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POSTURE IN OLDER ADULTS: EFFECTS OF STRENGTH TRAINING AND AQUATIC RESISTANCE

Pedro Vinicius de Jesus Rodrigues, Kauã Vieira Ginnari, Aryelle Karla S. Gomes dos Santos, Beneuan de Oliveira Timóteo, Maria Júlia dos Santos Meira, Raphaella Christine Ribeiro de Lima, Manoel da Cunha Costa, Keyla Brandão Costa, Tainá Maria de Souza Vidal, Wlaldemir Roberto dos Santos

School of Physical Education, University of Pernambuco, Recife, Pernambuco, Brazil

Corresponding author's e-mail: wlaldemir.santos@upe.br

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ABSTRACT

Background: Changes in posture resulting from aging occur due to several factors, such as alterations in hormonal production, sarcopenia, osteoporosis, and the natural reduction in physical activity levels.

Objective: The aim of this study was to evaluate and compare the effects of strength training and aquatic resistance on the posture of elderly women.

Methods: This is a cross-sectional exploratory study composed of 33 female volunteers aged 60 years or older, who practiced either strength training or aquatic resistance. The sample was divided into three groups: 10 in the strength training group (STG), 11 in the aquatic resistance group (ARG), and 12 in the control group (CG). The evaluation included the administration of a questionnaire, postural analysis using the Portland State University (PSU) method, and body composition assessment through an electronic scale and dual-energy X-ray absorptiometry (DXA).

Results: The results showed that the postural correction index (PCI) was higher in the STG (70.9 ± 8.1%), followed by the ARG (63.9 ± 4.8%) and the CG (57.5 ± 8.1%). The STG exhibited a significantly higher PCI compared to the CG (Δ = 18.9%; p = 0.001), but there was no significant difference compared to the ARG. A positive correlation was also observed between the PCI and lean mass (r = 0.544; p = 0.001).

Conclusion: This study suggests that strength training provides significant benefits for the posture of elderly women, with the STG showing better postural indices compared to the CG and higher values than the ARG.

KEYWORDS

Posture, elderly, strength training, aquatic resistance

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INTRODUCTION

Aging is a process inherent to human nature. During this period, various physiological and morphological changes affect the elderly, including postural changes. These modifications are associated with factors such as alterations in hormonal production, sarcopenia, osteoporosis, and the natural reduction in physical activity levels[1,2].

Women tend to be more affected by postural changes due to hormonal changes associated with aging, such as the decrease in estrogen production, which results in loss of strength, joint range of motion, and increased muscular fragility[3]. In men, the reduction in testosterone production causes similar effects, with loss of strength, lean mass, and contraction velocity[4]. Additionally, the decrease in the capacity and function of muscle components, attributed to processes such as sarcopenia and osteoporosis, often leads to chronic frailty[5], highlighting the importance of maintaining strength and lean mass as an essential strategy for controlling postural deviations in this population[6].

Good postural health in the elderly is essential for a better quality of life, as muscle imbalances and changes in body composition – characterized by increased fat and reduced lean mass – impair stability (both in the anteroposterior and lateral axes) and spatial perception, significantly increasing the risk of falls[7]. These changes highlight the cascade of physiological and postural alterations associated with aging and emphasize the importance of muscle strength care to prevent conditions such as sarcopenia, osteoporosis, and other functional and structural pathologies, promoting greater independence[8]. Given these factors, physical exercise becomes essential to minimize the impacts of postural and functional changes in the elderly. Modalities such as strength training and aquatic resistance play a key role in preserving muscle strength, preventing sarcopenia, and maintaining postural stability, contributing to a reduced risk of falls and promoting functional independence[9,10]. In addition to preserving lean mass, strength training helps control chronic conditions and reduce frailty, contributing to improved postural condition[9], with similar benefits observed in aquatic resistance, which provides better body and postural balance, enhancing overall functional fitness[10].

