and aging.”

All articles found in the different databases were imported into EndNote, a reference managing software. After exclusion of duplicated articles, an analysis in the titles of the studies was carried out; those articles that did not address Pilates were excluded. Later, the abstracts of the articles were analyzed, and those that were not related to the review goals, for example, did not include subjects with the age group of interest for the study (individuals aged 60 or older) were excluded. The articles that remained after the analysis of the abstracts were read in their entirety, and in the absence of reasons for their exclusion were included in this review. All article selection and evaluation processes were performed independently by two reviewers.

Included studies were assessed for quality according to Downs and Black Checklist.[14] This assessment was also carried out by two independent evaluators and, in case of

disagreement on the score awarded to items, a third evaluation was requested to another independent appraiser.

The assessment tool proposed by Downs and Black is composed of 27 questions divided into five sub-scales: evaluation of appropriate information (10 items), external validity (3 items), the internal validity of the detailed measurements and bias outcomes (7 items), confounding factors (6 items) and power (one item). The maximum score that can be achieved by the instrument is 32 points. Each item that makes up the checklist assigns scores ranging from 0 to 1, with the exception of that item that evaluates the description of confounding factors, which one can assign up to two points, and the item that assesses the description of the study power, which one can assign up to five points. The item 27 has been modified, in line with its use in other studies[15,16]; for this item, the score that originally ascribed 0–5 points was modified to ascribe between 0 and 1 point; thus, the score of 1 was awarded if the article showed a power calculation and/or sample size calculation, and 0 if not showed any of these calculations. After this modification, total scores ranging from 0 to 28 points were obtained with the checklist.

Results

After the search in various databases, 170 articles were identified. Of these articles, 83 were excluded because they were duplicates, and 53 were discarded because the title did not relate the article to the objectives of the present review. In addition, 13 articles were excluded after reading the abstracts. At the end of the selection process, 21 articles met the inclusion criteria and were included in the systematic review, as shown in the flow chart (Fig. 1).

The 21 studies included in this study received their scores by assessing their quality using the Downs and Black Checklist, ranging from 10 to 19 points out of 28 possible points to be achieved (average 14.76 ± 2.12). Studies with the highest score were performed by Bird et al.[17] and Mallery et al.[18] with 19 points; and studies with lower scores were the those by Kaesler et al.,[19] Newell et al.,[20] and Ruiz-Montero et al.,[21] with 12 points each. The quality criteria with lower scores were: lack of an accurate description of confounding factors; not reporting the most important adverse events; not displaying information on the environment and care received by the sample; not informing whether the subjects included in the samples were counterparts to those of the general population; not reporting adjustments for confounding factors; not reporting whether there were losses to follow-up, and if this fact was taken into account; lack of a control group for proper comparison; and lack of sample randomization. Furthermore, none of these studies conducted sample size or power calculations.

As for countries where the studies were carried out, four studies in Brazil,[22–25] four in Australia,[17,19,26,27] and four in South Africa,[28–31] two in Turkey,[32,33] and two in Hungary,[34,35] and one in Canada,[18] United Kingdom,[20] Serbia,[21] South Korea,[36] and United States[37] were found.

Table 1 summarizes the main characteristics of the articles that make up our review study, as well as the scope, methodological procedures and main results. Among these articles, 16 experimental studies,[17,18,21–24,27–36] four quasi-experimental studies,[19,25,26,37] and one observational study[20] were found, and the year of publication ranged between 2003 and 2014. The sample size of the studies ranged from eight[19] to 311[21] elderly subjects. The reported minimum age was 60 years; in 12 studies the samples were composed of both genders,[17–21,23,26,27,32,35–37] and in nine studies only women were evaluated.[22,24,25,28–31,33,34] The intervention period ranged from four weeks[18] to 12 months,[32] with a predominance of interventions of eight[19,20,22,28–31,37] (38%) and 12 weeks[26,27] (9.5%). In more than half of the studies ($n = 11$), there was no report of a gradual increase in exercise intensity, according to the evolution of the his/her practitioner.[17,22,23,25,26,28,29,31,32,35,36]

The main effects of the Pilates method reported for the age group studied were: increased balance,[19,22,26,32,33,36,37] flexibility,[23,29,32,34] and strength,[9,32] positive modifications in body composition,[21,28,32] and also improved functional autonomy[22,24,25] and less risk of falls[20,32,37] in the elderly.

