2022, *Retos*, *43*, 215-222
 ISSN: Edición impresa: 1579-1726. EdiciónWeb: 1988-2041 (https://recyt.fecyt.es/index.php/retos/index)

Sarcopenia and Physical Activity Predict Falls in Older Adults from Amazonas, Brazil

La sarcopenia y la actividad física predicen caídas en adultos mayores de Amazonas, Brasil

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Abstract. Introduction: Sarcopenia is a progressive and widespread skeletal muscle disorder involving loss of muscle mass and function, and is associated with several outcomes, including falls, functional decline, frailty, and mortality. Therefore, this study aimed: (1) to estimate the prevalence of sarcopenia, falls, and the risk of falls considering age, sex, and the level of physical activity (PA), and (2) to identify which of these predictors better explained the likelihood that participants present risk of fall. A total of 701 participants (433 women) with a mean age of 70.4±6.9. Sarcopenia was determined according to the most recent guidelines from the European Working Group (EWGSOP2). The prevalence of falls and the level of physical activity were assessed by questionnaires. The risk of falls was assessed using the Fullerton Advance Balance (FAB) scale. This study provides evidence that women (OR: 2.5, p<0.001), the oldest people (OR: 1.1 p<0.001), and people who had identified sarcopenia (OR: 2.9 p<0.001), and lower level of physical activity (OR: 2.9 p<0.001), were more likely to present the risk of falls. Implications for vulnerable aging are discussed.
Keywords: aging, sarcopenia; falls; exercise.

Resumen. Introducción: La sarcopenia es un trastorno del músculo esquelético generalizado y progresivo que implica pérdida de masa y función muscular y se asocia con varios resultados, que incluyen caídas, deterioro funcional, fragilidad y mortalidad. Por lo tanto, este estudio tuvo como objetivo: (1) estimar la prevalencia de sarcopenia, caídas y el riesgo de caídas considerando la edad, el sexo y el nivel de actividad física (AF), y (2) identificar cuál de estos predictores explicaba mejor la probabilidad que los participantes presentan riesgo de caída. Un total de 701 participantes (433 mujeres) con una edad media de 70,4 ± 6,9 años. La sarcopenia se determinó de acuerdo con las guías más recientes del Grupo de trabajo europeo (EWGSOP2). La prevalencia de caídas y el nivel de AF se evaluaron mediante cuestionarios. El riesgo de caídas se evaluó mediante la escala Fullerton Advance Balance (FAB). Este estudio proporciona evidencia de que las mujeres (OR: 2,5, p <0,001), las personas mayores (OR: 1,1 p <0,001) y las personas que habían identificado sarcopenia (OR: 2,9 p <0,001) y un nivel más bajo de AP (OR: 2,9 p <0,001), tenían más probabilidades de presentar riesgo de caídas. Se discuten las implicaciones para el envejecimiento vulnerable.
Palabras Claves: envejecimiento, sarcopenia; caídas; ejercicio.

Introduction

Sarcopenia is defined as the loss of skeletal muscle mass and the strength that occurs with ageing (Rosenberg, 1989). The European Working Group on Sarcopenia in the Elderly (EWGSOP2) defined this term as a progressive and widespread skeletal muscle disorder involving loss of muscle mass and function and is associated with several outcomes, including falls, functional decline, frailty, and mortality (Cruz-Jentoft et al., 2019). Sarcopenia has been considered a public health problem, affecting most older people and making them more vulnerable to falls (Pelegrini et al., 2018).

Falls are a common and most often shattering problem among older people (Zhang et al., 2019), dramatically increasing comorbidities and the use of health services. In Brazil, the prevalence of falls ranges between 10.7 and 59.3% in older people (Leitão et al., 2018), and falls have been associated with the occurrence of fractures and risk of death (Pimentel et al., 2018).

