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Original article

Trunk strength according to age and level of physical activity: are active elderly women as strong as inactive young women?

Força do tronco de acordo com a idade e o nível de atividade física: as mulheres ativas mais velhas são tão fortes quanto as jovens inativas?

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ABSTRACT

Objectives: To evaluate trunk extensors and flexors muscle strength according to age and physical activity level, in addition to comparing inactive young women with active older women on maximal trunk strength. **Methods:** Twenty-eight young and thirty older women physically inactive participated in the research. They became active later, with the inclusion of physical activity in their routines. Participants were evaluated for maximal isometric strength of trunk extensors and flexors muscles using a strength sensor connected to a stable wooden seat that isolated the trunk muscles. Dependent and independent t-tests were used for analysis regarding age and level of physical activity. The significance level adopted was ≤ 5%. **Results:** Regarding the strength of the trunk extensors and flexors, physically active young and older women had a higher level of strength when compared to inactive conditions. Regarding the comparison between inactive young and active older women, the active older women presented similar levels of extensor muscle strength when compared to the inactive young women. **Conclusion:** The strength of trunk flexors and extensors was influenced by age and physical activity level. Physically active older women have the same level of trunk extensor muscle strength as inactive young women.

Keywords: aging; muscle contraction; young adult.

RESUMO

Objetivos: Verificar o comportamento da força muscular de extensores e flexores do tronco conforme a idade e o nível de atividade física, além de comparar jovens inativas vs. idosas ativas sobre a força muscular. **Métodos:** Participaram da pesquisa 28 jovens e 30 idosas inativas fisicamente, as quais posteriormente se tornaram ativas, com a inclusão de atividade física em suas rotinas. As participantes foram avaliadas quanto à força isométrica máxima dos músculos extensores e flexores do tronco, por meio da utilização de uma célula de carga conectada a um assento estável de madeira, que isolou musculatura do quadril de maneira a ativar a musculatura do tronco. Testes t para amostras dependentes e independentes foram utilizados para a análise em relação a idade e o nível de atividade física. O nível de significância adotado foi ≤ 5%. **Resultados:** Quanto à força dos extensores e flexores do tronco, mulheres jovens e idosas ativas fisicamente possuíam um maior nível de força quando comparadas à condição inativa. Com relação a comparação entre jovens inativas e idosas ativas, foi verificado que as idosas apresentaram níveis semelhantes de força dos músculos extensores quando comparadas com as jovens. **Conclusão:** A força de flexores e extensores do tronco é influenciada pelos fatores idade e nível de atividade física. Idosas ativas fisicamente possuem o mesmo nível de força dos músculos extensores do tronco que mulheres jovens inativas.

Palavras-chave: envelhecimento; contração muscular; adulto jovem.

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Introduction

Aging is a global phenomenon and a natural process intrinsic to the human being, linked to biological and functional deteriorations in several systems that affect the quality of life due to the reduced ability to perform everyday tasks [1]. The decrease in these individuals' functional capacity occurs partly due to the reduction of strength levels over the years and causing an increase in the risk of suffering falls by 35% after age 65 [2], thus increasing the mortality rate [3]. Compared to men, women are more affected by this process due to hormonal changes linked to menopause [4].

Among the different strategies used to mitigate the consequences of senescence, increasing the level of physical activity has become the main non-pharmacological alternative capable of promoting positive adaptations to the organism of the elderly in a systemic way [5]. Studies show a decrease of up to 40% in the cross-sectional area of various muscle groups of the lower and upper limbs over the years. This decrease also implies a reduction in the ability to produce muscle strength [6,7]. However, in the literature, little research has observed the trunk muscles' changes over the years, even though they are essential for performing everyday tasks [8].