Discussion

In terms of methodology, according to the Downs and Black checklist, the assessed articles showed low scores, and more than half of them awarded a score ≤ 14, from a total of 28 points. The important and primary criteria for scientific soundness of studies have been missed, or at least have not been presented, in most of these studies. Among the missing quality indicators, stand out the objective description of confounding factors; the reporting of adverse events important to the study; the description of information on the environment and care received by the study sample; the indication of the representativeness of the samples; the adjustment for confounding factors; the reporting of losses and if this fact was taken into account; a control group and randomization of the sample. All these factors challenge the findings of some studies, which should be treated with extreme caution.

It was found that the studies were composed predominantly of female subjects or of both genders, with no study with a sample composed only of men. The greatest demand and adherence by females to Pilates may help explain this finding. On the other hand, with respect to the place of origin of the study, Brazil[22,24] and Australia[17,26] stand out, probably due to the demand for this method in these countries.[38]

Several studies which made up this review suggest that the practice of Pilates had a positive effect on increasing and preventing the reduction of flexibility levels in the elderly.[23,29,33,34] Despite the positive results of reports, the studies reviewed did not report on the control of confounding factors, and on blinding of those who applied the intervention and its potential adverse effects, as well as sample size calculation.

Other studies have shown, as the effects of the Pilates method, improvement of static and dynamic balance.[19,22,33,36,37] The main methodological problems in these studies refer to the lack of control for confounding factors, identification of potential adverse effects of the intervention, blinding of those who applied and who received the intervention, representativeness of samples, and sample size calculation.

Table 1 – Description of the characteristics and results of studies involving the Pilates method.

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Guimarães et al., 2014[23]/Brazil	Experimental	To verify the effect of the Pilates method in the hip and shoulder girdle flexibility levels in the elderly	60 elderly subjects: 30 CG/30 PG (85% women; 15% men)	Mean 68 (SD ± 5.1) years	Pilates exercises with and without the use of machines	60 min, 2× per week/average to moderate intensity, 10–12 repetition series for each exercise/12-week duration	Hip flexibility: CG normal and lower in pre-test and retest. PG pretest: 60% normal and 10% higher; and on retest 66.7% normal and 33% higher ($p = 0.180$). Shoulder flexibility: PG pre-test: 63% normal and 17% higher, and on retest 47% normal and 33% higher ($p = 0.001$)	13
Bird and Fell, 2014[26]/Australia	Quasi-experimental	To investigate the effect of Pilates exercise on the risk of physical fall risk factors	30 elderly subjects of both genders	Mean 69 (SD ± 7) years	Pilates classes	5 weeks of intervention (T1)/post intervention (T2)/12 months later (T3)	There were significant differences in dynamic balance and strength among participants who continued with Pilates *versus* those who discontinued. One year later, improvements in balance were maintained in all participants	14
Bird et al., 2012[17]/Australia	Experimental	To evaluate the effects of a Pilates intervention in balance and function in the elderly living in the community	32 elderly subjects, men and women (16 CG and 16 PG)	Over 60 years: mean 67.3 (SD ± 6.5) years	Pilates exercises	2 60-min group sessions per week/5-week duration	There were no significant differences between PG and CG for all measured variables. Static and dynamic balance improved significantly from pre to post-Pilates ($p < 0.05$)	19
Rodrigues et al., 2010[24]/Brazil	Experimental	Evaluate the effect of the Pilates method in the functional autonomy of elderly women	52 elderly women (27 PG, 25 CG)	60–78 years: PG (66.9 ± 5.3 years); CG (65.2 ± 3.9 years)	Pilates practice, using a Bobath ball and specific devices of the method	2 sessions twice per week. Each session lasting 1 h/8-week duration	PG showed significant improvement in the functional performance of older subjects ($p < 0.05$)	15