Fecha recepción: 22-03-21. Fecha de aceptación: 02-07-21
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Additionally, another associated problem is also the fear of falling (Santos & Figueiredo, 2019), since it increases the restriction of being involved in basic activities (i.e., carrying out day-to-day activities), the decline in health, and the increased risk of institutionalization (Sousa et al., 2016).

The literature about the relationship between sarcopenia and falls is still controversial. For example, a recent systematic review and meta-analysis showed that sarcopenia was identified as a risk factor for falls among older residents in the community but not in nursing homes (Zhang et al., 2019). Others have been demonstrating a relationship between sarcopenia and risk of falls, with higher levels of sarcopenia being present in people who have a higher number of falls (Landi et al., 2012; Lera et al., 2017; Matsumoto et al., 2017; Menant et al., 2016; Tanimoto et al., 2014). However, there are also some studies that did not find any significant relationship between the levels of sarcopenia and the number of falls in the elderly population (Clynes et al., 2015; Dietzel et al., 2015; Schaap et al., 2018). The inconsistency observed in the literature about the relationship between sarcopenia and falls lead us to believe that this relationship depends on other factors (i.e., age, gender, and level of physical activity/behavior). According to current guidelines, although sarcopenia and falls are a multifactorial process, they claim that the decrease in the level of physical activity is part of the underlying mechanisms of sarcopenia, aggravating the risk of falls (American College of Sports Medicine [ACSM] 2018; Freiberger et al., 2011; Montero-Fernández & Serra Rexach, 2013). Recently, a study carried out in Amazonas reported that older men and women had poor performance in lower body strength and low aerobic endurance compared to other populations (Lima et al., 2021). Clinically, those functional fitness parameters are viable risk indicators for falls and future disabilities (Lenardt et al., 2019; Perera et al., 2016; Sousa et al., 2016). Therefore, a better understanding of these relationships in this particular population (i.e., more vulnerable) will support public health policies that enhance healthy ageing. The contradictory results found in the literature on the association between sarcopenia and the risk of falling and the absence of studies in the state of Amazonas lead us to contribute with more knowledge about the topic. Thus, the main purposes of the present study were to estimate the prevalence of sarcopenia, falls, and the risk of fall considering age, sex, and the level of physical activity, and to identify which of these factors better explained the likelihood that participants present risk of fall.

Methods

Participants

The participants were part of the research project: «Health, Lifestyle and Fitness in Adults and Senior Adults in Amazonas» (SEVAAI). This cross-sectional study included 701 participants, 433 women (aged 69.7±6.7 years old) and 268 men (aged 71.4±7.0 years old). Participants were volunteers with unique geographical and cultural characteristics. They were recruited through advertisements for a major study on health, lifestyles, and functional fitness, published in newspapers, churches, elderly support centers, and elderly groups or associations in Manaus, Fonte Boa and Apuí, state of Amazonas, Northern Brazil. For power samples calculation we used the GPower, (Heinrich-Heine-University, Düsseldorf, Germany; 3.1.9.7 software) (Faul et al., 2007). The calculations were based on the direct logistic regression, z tests family. Considering an odds ratio of 1.5 and á=0.05, a compute achieved power of 0.99 was found for the total sample (n=701), 0.87 for Manaus (n=300), 0.81 for Fonte Boa (n=250), and 0.62 for Apuí (n=151).

The inclusion criteria were (1) living in one of the three regions of Brazil mentioned above; (2) be at least 60 years old; (3) being able to walk independently to visit local institutions where the evaluations were carried out, and (4) having autonomy and independence in carrying out activities of daily living and not reporting serious health problems that were considered absolute contraindications to practice physical activity. The only exclusion criterion was the inability to understand and follow the assessment protocol of the study, assessed by MMSE (MMSE score <15/30 points; (Creavin et al., 2016).

This research followed the ethical principles contained in Resolution 466/12 of the National Health Council of the Ministry of Health and approved by the Human Research Ethics Committee of the University of the State of Amazonas (n. º 1,599,258 – CAAE: 56519616.6. 0000.5016). This research was also presented and approved by the Scientific Committee of the Department of Physical Education and Sports of the Faculty of Social Sciences of the University of Madeira, Portugal. All participants were informed about the study procedures and voluntarily signed an informed consent form.