The trunk muscles are part of the core. The core is a neuromuscular and osteoarticular complex responsible for stabilizing the trunk and maintaining postural control. Also, it has the function of transferring forces to the body members during the execution of motor tasks developed by the human being [9]. Thus, the core must remain strong and perform its functions efficiently during aging, knowing that the decrease in these muscles' strength can increase low back pain [10,11] and increase the spine's mechanical stress [12]. As for the trunk muscles' morphology, reductions of 26 to 48% in thickness were observed in older individuals compared to younger people [13].

Therefore, maintaining strength levels in the trunk muscles becomes essential for maintaining older individuals' quality of life. However, it is unknown how age and the level of physical activity can influence the ability to produce strength during trunk movements since physical activity can generate neuromuscular adaptations in middle-aged and older adults. Besides, both populations can increase muscle strength with approximate measurements [14]. This result leads us to believe that these adaptations can also happen with the core muscles, which can include the trunk's extensor and flexor muscles.

Thus, our objective was to verify the muscular strength of trunk extensors and flexors according to age and physical activity level in young and older women who were inactive and became physically active. Another objective was to determine whether active older women have the same capacity as inactive young people to produce strength in the trunk's extensor and flexor muscles. We hypothesize that the maximum isometric strength will increase with the increase in the level of physical activity in both muscle groups in both young and older women. Besides, physically active older women may have the same capacity to produce strength as young women in trunk muscle groups.

Methods

Experimental design

This study is a prospective observational study, according to Thomas, Nelson, and Silverman [15], in which, at the first moment, questions were asked about the level of physical activity, using the IPAQ International Physical Activity Questionnaire - short version [16] to young and older women who were interested in participating in university extension programs that the study authors did not control. After answering the IPAQ, the participants were classified as inactive and became part of the research. After the initial selection, the maximum isometric strength of the trunk flexors and extensors of the volunteers was assessed in the second moment. Subsequently, the strength test was carried out, and the volunteers were advised to increase the level of physical activity according to the recommendations of the World Health Organization [17], that is, during the week, practice 150 minutes of moderate-intensity physical activity or 75 minutes high intensity, for 12 months.

During this period, the volunteers entered the extension programs that were different for each audience (young and old), and they were helped to have a more active lifestyle through the physical activities developed and guided by the projects, without the interference of the researchers of the present study. The university extension projects lasted for four months in the first semester (February 2018 to May 2018) and another four months in the second semester (August 2018 to November 2018). Each group participated twice in the projects during the year, in which volunteers performed their physical activities outside the institutions. Despite not controlling the extension programs and physical activities, weekly contacts were maintained through calls with the study participants to determine if they were maintaining their physical activity levels. Volunteers who did not remain active were excluded as we did not intend to treat, that is, follow the participants who were not meeting the recommendations for active physical behavior during the research period.

After 12 months, the participants who followed the instructions and continued to practice physical activity for the entire period of the survey returned and answered a new assessment of the classification of physical activity level through the IPAQ questionnaire - short version. Based on the considerations of the responses obtained by the questionnaire, the volunteers who were classified as active were also reassessed for maximum isometric strength of trunk flexors and extensors.