Despite these findings, there are gaps in the literature regarding the number of studies comparing different physical exercise modalities in relation to postural condition in the elderly, which hinders the clear definition of which modality is most effective in improving posture. This gap makes it difficult to make informed decisions when designing physical exercise programs as interventions to improve the postural condition of the elderly. Thus, the aim of this study was to evaluate and compare the effects of strength training and aquatic resistance on the posture of elderly women, with the goal of identifying which of these modalities yields better results in improving postural condition and contributes to the maintenance of postural health in this population.

MATERIALS AND METHODS

Study type and population

This is an exploratory cross-sectional study conducted with participants from the "Master Life" university extension project at the School of Physical Education of the University of Pernambuco (ESEF/UPE). The evaluations were conducted at the Human Performance Assessment Laboratory (LAPH) at UPE. The study was approved by the Research Ethics Committee with Human Beings at the University of Pernambuco (HUOC/UPE), under opinion nº 6.855.902, in accordance with Resolution 466/12, which regulates research involving human subjects.

The study included women participants of the "Master Life" program who engaged in aquatic resistance or strength training modalities. The volunteers were required to be at least 60 years old, have been enrolled in the program for at least 6 months, and have attended at least 75% of the semester sessions. Those who had difficulties in completing the assessment were excluded.

The volunteers were recruited through personal invitations made by the researchers themselves. All participants of the program were invited (a total of 253 women), with those who practiced strength training (a total of 30 women) forming the strength training group (STG), and those who practiced aquatic resistance (a total of 188 women) forming the aquatic resistance group (ARG). Invitations were made on training days: strength training on Tuesdays and Thursdays, from 10 a.m. to 12 p.m., and aquatic resistance on Wednesdays and Fridays, from 7 a.m. to 9 a.m.

In addition to the groups that participated in training (STG and ARG), a control group (CG) was recruited, consisting of women contacted by phone who were on the waiting list for the project (a total of 45 women). To be included in the CG, the volunteers had to be at least 60 years old and not engage in regular physical exercise for at least 6 months. Those who had difficulties in completing the assessment were also excluded.

Study design

After being invited to participate in the study, 55 volunteers agreed to take part. Of these, 22 were excluded for not meeting the inclusion and exclusion criteria, resulting in a final sample of 33 volunteers: 10 for the STG, 11 for the ARG, and 12 for the CG. The volunteers then had their assessments scheduled to be conducted at LAPH/UPE, between 10 a.m. and 12 p.m. They were instructed not to engage in physical exercise for at least 24 hours before the assessment and to attend the location wearing a swimsuit or top to facilitate the procedure.

The assessment was divided into three stages: in the first stage, the volunteers answered a questionnaire to characterize their personal conditions; in the second stage, they underwent postural evaluation using the Portland State University (PSU) method[10-12]; and in the third stage, body composition assessment (including body mass, lean mass, and body fat percentage) was performed using an

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electronic scale and dual-energy X-ray absorptiometry (DXA)[11,12].

The CG consisted of elderly women who did not engage in regular physical exercise, according to the inclusion criteria mentioned. The volunteers in the CG also had their assessments scheduled and followed the same procedures as the STG and ARG.

Training program

The training groups (STG and ARG) trained twice a week, on alternate days (STG: Tuesdays and Thursdays; ARG: Wednesdays and Fridays), with similar sessions. All classes lasted 60 minutes and used a full-body strategy.

Collection instrument

The questionnaire answered by the participants consisted of semi-structured questions developed by the researchers, aimed at characterizing the study sample. It addressed information on personal and health conditions, providing a comprehensive view of the participants' profile. Additionally, height and body weight measurements were taken using a digital scale from the brand Sanny (model Personal S-1002), equipped with an attached stadiometer, ensuring accuracy in the anthropometric measurements.

The next step was the postural assessment using the PSU method, which is used to evaluate posture in different populations. The protocol allows for the quantification and evaluation of the Postural Correction Index (PCI) through subjective observation and the use of mathematical equations (detailed below) to generate a score. For the assessment, the body should be observed as naked as possible, in the orthostatic position, with posterior and left lateral views, optionally using a plumb line or a simetrografo as a body reference. The individual being assessed should be comfortable, with the feet slightly apart (approximately shoulder-width), and the arms positioned comfortably at the sides of the body. Fifteen body segments are observed: head and neck region (HNR; 5 regions); dorsal and lumbar spine region (DLS; 3 regions); abdomen and hip region (AHR; 3 regions); and lower limbs region (LLR; 4 regions). Each segment is evaluated and scored as follows: 'accentuated deviation' receives 1 point, 'slight deviation' receives 3 points, and 'no deviation' receives 5 points. These scores are then used in the mathematical equations to calculate the PCI result[13].