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Curi Pérez et al., 2014[25]/Brazil	Quasi-experimental	To analyze the Pilates Method (PM) to assess whether it can help to improve the performance of activities that older people perform in their daily lives	22 elderly women	65–74 years	Pilates classical method	50-min sessions twice per week/12-week duration	After 12 weeks of training, the elderly women began to take less time to perform the activities of daily living	14
Fourie et al., 2013[28]/South Africa	Experimental	To determine the effects of a Pilates program in body fat in older women	50 elderly women (25 CG, 25 PG)	60 years and over	Pilates exercise program	3 weekly sessions lasting 60 min/8-week duration	PG showed a significant reduction in total body fat	14
Fourie et al., 2013[29]/South Africa	Experimental	To describe the range of motion of single or multiple joints in frail elderly people	50 elderly women (25 CG, 25 PG)	60 years and over	Pilates exercise program	3 weekly sessions lasting 60 min/8-week duration	Significant improvement in shoulder flexion (from 152.84 ± 21.32 degrees to 179.60 ± 10.53 degrees; $p = 0.000$) and hip flexion (from 74.36 ± 13.07 degrees to 82.60 ± 16.40 degrees;. $p = 0.002$)	14
Hyun et al., 2014[36]/South Korea	Experimental	To compare the effects of Pilates practice in balance and stability of elderly female	40 elderly subjects of both genders (divided into PG and CG)	65 years and over	Pilates exercises	3 times per week, each session lasting 40 min/12-week duration	After the intervention period, oscillation duration and balance oscillation speed lowered significantly ($p < 0.05$) in both groups	14

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Siqueira Rodrigues et al., 2010[22]/Brazil	Experimental	To evaluate the effects of the Pilates method in personal autonomy, static balance and quality of life in healthy older women	52 elderly women (27 PG, 25 CG)	60 years and over	Pilates exercises	2 sessions of 1 h per week/8-week duration	There was a significant difference in the post-test in the PG for balance (Delta% = 4.35%, $p = 0.0001$); for functional autonomy index (% Delta = −13.35%, $p = 0.0001$) and for quality of life (Delta% = 1.26%, $p = 0.0411$)	15
Irez et al., 2014[32]/Turkey	Experimental	To compare the effects of Pilates and a walking exercise program on dynamic balance, flexibility and muscle strength in an elderly population. Determine the effects of Pilates in resting heart rate, resting blood pressure, fasting glucose, cholesterol and triglycerides in older women	45 elderly subjects of both genders (15 PG, 15 CG and 15 walking group) with 10 female and 5 male in each group	Over 65 years	Mat Pilates exercises	3 times per week, each session lasting 60 min/14-week duration	Statistically significant differences were found in pre- and post-intervention scores for weight ($z = -2.94$; $p = 0.03$), flexibility ($z = -2.87$, $p = 0.04$), muscle strength of hip flexion ($z = -2.37$, $p = 0.02$), balance ($z = -2.67$, $p = 0.03$), balance confidence ($z = -2.24$; $p = 0.04$), and Downton fall risk index ($z = -2.12$, $p = 0.03$) in Pilates group	16
Marinda et al., 2013[30]/South Africa	Experimental	To determine the effects of Pilates in resting heart rate, resting blood pressure, fasting glucose, cholesterol and triglycerides in older women	50 elderly women (25 CG and 25 PG)	60 years and over; mean 65.32 (SD ± 5.01) for CG and 66.12 (SD ± 4.77) for PG	Pilates exercise program	60 min, 3× per week/Progressive intensity/8-week duration	Statistically significant reduction in systolic blood pressure, increase of blood glucose	15