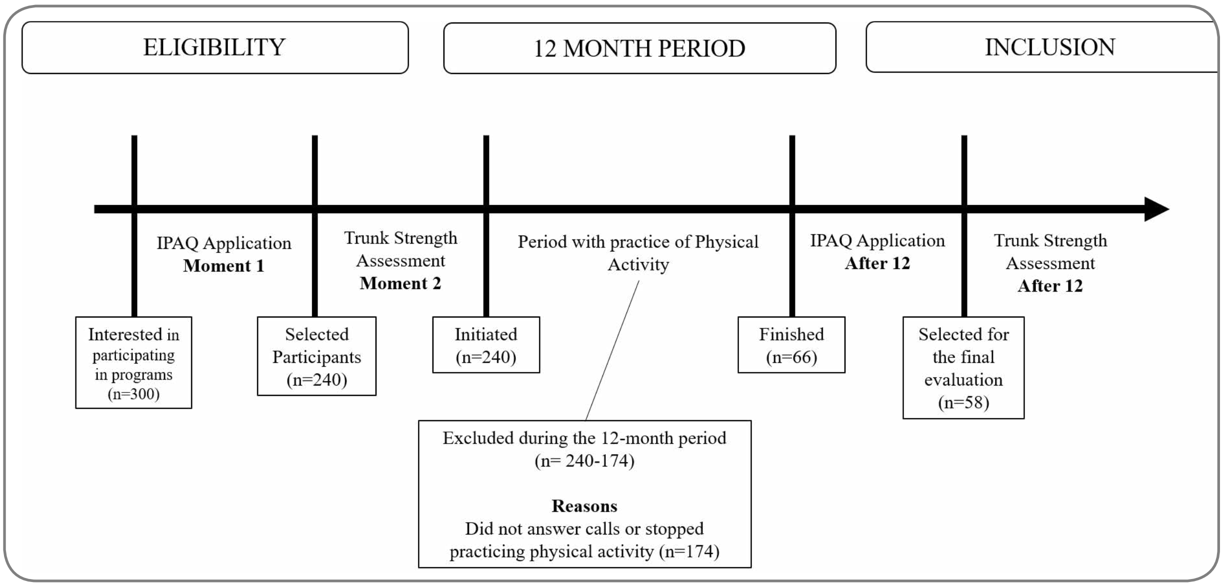


Figure 1 - Experimental approach to the study

Sample and criteria for participation in the study

The sample consisted of 58 physically inactive participants (28 young and 30 elderly), according to the IPAQ - short version [16], and these were divided into two groups: young people (24.7 ± 5.5 years; BMI = 23, 9 ± 3.3 kg/m^2) and elderly (65.6 ± 3.2 years; BMI = 28.3 ± 6.1 kg/m^2). All participants read and signed a free and informed consent form after being informed verbally and writing the study's objectives and procedures, previously prepared following the Declaration of Helsinki and approved by the Ethics Committee (060568/2017) and local research.

The inclusion criteria for the group of young and older women were: 1) being between 18 and 40 years old for young people and equal to or above 60 years old for older women; 2) being a woman; 3) be considered insufficiently active, according to IPAQ - short version; 4) not performing any systematic physical activity in the past three months; 5) not having low back pain in the last six months. The exclusion criterion adopted was: 1) not to maintain weekly contact with the evaluators to inform about the practice of physical activity; 2) not be classified as active by the IPAQ - short version after 12 months; 2) not completing the final assessment.

Data collection procedure

An anamnesis in which personal questions were asked and related to health history in the interview format was carried out with each volunteer. Body mass (kg) and height (cm) were measured using an anthropometric scale (Líder®, P150C, São Paulo, Brazil) with a maximum capacity of 150 kg and a stadiometer (Sanny, ES2030, São Paulo, Brazil), with an accuracy of 0.1 cm, respectively.

A stable wooden seat with adjustable support for the hip and lower limbs was used to assess the isometric strength so that it only isolated the trunk muscles at the time of the test. The muscular strength of the trunk flexors and extensors was measured using a digital load cell (Ktoyo, 333 A, Hown Dong, South Korea), which was connected to the Muscle Lab® data analysis system (Ergotest Innovation , Porsgrunn, Norway) which gave the force value in Newtons (N). To assess the strength of the trunk extensors, the participants were positioned at 0 ° of trunk flexion, since this positioning decreases the activation of the hip flexors [18]. The load cell was fixed to a wall by an adjustable tensioner so that it was parallel to the ground and connected to the individual by means of a velcro strap at the level of the xiphoid process. Thereafter, a maximum isometric contraction in trunk extension was performed. To assess the trunk flexors, the load cell was attached to the wall behind the subject, with the strap below the lower angle of the scapula. Then, a maximum isometric contraction in trunk flexion was performed. It is worth mentioning that the wooden seat used in the test was adjusted to the level of hips and lower limbs according to the individual's height, causing only the trunk muscles to be activated during the test protocol [18,19].