To determine the PCI, the results obtained from the diagnostic score of the evaluation are calculated. The values are generated according to the following guidelines: the sum of the 15 body segments (7 posterior and 8 lateral) is calculated, then the result is divided by 75 (the maximum sum of points established by the method) and multiplied by 100, resulting in a percentage score. The sum of the regions is composed as follows: (HNR - body division coding: 1.1 + 1.2 + 2.1 + 2.2 + 2.3/25) x 100; (DLS - body division coding : 1.3 + 2.4 + 2.5/15) x 100; (AHR - body division coding: 1.4 + 2.6 + 2.7/15) x 100; and (LLR - body division coding: 1.5 + 1.6 + 1.7 + 2.8/20) x 100. Thus, the PCI is determined by the formula: PCI = (HNR + DLS + AHR + LLR) x 100 / (25 + 15 + 15 + 20)[13]. Based on the value obtained, the classification of the body posture is made so that good or acceptable postures have percentage results above 65% (for adults) and 85% (for children)[10-12]. For the analysis of the photographs, the segmented division proposed by the PSU method is used, considering the segments in the dorsal position, according to the following body coding: 1.1 (head), 1.2 (shoulders), 1.3 (spine), 1.4 (hips), 1.5 (knees), 1.6 (feet), 1.7 (arch of the foot) and in the lateral position: 2.1 (neck), 2.2 (thorax), 2.3 (shoulders), 2.4 (thoracic spine), 2.5 (torso), 2.6 (abdomen), 2.7 (lumbar spine) and 2.8 (knees)[13].

For this study, the participants were instructed to wear a swimsuit or top to allow for a clear analysis. The assessment was conducted through photographic records, captured from the posterior and lateral views. The participant was positioned in front of a white background wall, initially assessed from the posterior view, with the legs abducted over a 30 cm marking on the floor and arms extended at the sides of the body. For image capture, an iPhone camera with dual lenses was used: a 12 MP wide-angle lens with an f/1.6 aperture and a 12 MP ultra-wide lens with an f/2.4 aperture. The photo was set to a 4:3 resolution (4032 x 3024 pixels), with a density of 300 PPI (pixels per inch), which translates to a width of 34.2 cm and a height of 25.6 cm. The camera was positioned on a tripod, horizontally 2 meters from the participant's midline and 85 cm above the floor.

The quantification of the body segment deviations was performed through the analysis of the photographs, which were directed to a virtual goniometer in a Microsoft Excel spreadsheet (version 365). This spreadsheet was programmed with a rectangular grid containing 9 sagittal lines and 18 transverse lines, sized at 34.2 cm in width and 25.6 cm in height, fitting the photo, resulting in 180 quadrants of 100 pixels each. After exporting the photo to the spreadsheet, the lines helped visualize the body alignment. To ensure correct photo alignment, the participant was positioned next to a calibrated plumb line, aligned with the sagittal line 3 of the virtual goniometer, ensuring alignment accuracy.

The PCI was calculated using the symmetrometer spreadsheet. In specific and labeled cells, the researchers quantified each body segment, and the calculation was performed automatically based on the PCI formula described earlier. For each participant, an individual spreadsheet was created. The PCI results were then exported to an additional spreadsheet, which consolidated all the study variables.

Finally, the body composition of the torso was assessed using DXA (Hologic® brand, Discovery CI/WI model). Lean mass and body fat percentage were measured. The total body scan method was used, where the participant was positioned in a supine position, centered on the scanner table, with the central line as a reference. She kept her

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hands open, with the palms resting on the exam table, and her arms and legs extended along her body for an average time of 6 minutes. The participant was instructed to remove all metallic objects, both in clothing and on the body, before the exam[14-16].