Procedures

Muscle strength

Muscle strength was measured by handgrip (FPM) using a CONSTANT hand dynamometer, model 14192-709E 5001. The test protocol consisted of two consecutive measurements, an interval of 10 seconds between each attempt (Oja & Tuxworth, 1995). The best result between the two attempts was considered. Participants were asked to perform the movement with their maximum strength while verbal encouragement was offered. The equipment calibration was performed according to the manufacturer's specifications before each test session. The cutoff point was considered in the EWGSOP2 study, being <16kg for women and <27kg for men (Cruz-Jentoft et al., 2019; Dodds et al., 2014).

Muscle mass

Muscle mass was assessed using calf circumference. Measured with a flexible measuring tape, with the elderly in an upright position, with feet 20 cm apart, a horizontal measurement was made at the level of the maximum circumference between the knee and ankle, perpendicular to the long axis (zone of greatest calf circumference) (Lohman et al., 1988). The cut-off point was the value considered by the EWGSOP2 study, being <31 cm from the largest calf circumference zone (Cruz-Jentoft et al., 2019; Landi et al., 2014).

Physical Performance

Physical performance was measured by the 6-minute walk test (Rikli & Jones, 2013). The test involves measuring the maximum travel distance, for 6-minute, along a 50 m course, with markings every 5-minute; The internal perimeter of the measured distance was delimited with the cones; the rounds were recorded with paper records. The procedures were fully explained before the assessment. During the race, individuals were encouraged and motivated. At the signal, «go», the participants started walking as fast as possible (without running) and covered the longest distance possible in 6-minute. The cut-off point considered to assess the loss of physical performance was adapted from the value considered by the EWGSOP2 study, with the non-completion or <400 m of the 6-minute test (Cruz-Jentoft et al., 2019; Newman et al., 2006).

Classification of sarcopenia

The measures for sarcopenia are in accordance with the most recent definition of the European Working Group on Sarcopenia in Older People (EWGSOP2), which defines: 1) probable sarcopenia – loss of muscle strength; 2) confirmed sarcopenia – loss of strength and muscle mass; and 3) severe sarcopenia – loss of strength and muscle mass and low physical performance (Cruz-Jentoft et al., 2019).

Risk of Falls

To assess balance, the results of the short version of the Fullerton Advanced Balance (FAB) scale (Rose et al., 2006) were analyzed. The FAB is an assessment tool used to measure the multiple dimensions of balance in older adults. In this research, the short version of the scale was used, composed of 4 tests: (i) stepping up and over a 15 cm bench (ii) tandem walking (iii) standing on one leg, and (iv) rem standing on foam with eyes closed. Each test item is scored using a 4-point ordinal scale (0–4), resulting in a maximum score of 16 possible points, representing an optimal balance performance. The cut-off score of 9 out of 16 points on the FAB scale produced the highest sensitivity and specificity in predicting the recurrent faller status (Rose, 2010), allowing to conclude that an older adult who scores 9 or lower on the short FAB scale version is considered to be at heightened risk for falling.

Fall Prevalence

The occurrences of falls were assessed by the following questions: In the last year (12 months) how many times did you fall? How many times did you fall in the last month? Taken from the general health questionnaire, a modified version of the health questionnaire was used in the FallProof program (Rose, 2010).