At first, the participants performed a repetition to familiarize themselves in each position of the test. After that, three attempts of maximum contraction lasting five seconds were performed. For the analysis, the highest strength value was used. The attempt was only considered valid if the force happened gradually. The subjects had a rest of 30 seconds between each repetition, and in all attempts, the evaluators made a strong verbal encouragement.

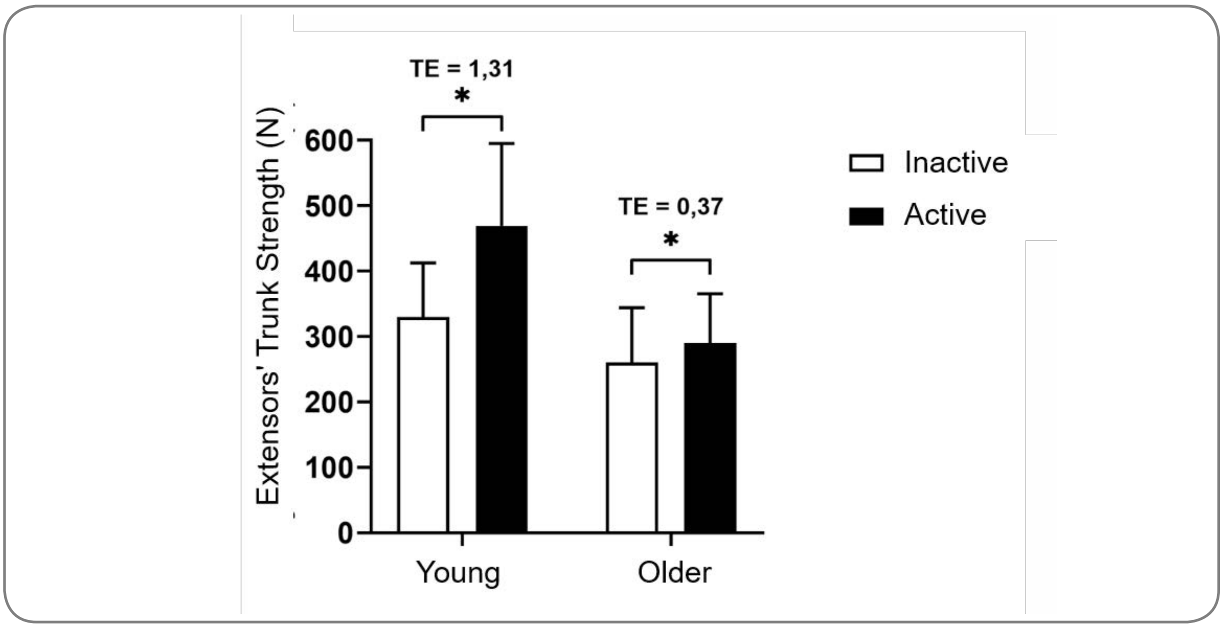
Data analysis

Data were expressed as means and standard deviations. The Kolmogorov-Smirnov test was applied to prove the normality of the data. T-tests for dependent samples were performed to check the trunk strength's behavior, according to the level of physical activity (inactive vs. active young and inactive vs. active elderly). Then, a t-test for independent samples was calculated to compare inactive young women vs. active older women. The size of the Cohen effect (TE) was calculated and the values were classified as follows: trivial effect (< 0.20), small (0.20-0.59), moderate (0.60-1.19), high (1.2-2.0) and very high (> 2.0) [20]. For all analyzes, the statistical significance considered was $p \leq 0.05$. All procedures were performed using SPSS® software version 23.0 (IBM Corporation, Armonk, NY, USA)