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Newell et al., 2012[20]/United Kingdom	Observational	To investigate whether elderly subjects participating in a supervised Pilates community program improved in terms of gait and balance pattern	9 elderly subjects of both genders	60–76 years; mean 67.8 (SD ± 5.0)	Mat Pilates exercises and accessories	60 min/1× per week/intensity was not reported/8-week duration	Significant improvement in walking speed and step cycle. Significant increase in stride length. Decrease in both anterior and posterior oscillation with improved risk of falling index	12
Irez et al., 2011[33]/Turkey	Experimental	To determine whether an exercise program based on Pilates method was effective in improving dynamic balance, mobility, postural stability, in order to reduce the number of falls in the elderly	60 elderly women: 30 CG and 30 PG	Over 65 years: mean, 72.8 ± 6.7 years for PG and 78 ± 5.7 years for CG	Mat Pilates exercises and accessories, elastic and ball	60 min/3× per week/intensity was not reported/12-week duration	PG showed a significant improvement in dynamic balance compared to the control group. Regarding flexibility, PG showed significant improvement in the Sit and Reach test from pre- to post test, while CG showed no significant difference. PG also showed improvement in muscle strength and reaction time, both in simple and choice, after 12 weeks of Pilates. A smaller number of falls was reported by PG	18

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Kuo et al., 2009[27]/Australia	Experimental	To determine changes in sagittal spinal posture in older adults during standing and sitting after a Pilates-based exercise program	34 elderly subjects (10 men, 24 women)	Over 60 years: mean, 64 ± 6 years	Pilates exercises performed on the ground, in equipment and with accessories	75 min, 2× per week/intensity was not reported, but the level of exercise was in accordance with the participant's progress/12-month duration	Standing and sitting posture remained unchanged, except the angle of the lumbar spine in sitting posture. Immediately after the Pilates exercise program, the elderly subjects presented a small reduction in chest flexion in standing posture, and sitting with increased lumbar extension	14
Pata et al., 2014[37]/United States	Quasi-experimental	To determine changes in sagittal spinal posture in older adults during standing and sitting after a Pilates-based exercise program	35 elderly subjects (31 women and 4 men)	61–87 years	Exercises using the key principles of Pilates designed for seniors	60 min/2× per week/progressive exercises/8-week duration	Significant improvement in Timed Up and Go Test, Turn-180 Forward Reach tests. Improved confidence, with respect to fear of falling. Results suggest that a program based on Pilates method can be effective in improving balance, mobility, postural stability and in reducing the number of falls	18

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Kaesler et al., 2007[19]/Australia	Quasi-experimental	To examine an intervention through exercises designed to improve balance in an upright position, based on Pilates techniques	8 elderly subjects, men and women	66–71 years	The selected exercises and techniques were based and inspired by the Pilates principles: dissociation, stabilization, mobilization and dynamic stabilization	60 min/2× per week/progression of the exercises as needed, the subject should perform 15 repetitions/8-week duration	Significant improvement in some static and dynamic components of postural sway, as well as improvement in functioning demonstrated through a better response to the Timed Up and Go Test. The results suggest that a short training period based on Pilates can improve postural stability, and also functioning in the elderly	12
Plachy et al., 2012[34]/Hungary	Experimental	To assess whether a regular training program lasting one year can have a positive effect on flexibility, range of motion, and aerobic endurance in a sample of elderly women	42 elderly women divided into three groups: PG: $n = 15$ PG + water: $n = 15$ CG: $n = 12$	Mean, 67.1 ± 4.5 years	Pilates exercises and water exercises	60 min/3× per week (PG - 3× Pilates, PG + A – 2× water exercise, and 1× Pilates)/intensity was not reported/6-month duration	For those subjects in both groups who performed exercise, all variables showed significant differences. The results with a more significant difference for PG were the 6-min walk and the sit-to-stand tests; with regard to both intervention groups, improved shoulder and hip flexibility stood out. The results suggest that a training program impacts on physical performance improvement and on requirements of daily life in elderly	14