Physical Activity Level

The level of physical activity was measured by the modified Baecke Questionnaire for the elderly (Voorrips et al., 1991). The instrument consists of questions related to domestic physical activity, sports physical activity, and leisure physical activity. The questionnaire also provides a measure of total physical activity, which is the sum of these three specific domains. Previously, intra-class correlation-coefficients were calculated to determine the test–retest reliability of the questionnaire in a pilot study involving 90 participants (61 females) aged 68.2± 6.7 years old. Over an interval of 1 week, correlations ranged between 0.91 (*CI*: .86 - .94), 0.98 (*CI*: .97 - .99), 0.96 (*CI*: .94 - .97) and 0.97 (*CI*: .96 - .98) for the household, sport, leisure-time, and total

score index respectively

Statistics

Based on the criteria of EWGSOP2 (Cruz-Jentoft et al., 2019; Newman et al., 2006), the prevalence of sarcopenia was expressed through percentage. All data were tested for normality and preliminary analyses were performed to ensure no violation of the assumptions. An independent-samples t-test was conducted to compare means in the descriptive characteristics of the sample by sex. In addition, to study the association between sex, age, and PA categories with the prevalence of falls and the increased risk for fall, a Chi-square test for independent measures was used. Finally, using direct logistic regression, a model that contained age, sex, physical activity, and sarcopenia was tested to identify what factors better explained the likelihood that participants would present risk of falls. Odds ratios and 95% confidence intervals were also presented to quantify the change in odds of having sarcopenia when the value of a predictor increases by one unit. All statistical analyses were performed using IBM SPSS, version 26. The significance level was defined as $p<0.05$.

Results

Means, standard deviations, and CI (95%) of descriptive characteristics of the sample by sex are presented in Table 1. An independent-samples t-test was conducted to compare the descriptive characteristics for men and women.

Table 1:
Descriptive characteristics of the sample by sex.

	Men (n=268)			Women (n=433)			*p*
Variables	Mean	SD	CI (95%)	Mean	SD	CI (95%)	
Age (years)	71.4	7.0	70.6-72.3.	69.7	6.7	69.1-70.3	0.001
CACI (cm)	35.2	3.8	34.7-35.6	35.0	4.0	34.6-35.4	0.504
6-min. walk test (m)	439.5	95.9	428.0-451.1	407.6	79.3	400.1-415.1	<0.001
Handgrip (kg)	3.5	7.2	31.6-33.3	22.3	5.1	21.8-22.8	<0.001
FAB (n)	13.0	3.5	12.6-13.4	11.9	3.3	11.5-12.2	<0.001
PA (units)	6.7	3.9	6.2-7.1	7.1	3.4	6.7-7.4	0.145

Abbreviations: CI, confidence interval; CACI, calf skinfold; PA, physical activity; FAB, Fullerton Advanced Balance

The prevalence of non-sarcopenia, sarcopenia probable, sarcopenia confirmed and sarcopenia severe were 86%, 14%, 4.7%, and 3.4%, respectively. The prevalences according to sex, age, and physical activity level are presented in table 2. The oldest people and people with a lower physical activity level had a higher prevalence of sarcopenia (probable, confirmed, and severe).

Table 2:
Prevalence of sarcopenia by sex, age, and physical activity level.

		Sex		Age		PA	
	Total	Women	Men	≤69 yrs	≥70 yrs	High PA	Low PA
Non-Sarcop. (%)	86	89.8	79.9	94.2	76.0	92.4	79.8
Sarcop-Prob (%)	14	10.2	20.1	5.8	23.0	7.6	20.2
Sarcopenia (%)	4.7	4.2	5.6	0.5	9.7	0.9	8.4
Sarcop-severe (%)	3.4	3.7	3.0	0.5	6.9	0.9	5.9

Abbreviatoin: Sarcop, sarcopenia; PA, physical activity

The prevalence of falls was higher in women (34.4%), older people (34.0%), and people with a lower physical activity level (34.5%). Women, the oldest people, and people with low physical activity levels had a significant increase risk of falling in comparison to men, younger people, and people with high physical activity levels (Table 3).

Table 3:
Prevalence of falls and increased risk for fall by sex, age, and physical activity level.