Results

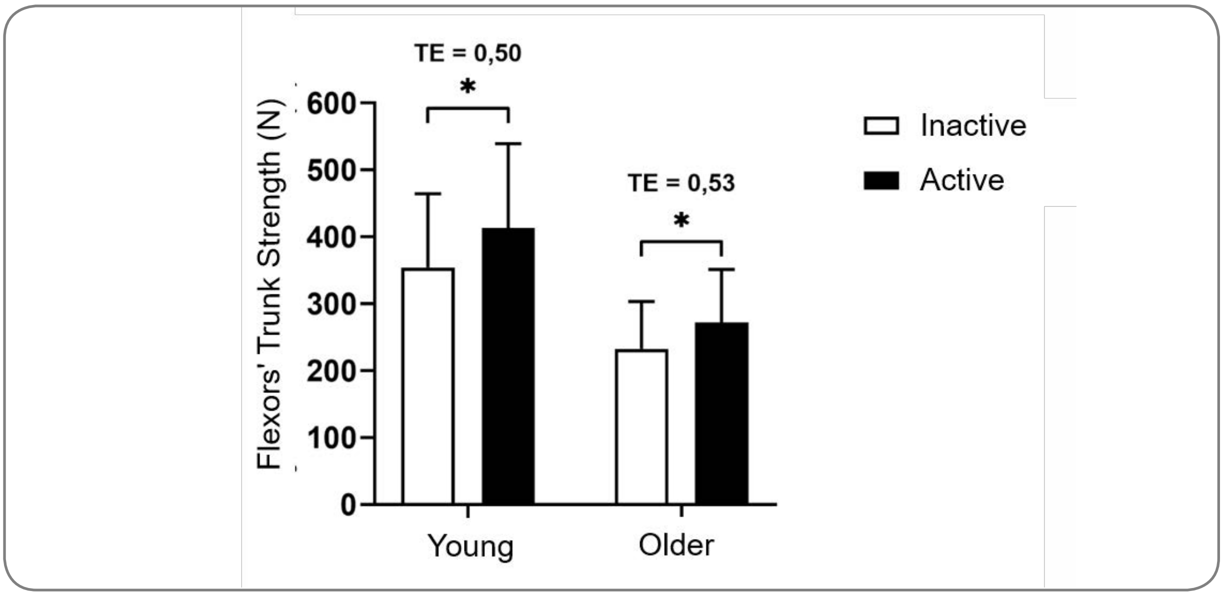
The values of isometric strength of the extensor and flexor muscles of the trunk were presented in Figures 2 and 3, respectively, for young and old in the two categories analyzed (inactive and physically active). After changing the category, both young and old women had higher strength values during extension (inactive young people = 329.7 ± 82.8, active young people = 469.4 ± 125.7; $t(27) = -5.051$; $p < 0.001$; inactive elderly women = 260.6 ± 83.3, active elderly women = 289.8 ± 75.8; $t(29) = -2.237$; $p = 0.033$) and trunk flexion (inactive young women = 353.8 ± 110.6, active young women = 413.5 ± 125.5; $t(27) = -2.660$; $p = 0.013$; inactive elderly women = 232.3 ± 70.7, active elderly women = 271.9 ± 78.9; $t(29) = -3.033$; $p = 0.005$).

The comparison between active elderly and inactive young women was shown in Figure 4. Inactive young women produced greater isometric strength than active elderly women during isometric trunk flexion (inactive young people = 353.8 ± 110.6; active elderly women = 271.9 ± 78.9; t (56) = -3.261; p = 0.002). However, the active older women obtained values similar to the inactive young women during trunk extension. There was no statistical difference between them regarding the strength of the trunk extensors (inactive young people = 329.7 ± 82.8; active elderly women = 271.9 ± 78.9; t (56) = -1.916; p = 0.061).