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Ruiz-Montero et al., 2014[21]/Serbia	Experimental	To evaluate the differences in body composition and anthropometric measurements in a sample of Serbian women over 60 years in a 24-week clinical intervention study, through a guided program that combined aerobic exercises and Pilates	311 elderly subjects: 303 women and 8 men	60–70 years	Training program consisted of aerobic exercise with music, and exercises of basic and intermediate levels of Pilates	55–60 min/2× per week/intensity was gradually increased based on the perception of the first session effort on the Borg scale (0–10)/24-week duration	Increase in post-test systolic and diastolic blood pressure. Significant reduction of body fat. Bone diameter bone and muscle circumference were not significantly different. A high correlation was found between body fat and waist-hip ratio. Based on the results, the practice of a mixed program of Pilates and aerobic exercise generate an effect of improving muscle mass and reducing body fat, without causing deterioration during practice and in the post-exercise period	12
Mallery et al., 2003[18]/Canada	Experimental	To measure adherence and compliance to a resistance program when performed during acute treatment in a hospital	39 elderly subjects of both genders: PG – $n = 19$ (5 men and 14 women), CG - $n = 20$ (11 men and 9 women)	Over 70 years: mean age: PG – 82.7 (SD ± 8.5), CG – 81.4 (SD ± 6.1)	Exercises based on the principles of resistance training and Pilates. The control group received conventional physical therapy through passive motion	Mean session of 10 min/3× per week/intensity: 60–80% 1RM, up to 10 repetitions/duration relied on length of hospital stay; however, a maximum of 4 weeks	PG participation was 71% ($p = 0.004$), with 63% adherence ($p = 0.020$); CG participation was 96% with 95% adherence	19

Table 1 – (*Continued*)

Author – year/ country of origin of the study	Study design	Objective	Sample	Age	Intervention	Frequency/intensity/ duration	Primary endpoint/results	Downs and black checklist
Gildenhuys et al., 2013[31]/South Africa	Experimental	To check the effects of Pilates training in agility, functional mobility and VO_2 max. in older women	50 elderly women (25 CG, 25 PG)	60 years and over	Pilates exercise program	3 weekly sessions lasting 60 min/8-week duration	Prescription of resistive exercise for hospitalized patients results in acceptability and adherence. The training improved significantly agility (from 6.18/1.22 s to 4.70/0.90 s; $p = 0.000$) and functional mobility (in all tests, $p = 0.000$). Significant improvement in VO_2 max was not observed	14
Kovach et al., 2013[35]/Hungary	Experimental	To measuring the effects of Pilates and water training on functional fitness and quality of life in older individuals	54 elderly subjects of both genders divided into three groups: PG: $n = 22$ Aquatic fitness group: $n = 17$ CG: $n = 15$	Mean 66.4 (SD ± 6.2) years	Pilates exercises and water exercises	60 min/3× a week (PG and water exercises)/intensity was not reported/6-month duration	Significant improvement in lower and upper extremity strength, flexibility, physical mobility (especially dynamic balance), and aerobic endurance was found in Pilates group. Shoulder flexibility significantly improved in the aquatic fitness group. BMI did not change significantly in any of the groups. WHOQOL (quality of life) showed improvement in the perception and autonomy in PG, aid in sociability in the aquatic group	14

CG, control group; PG, Pilates group; SD, standard deviation of means.

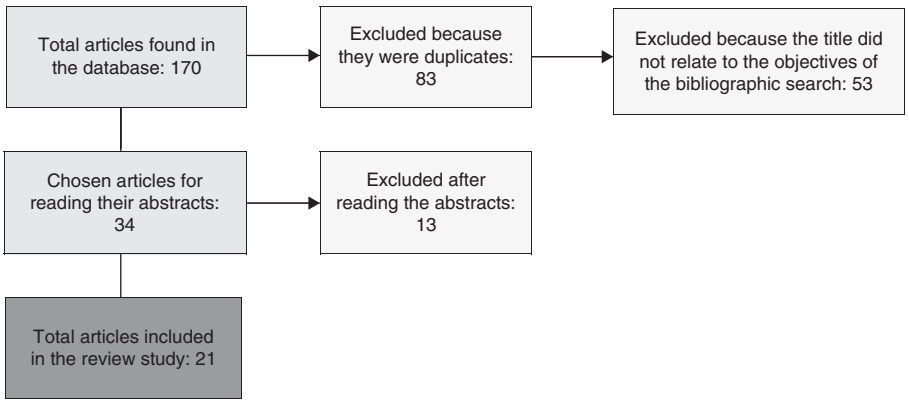

Fig. 1 – Flowchart of database search.