To ensure greater reliability of the assessments, all evaluations were conducted by two examiners who had been previously trained for their respective analyses—one responsible for the PSU assessment and the other for the DXA. For the PSU evaluation, the examiner was in charge of positioning the participant, capturing the photographic image, and subsequently performing the analysis. Similarly, for the DXA assessment, the examiner positioned the participant, conducted the scan, and analyzed the results.

Data analysis and processing

The statistical analysis was performed using Jeffrey's Amazing Statistics Program (JASP) 0.19.1. For sample characterization, a descriptive analysis was conducted, presenting the mean and standard deviation of age, height, body mass, body mass index (BMI), and duration of participation in the training program. The Shapiro-Wilk test indicated that the data followed a normal distribution. To identify differences in PCI, body mass, lean mass, and fat percentage, an analysis of variance (ANOVA) was performed, followed by a Post Hoc test. To compare the PCI reference values[13] with the values obtained in each group, a one-sample t-test was used, adopting a significance level of $p < 0.05$ in both analyses. Additionally, to evaluate the correlation between PCI and body composition variables, as well as the duration of participation in the training program, Pearson's correlation test was applied, using the same significance level of $p < 0.05$. Pearson's test quantifies the strength and direction of the linear relationship between two variables, with results interpreted based on values ranging from -1 to 1, where values close to 1 indicate a strong positive correlation, values close to -1 indicate a strong negative correlation, and values close to 0 indicate no correlation.

A post-hoc sample size calculation was performed based on the results of the PCI, considering the observed mean difference between the STG and CG (Δ = 13.4%; σ = 8.1), resulting in a Cohen's effect size (d) of 1.66. Using a significance level of 5% (α = 0.05) and the actual group sizes of 10 (STG) and 12 (CG), the estimated statistical power ($1 - \beta$) was approximately 98%. These results indicate that the sample used was sufficient to detect significant differences in the primary outcome between groups. The effect size and power analysis followed the criteria established by Cohen[17].

RESULTS

Thirty-three volunteers participated in the study, with a mean age of 70.2 ± 8.1 years, divided into three groups: 10 in the STG, 12 in the ARG, and 11 in the CG. The STG participants had been practicing training for an average of 8.5 ± 2.4 months, while those in the ARG had an average training duration of 11.1 ± 2.1 months. The complete characterization of the sample is described in *Table 1*.

When comparing body composition, no significant differences were observed between the groups ($p > 0.05$). *(Table 2)*.

When examining the PCI, the highest values were observed in the ARG (70.9 ± 8.1%), followed by the HG (63.9 ± 4.8%)

	Total (n = 33) Mean ± SD	STG (n = 10) Mean ± SD	ARG (n = 12) Mean ± SD	CG (n = 11) Mean ± SD
Age (years)	70.2 ± 8.1	71.8 ± 9.0	71.8 ± 8.2	67.0 ± 6.7
Height (cm)	154.0 ± 7.0	155.0 ± 4.5	154.0 ± 8.9	153.0 ± 7.2
Body mass (kg)	67.5 ± 11.5	63.5 ± 11.6	72.1 ± 12.9	66.4 ± 8.9
BMI (kg/cm^2)	28.6 ± 4.7	26.6 ± 4.39	30.6 ± 5.2	28.4 ± 4.1
Training (months)	6.6 ± 5.2	8.5 ± 2.4	11.1 ± 2.1	-

Table 1. *Sample characterization (n = 33).*

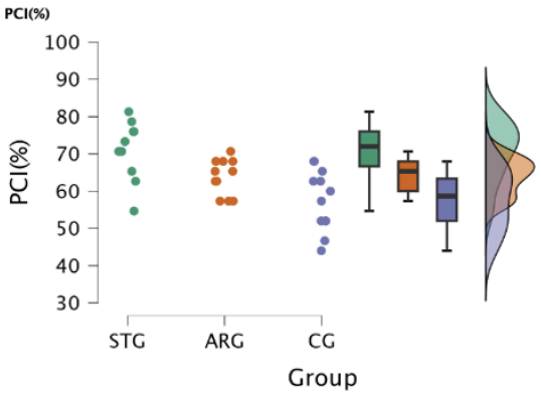
Abbreviations: STG, strength training group; ARG, aquatic resistance group; CG, control group; BMI, body mass index.