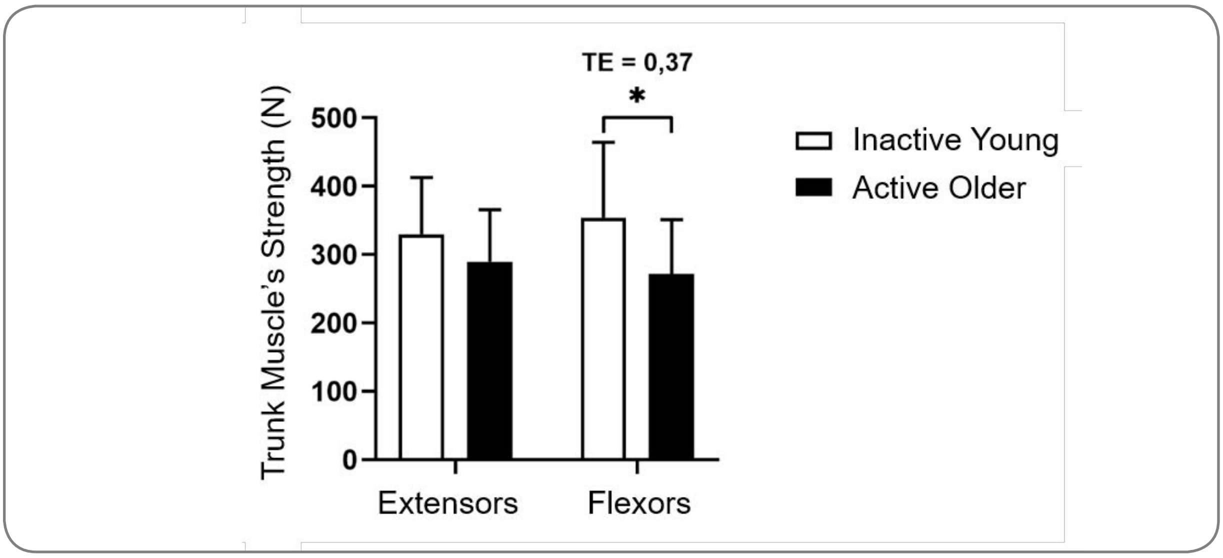
Values expressed as a mean and standard deviation; *Statistical difference about inactive ($p \leq 0.05$); TE = effect size (Cohen's d)

Figure 2 - Comparison of the trunk extensors' muscular strength between inactive and active young people and between inactive and physically active older women



Values expressed as a mean and standard deviation; * Statistical difference about inactive ($p \leq 0.05$); TE = effect size (Cohen's d)

Figure 3 - Comparison of the trunk flexors' strength between inactive and active young people and between inactive and physically active older women



Values expressed as a mean and standard deviation; *Significant difference about active older women ($p \leq 0.05$); TE = effect size (Cohen's d)
Figure 4 - Comparison of the muscular strength of the trunk between inactive young and active older women

Discussion

This study verified the isometric strength of the trunk muscles in women according to age and physical activity level. Its central finding suggests that with the increase in the level of physical activity, older women may have the same levels of strength in the extensor musculature as young women who do not meet the recommendations for the practice of physical activity. There is a consensus in the scientific literature that, with age, muscle strength levels [6,21] decrease and that the practice of physical activity can mitigate such a decline in strength.

Thus, our study brought new findings regarding the behavior of the trunk's muscular strength according to age and level of physical activity. Previous studies have verified these issues when assessing the strength of the human body members [22,23]. However, there is no consensus in the scientific literature on how age and the level of physical activity can influence trunk muscle strength. Since the trunk muscles are part of the core, it is assumed that the decrease in the strength of this musculature can influence the appearance and increase of chronic low back pain [9,24,25].

The maximum trunk strength test used to evaluate the sample has good reliability. This test's reproducibility was analyzed in previous research [19], and high and very high intraclass correlation coefficient and variation coefficient values were found for the trunk extensor and flexor muscles, respectively.

The strength of the trunk extensor muscles of both young and older women increased as they became physically active. The magnitude of differences between means was high (TE = 1.31), while in older women, it was small (TE = 0.37). In the scientific literature, it has been documented that elderly women have the same potential as young women to increase isometric strength after increasing physical activity levels [26,27]. Our findings are not following the above. However, such studies have evaluated the strength of lower limbs. In this way, the trunk muscles may increase the isometric strength different from the muscles of the body's limbs in older women. Also, in the present study, muscle strength was assessed only in an isometric way, and there may be changes in the results when it is assessed dynamically.