With regard to advances in personal autonomy, the studies reviewed have reported that Pilates exercise caused significant evolution in the functional performance of healthy elderly women in activities like wearing a shirt, getting up from sitting and lying position[22,24] and gait.[20] However, these studies have their findings weakened as a result of the lack of an objective description of confounding factors, characteristics of the subjects of the samples that have been lost, blinding to the intervention, and sample size calculation.

As for body composition, Fourie et al.[28] report that the method was effective in stabilizing and even reversal of bodily implications of the aging phenomenon, as in lean mass loss and, also, in normalization and reduction of body fat, controlling or reversing morbidities associated with obesity (p. ex., hypertension and glucose intolerance). In relation to this study, several important factors to be considered in the assessment of the quality of the article could not be determined, because the lack of description of such factors in our survey (sample representativeness, blinding process, adherence to the intervention, randomization, control for confounding factors, and report of losses to follow-up).

Perez et al.[32] obtained positive results with the practice for muscle strength gains that, along with the increase or stabilization of loss of balance and of flexibility, lead to a decrease in the number of falls among the elderly. However, important aspects of quality are not clear in their study, including the distribution of main confounders in each group of subjects that were compared, possible adverse effects of the intervention, and sample size calculation.

Also in relation to outcomes related to body composition, Ruiz-Montero et al.[21] reported that the combination of Pilates with aerobic exercise resulted in positive changes, such as reducing skin folds and preventing lean body mass loss. Despite these apparently promising results, this study[21] showed the lowest score on the scale of assessment of methodological quality (12 points) among all evaluated studies. This fact undermines the credibility of the conclusions of their research.

Regarding postural changes, the study by Kuo et al.[27] informs, as a their main result, that the reduction of kyphosis in the standing position was detected in the sagittal plane, immediately after the Pilates program. This study did not describe the distributions of principal confounders in each group of subjects, nor blinded these subjects for the intervention, did not perform randomization, and showed no sample size calculation.

Only the study by Marinda et al.[30] related the Pilates method with cardiac and metabolic variables; this study showed that eight weeks of Pilates produced no improvement in cardiometabolic variables tested, except for a decrease of systolic blood pressure. The authors did not describe the characteristics of the sample and the study dropouts, distributions of main confounders in each group, potential adverse effects of the intervention, the blinding of individuals, and whether the sample size calculation was made.

A study related positive changes in parameters such as functionality, stability, mobility, dynamic and static balance, muscle strength, and flexibility, among others, with improved self-confidence, and a decrease in fear of falling and in the number of falls in the elderly.[37] Despite being one of the studies with the highest score in the methodological assessment carried out, there was no information on significant adverse effects of the intervention; and blinding of subjects to intervention, sample randomization and sample size calculation were not presented.

In conclusion, although the studies are pointing to physical and motor benefits with the use of Pilates in the elderly, we cannot state whether or not the method is effective, in view of the low methodological quality of the studies included in this review.

Therefore, it is suggested that new studies, especially randomized clinical trials, are conducted with larger samples, longer intervention periods, and involving individuals of both genders. It would also be critical a more detailed methodological control, considering that the scores obtained in evaluating the quality of the studies included in this systematic review were low, especially when it came to the inclusion of a control group, adjusting for confounder factors, information on important adverse events, sample size and power calculation, and reporting on loss of follow-up. We also point out the need of studies that compare the Pilates method with other types of exercise, as well as studies confronting the exercises of

the method performed on the ground *versus* practices using accessories and/or devices.

Conflicts of interest

The authors declare no conflicts of interest.

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