	STG (n = 10) Mean ± SD	ARG (n = 12) Mean ± SD	CG (n = 11) Mean ± SD	*p vaule*
Body mass (kg)	63.5 ± 11.6	72.1 ± 12.9	66.4 ± 8.9	0.217
Lean mass (kg)	33.1 ± 44.9	34.6 ± 45.5	34.8 ± 54.5	0.638
Fat mass (%)	40.7 ± 7.1	41.5 ± 3.6	45.4 ± 3.7	0.070

Table 1. *Comparison of body mass, lean mass and fat percentage between the strength training group, aquatic resistance group and the control group.*

Abbreviations: STG, strength training group; ARG, aquatic resistance group; CG, control group.

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STG – ARG: p = 0.080 (CI: - 0.6 – 14.8); STG – CG: p = 0.001 (CI: 5.8 – 20.9); ARG – CG: p = 0.106 (CI: - 1.1 – 13.7)

Figure 1. *Comparison of the Postural Correction Index between the strength training group, aquatic resistance group and the control group.*
Abbreviations: PCI, postural correction index; STG, strength training group; ARG, aquatic resistance group; GC, control group.

and the CG (57.5 ± 8.1%). The ARG showed a higher PCI compared to both the HG and the CG, with a significant difference only in relation to the CG (Δ = 18.9%; p = 0.001) *(Fig. 1)*. When comparing the reference values of the PCI with the values obtained for each group, a significant positive difference was observed in the ARG (9.1%; p = 0.046) and a significant negative difference in the CG (11.5%; p = 0.009) *(Table 3)*. When correlating the PCI with the body composition variables, a positive correlation (directly proportional) with lean mass was identified (r = 0.544; p = 0.001). Regarding total body mass, fat, and duration of participation in the project, no significant correlations were found (p >0.05) *(Table 4)*.

DISCUSSION

The results indicated, according to the PCI, that the STG showed better postural conditions compared to the CG, with a significant difference of 18.9% (p = 0.001). However, no significant differences were observed between the STG and the ARG, nor between the ARG and the CG.

Postural changes associated with aging are a natural process resulting from physiological adaptations, and this age group tends to experience progressive changes in posture due to factors such as hormonal changes, sarcopenia, osteoporosis, frailty, and reduced physical activity levels[1,2]. Women seem to be more affected, as hormonal changes, such as the decrease or cessation of estrogen production, result in muscle weakness and reduced joint range of motion, negatively impacting movement execution and strength levels[3]. In men, postural changes related to aging are associated with a decline in testosterone production, leading to the loss of lean mass, reduced contraction velocity, and maximum strength[4].

A large portion of the elderly population presents sarcopenia and osteoporosis, conditions that lead to chronic frailty and directly affect muscle function, capacity, and strength. This context highlights the importance of maintaining strength to control postural changes in this population[6]. As a consequence of these postural changes, muscle imbalances occur, significantly increasing the risk of falls, mainly due to problems that affect stability and postural balance[7]. The combination of aging with postural and muscular changes shows that older adults tend to lack stability in the antero-posterior and latero-lateral planes, impacting their ability to maintain balance[7].

Another relevant aspect is the change in body composition, characterized by increased fat and decreased lean mass in body segments. These changes impair neuromuscular responses and spatial perception, affecting muscular structures and thereby increasing the risk of falls[7]. Therefore, attention to muscle and postural imbalances, especially concerning strength levels, is crucial for healthy aging, as they are key factors in preventing sarcopenia, osteoporosis, and falls. Postural misalignment can also lead to the emergence of functional and structural pathologies[8].