The strength of the trunk flexor musculature increased in both young and older women after becoming physically active. However, the magnitude of the differences between the means was small in both groups. The ability to increase isometric strength was similar in young men and women after increasing physical activity levels. This finding agrees with studies in the scientific literature that assessed the isometric strength of the body's limbs [26,27]. There was a difference regarding the increase in isometric strength between the extensor and flexor muscles of the trunk in young women. There was a small capacity to increase the trunk muscles' isometric strength (extensors and flexors) in older women after changing physical activity levels. However, young women had a high potential to increase strength only on the trunk's extensor musculature. This result may have occurred since, with technological advances, human beings started to adopt a kyphotic posture, leading to less activation of the trunk extensor muscles, making this musculature more sensitive to changes arising from the habit of practicing activity physics [28]. Thus, with the practice of physical activity, this musculature becomes more demanded in order to maintain a better posture [29,30]. Thus, when young, the extensor musculature has a high possibility of increasing isometric strength. However, by becoming an older woman, this possibility is diminished [31].

The present study also had as one of its objectives the comparison between young inactive young women vs. active older women, because according to Hakkinen *et al.* [14], physical activity can generate neuromuscular adaptations, making older women able to increase muscle strength with measures similar to those of a young adult. Thus, our results indicated that the trunk's flexor musculature tends to be more affected with aging than the extensor muscles, corroborating the literature [32,33]. However, the magnitude of the difference between the averages was small. A justification for this result is the composition of the fibers of the trunk's extensor and flexor muscles. The flexor musculature is predominantly composed of type II fibers [34], which present a greater decrease in their diameter than type I fibers [35]. In this way, the musculature that presents a more significant amount of type II fibers will have greater muscular atrophy [36,37]. Also, the extensor muscles are activated in our daily lives through gravity's effect to stay upright, causing less strength to be reduced compared to the flexor muscles, since this does not occur with the flexor muscles [33.38].

The present study has some limitations. The study sample was composed only of women, which reduces the interpretation of results for this sex only, knowing that in males, aging and physical inactivity act in a different manner when compared to females [4]. Also, muscle strength was assessed only in an isometric manner, and there may be changes in the results if it had been assessed dynamically and other variables were not assessed, such as trunk stability and resistance [39] necessary for the functional performance of the elderly.

However, it is essential to emphasize that the reduction of isometric strength affects the functional capacity of the elderly during daily activities [21,40]. Thus, our results suggest practical applications, which lead to the direction of strategies designed to improve the strength of the trunk of the elderly, especially the flexor musculature, as there is a more significant reduction in strength in this musculature throughout the age.

Conclusion

We conclude that the isometric strength of the trunk muscles is influenced by age and physical activity level. Becoming physically active increases the strength of the extensor and flexor muscles of the torso of both young and older women. Besides, older women who are physically active have similar levels of isometric strength when compared to young women who are inactive on the extensor musculature of the trunk. Thus, we suggest that the strength of the flexor musculature is the most affected by advancing age.

Conflict of interest
No conflicts of interest with potential potential for this article have been reported..

Financing source
There were no external sources of funding for this study.

Authors' contributions
Conception and design of the research: Fernandes IGS e Da Silva- Grigoletto ME. **Data collection:** Fernandes IGS, Oliveira LA, Santos DAN, Santos MS. **Analysis and interpretation of data:** Fernandes IGS, Santos MS. **Statistical analysis:** Fernandes IGS, Oliveira LA, Santos MS, Da Silva-Grigoletto ME. **Writing of the manuscript:** Fernandes IGS, Oliveira LA, Santos DAN, Santos MS. **Critical review of the manuscript for important intellectual content:** Da Silva- Grigoletto ME.

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