		Sex		Age		PA	
	Total	Women	Men	≤69 yrs	≥70 yrs	High PA	Low PA
Falls‡(%)	32.4	34.4	29.1	31.1	34.0	30.2	34.5
Incres. Risk Falls (%)	18.4	21.5	13.4***	10.0	28.3***	14.5	22.1***

*** Chi-Square p<.05; ‡at least one fall in the last year; PA, physical activity

Predicting Likelihood of Presenting Sarcopenia

Logistic regression was performed to assess the role of age, sex, identified sarcopenia status, and physical activity for the likelihood that participants would present the risk of falls. The full model containing all predictors was statistically significant (x^2 (4) = 136.72, p<.001), indicating that the model was able to distinguish between the risk of falls. The model as a whole explained between 18% (Cox & Snell R square) and 29% (Nagelkerke R square) of the variance in the risk of falls status, and correctly classified 84% of the cases. The quality of the model founded was assessed by chi-square value for the Hosmer-Lemeshow Test (x^2 = 8.52, p=.385). As shown in Table 4, all predictors made a unique statistically significant contribution to the model. The strongest predictor of the risk of falls in this sample was «identified sarcopenia», recording an odds ratio of 2.90. This suggests that being «identified sarcopenia» (with any of the criteria studied) the odds of presenting a risk for falls increased by a factor of 2.9. Similarly, the physical activity level recorded an odds ratio of 2.92. For every point decrease in the level of physical activity the risk of falls increased by a factor of 2.9. Additionally, sex was also identified as a significant predictor of the risk of falls with an odds ratio of 2.47. This suggests that being women the odds of presenting the risk of falls increased by a factor of 2.5. Importantly, age (OR: 1.12, p<.001) was also a significant predictor of risk of falls. This suggests

Table 4:
Logistic regression predicting the likelihood of presenting the risk of falls.

Predictors	B	S.E.	Wald	df	*p*	Odds Ratio	95% C.I. for EXP(B)	
							Lower	Upper
Sex (M=1; W=2)	0.90	0.25	13.39	1.00	<.001	2.47	1.52	4.00
Age (years)	0.11	0.02	45.58	1.00	<.001	1.12	1.08	1.15
Sarcopenia	1.06	0.25	18.63	1.00	<.001	2.90	1.79	4.69
PA (n)	-1.07	0.24	20.78	1.00	<.001	0.34	0.22	0.54
Constant	-8.90	1.29	47.88	1.00	<.001	0.00		

Abbreviations: PA, physical activity; FAB, Fullerton Advanced Balance; M, men; W, women

that for each 1-year increase in age, the odds of presenting sarcopenia increased by a factor of 1.12.

Discussion

This study aimed to estimate the prevalence of sarcopenia, falls, and the risk of falls, and to identify factors that better explained the likelihood that participants present risk of falls. In this analysis, we considered age, sex, and the level of physical activity as the main predictors in the model. The results of the present study showed that the prevalence of people with sarcopenia was 22.1%. Considering the EWGSOP2 guidelines, our results corroborate the findings of Borges (2019) in the population of Ceará, Brazil. In the present study, women had a higher risk of severe sarcopenia, however, men demonstrated a higher rate of probable sarcopenia and confirmed sarcopenia. Previous studies have shown that the prevalence of sarcopenia increases in both genders with age, but a higher increase is more common in older men (e»70 years of age) (Lau et al., 2005; Roubenoff & Hughes, 2000).

Our results are consensual with the literature regarding the increase in the prevalence of sarcopenia with increasing age (Borges, 2019; Cruz-Jentoft et al., 2014; Martone et al., 2020). There seems to be no doubt that regardless of the criteria used in the definition of sarcopenia as well as sex, the prevalence of sarcopenia can vary among older people depending on the environment, but always with higher prevalence rates in older groups (Cruz-Jentoft et al., 2014). Our study also reinforces that people with lower physical activity levels had a higher prevalence of sarcopenia. These results corroborate others found previously, who identified physical activity as a key factor for the control and prevention of sarcopenia in older people (Borges, 2019). Currently, it was found that the level of physical activity was related to the maintenance of functional capacities, preservation of lean body mass, and decreased risk of developing sarcopenia (Manso et al., 2019). Similar results were also presented in a meta-analysis study, where physical activity was identified as a protective factor against sarcopenia (Steffl et al., 2017). In general, these results suggest greater attention to EWGSOP2 recommendations, which aim to facilitate early detection and better treatment of sarcopenia in clinical practice (Cruz-Jentoft et al., 2019), as well as promoting physical activity among older people.