As an important resource for improving postural condition, muscle strengthening through exercise is essential for the elderly population. As discussed earlier, one of the main causes of postural changes in this group is sarcopenia, which leads to the loss of function and lean mass. Thus, strength training is crucial for increasing or maintaining strength levels and lean mass, which is essential for preserving independence and quality of life. This type of training also helps control chronic conditions and frailty, which are directly related to postural stability in the elderly[9]. Furthermore, considering that postural changes are associated with body composition and functional

Group	PCI reference value	Δ % (p value)
Strength training	65%	↑ 9.1 (0.046)
Aquatic resistance	65%	↓ 1.7 (0.459)
Control	65%	↓ 11.5 (0.009)

Table 3. *Difference between the reference values for the Postural Correction Index and the values found in each group.*
Abbreviations: PCI, postural correction index; ↑, above the reference value; ↓, below the reference value.

Variables (n = 33)	PCI *r (p)*
Body mass (kg)	0.207 (0.256)
Lean mass (kg)	0.544; (0.001) *
Fat mass (%)	- 0.049 (0.786)
Training (months)	- 0.162 (0.367)

Table 4. *Correlation between the postural correction index and the variables of body mass, lean mass, fat percentage and training time.*
*Abbreviation: PCI, postural correction index; * p <0.05.*

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capacity, water exercises, such as aquatic resistance, also prove to be effective for maintaining or improving muscle and postural balance in the elderly. Aquatic resistance contributes to increased functional fitness, with benefits for strength, cardiorespiratory capacity, and cognitive function, which is also related to postural balance and strength levels[9].

In this study, in addition to the STG presenting a higher PCI than the CG, we observed that only this group (70.9 ± 8.1%) achieved a PCI greater than 65%[10-13], which represented a significantly above-average result of 9.1% (p = 0.046), surpassing both the ARG, which did not show a significant difference from the average values (p = 0.459), and, most notably, the control group, which was 11.5% below the average values (p = 0.009). Furthermore, reinforcing muscle strengthening as one of the main factors for postural improvement, this study identified a moderate and positive correlation between lean mass and PCI (r = 0.544; p = 0.001), suggesting that lean mass is directly proportional to PCI, i.e., the higher the lean mass, the higher the PCI.

These findings suggest that strength training may be more effective than aquatic resistance in improving posture in older women, which has important implications for exercise prescription in public health programs aimed at preventing falls and functional decline. The superiority of the STG over the CG highlights the potential of muscle strengthening as a priority intervention in this population.

The statistically significant association between PCI and lean mass further supports the interpretation that interventions targeting lean mass development may directly improve postural control. This is especially relevant for clinicians and exercise professionals as it validates the use of PCI as a sensitive indicator of posture improvements derived from resistance training.

In this context, the study by Katzman et al.[18] highlighted the relevance of strength training in postural improvement in older adults. Exercises to strengthen the spine, with an emphasis on the extensors, were performed along with accessory postural correction exercises in a group of 99 older adults. Over six months, these participants trained three times a week. At the end of the intervention, they were compared to a control group, and the results showed an improvement of 3° in the Cobb angle of the kyphosis. Thus, it was demonstrated that a strengthening program combined with postural adjustment is beneficial for correcting excessive spinal curvature in thoracic kyphosis.

According to Benedetti[19], who assessed postural improvement in 34 older adults (28 women and 6 men) using protocols that combined strength training with flexibility exercises for the hip muscles, a significant reduction in the flexed posture of the participants was observed. In addition, there was a considerable increase in the strength of the spinal extensors (the main focus of the study) and abdominal muscles. These results support the idea that muscle strengthening is effective for improving and controlling posture in this population. The study involved a protocol that lasted 3 months, with training twice a week for 1 hour per session.

In a systematic review with meta-analysis, Gonzalez-Gálvez, Gea-Garcia, and Marcos Pardo[20] indicated that strength training, when combined with other types of exercises focused on strengthening, especially the dorsal (antigravitational) muscles, can be a key ally in reducing postural changes caused by aging. According to the authors, the inclusion of strength training in exercise programs is beneficial for improving excessive spinal curvatures, particularly thoracic hyperkyphosis. Using methods such as the flexicurve and Cobb angle analysis (measured by radiographs), significant improvements were observed in the degree of hyperkyphosis in individuals who underwent the exercise, with an average duration of 12.5 ± 8.5 weeks and an average frequency of 3 ± 1.2 sessions per week. The review included 10 studies, 7 of which measured the angle of thoracic kyphosis, and 6 of these studies showed significant improvement in the curvature. Thus, the authors suggest that strengthening exercises are more effective in postural correction or improvement compared to other methods.

In a systematic review, Warneke, Lohmann, and Wilke[21] investigated the effects of strengthening and/or stretching exercises on the postural degrees of older adults through the analysis of randomized clinical trials. It was observed that most of the studies assessed posture using the Cobb angle, lordosis angle, anterior head tilt angle, neck flexion, hip extension, and three-dimensional motion capture methods (based on markers), in addition to radiography, photographs, and flexicurve rulers. These studies demonstrated significant results in the chronic improvement of posture with muscle strengthening exercises. However, no significant changes were observed in the pelvis and lumbar region. On the other hand, a significant influence was found on the posture of the thoracic and cervical spine.

Based on the literature[20,21] and the results found, this study suggests that strength training, particularly focused on the dorsal musculature and spinal extensors, is effective in improving posture in older adults, with a positive impact on postural condition. The STG showed a significant improvement compared to the CG, which reinforces the importance of muscle strengthening to counteract the postural changes resulting from aging.

One of the strengths of this study lies in the use of a standardized PSU combined with precise body composition analysis via DXA, enhancing the accuracy of the relationship between morphological and postural changes. In addition, the post-hoc power analysis (98%) confirms the statistical robustness of the main comparison between STG and CG, strengthening confidence in the findings.

However, this study has some limitations that deserve consideration. Firstly, the sample was limited to a specific number of individuals, which may restrict the generalization of the results to the entire elderly population. Additionally,

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the intervention was not controlled and was limited to what was carried out in the programs in which the participants were enrolled. Although the protocols adopted align with previous studies, they may not reflect the needs of all older adults, especially those with comorbidities that may interfere with protocol adherence. The lack of control over factors such as diet, medication use, and the presence of other health conditions could also influence the results obtained.

Another important limitation is that the control group had a noticeably younger mean age—approximately five years younger than the intervention groups. This age discrepancy introduces a potential confounding factor in studies involving elderly populations, particularly in outcomes related to posture and muscle function. Moreover, the duration of participation in the training programs also differed between the groups by nearly three months, which may have influenced the results and should be considered either as a limitation or a covariate in future analyses.

Concerns related to the study design must also be noted. The use of a cross-sectional approach to compare the effects of two exercise interventions is fundamentally inadequate for assessing causality or true training effects. A longitudinal, randomized controlled trial would be the appropriate design to address this research question. Without baseline measurements and pre-post intervention comparisons within subjects, the current results cannot support causal inferences.

Furthermore, no baseline controls or intra-subject pre- and post-intervention comparisons were conducted. This significantly limits the interpretability of the data, as any observed differences might be due to pre-existing variability rather than the interventions themselves.

Lastly, issues related to sampling and group comparability must also be highlighted. The groups differed not only in age and training duration but possibly in other unmeasured baseline characteristics, which could have influenced the outcomes. Future studies should aim to better match comparison groups or include baseline covariates in the analysis.

Nevertheless, it is important to highlight that, although the topic is highly relevant to the elderly population, more studies are needed to strengthen the existing evidence. Therefore, the findings should be interpreted with caution, but they provide a foundation for future randomized clinical trials with larger and more diverse samples and stricter control of confounding variables. Replicating these results in other contexts may strengthen the evidence for the efficacy of strength training in postural correction among older adults.

CONCLUSIONS

This study suggests that strength training provides significant benefits for the posture of elderly women, with the STG showing better postural indices than the CG and higher than the ARG. Although both exercise practices are advantageous, strength training proved to be more effective in improving posture, likely due to the more intense muscular strengthening. These findings emphasize the importance of muscle strengthening programs to promote postural health and reduce the risk of falls and other complications common in the elderly population.

For future research, a more diverse sample and greater control of additional variables that may influence the results are recommended. Furthermore, it would be interesting to investigate the combined effects of strength, flexibility, and aerobic conditioning to identify more comprehensive intervention approaches for the elderly population.

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