In our study, the prevalence of falls was higher in women, in the oldest people, and people with lower physical activity levels. In addition, as expected, women, the oldest people, and people with low physical activity levels had a significant increase risk of falling. The prevalence of falls in this sample (32%) was lower than other reported in other regions of Brazil (Ceará, 44%; Borges, 2019) and Portugal (36%; Gouveia et al., 2017), but higher than those reported in the Rio Grande do Sul, Brazil (29%) and those reported in a systematic review and meta-analysis including the Central region of Brazil (27%; Elias Filho et al., 2019). The results of the present study partly corroborate the estimates presented by the World Health Organization (WHO), 28-35% of people aged 65 and 32-42% for those over 70 years of age (WHO, 2007).

There is a greater consensus in the literature regarding the fact that the prevalence of falls is higher in women compared to men (Elias Filho et al., 2019; WHO, 2007). However, concerning age, some studies have not reported a significantly higher prevalence of falls in older people (Gouveia et al., 2017). This fact may be associated with a greater fear of falling at an advanced age (Perracini & Ramos, 2002), and a substantial decrease in physical activity with increasing age (Gouveia et al., 2019). About physical activity, there is strong evidence demonstrating that physical activity reduced the risk of fall Gouveia et al. (2019). On the other hand, older people with a lower level of physical activity are more prone to muscle weakness and impaired balance (Gouveia et al., 2019), which puts them at a higher level of risk for falling. Generally, these results support the urgency of implementing programs aimed at preventing falls among older people living in the community of Amazonas, where women, older people, sarcopenic are considered more vulnerable groups.

The second purpose of this study was to identify factors that better explained the likelihood that participants would present a risk of falls. Our study emphasizes that women, the oldest people, and people who had identified sarcopenia and lower physical activity level, were more likely to present a risk of falls. The logistic regression analysis was performed to provide an accurate indication of the relative importance of each predictor as well as the interaction among variables to explain the risk of falls. First, people who have identified sarcopenia, that is, who have at least one of the following factors, low muscle strength, low muscle mass, or low physical performance, were almost 3 times more likely to be at risk of falling. These results corroborate other studies that showed a relationship between sarcopenia

and falls (Lera et al., 2017;Yeung et al., 2019; Zhang et al., 2019). In particular, a study in older people aged 80, found that sarcopenic participants were three times more likely to fall than non-sarcopenic individuals, regardless of age, gender, and other associated factors (Landi et al., 2012). Schaap et al. (2018), when examining the individual components of sarcopenia, found that muscle strength was associated with recurrent falls, regardless of low lean mass and slow gait speed. These results are reinforced by Moreland et al. (2004), who in a meta-analysis identified muscle weakness as a determinant risk factor for falls. Additionally, in the study developed by Gouveia et al. (2019) in older people, where the relationships between balance, muscle mass, and muscle strength were investigated, they found that both muscle mass and muscle strength were positively correlated with balance. Together, our study supports that low muscle strength, low muscle mass, and low physical performance are important conditions that must be considered in the clinical assessment of the risk of falling in older people.

One of the most important results of this study is that a lower level of physical activity increases the risk of falls by about three times when sex, age, and sarcopenia are controlled. This result partially supports the relationships previously found between the identified sarcopenia and the increased risk of falling. That is, people who maintain a higher level of physical activity will be able to maintain strength levels, muscle mass, and physical performance in turn (Manso et al., 2019). Other studies have also reinforced that older age (e»70 years) and low level of physical activity have been identified as risk factors for sarcopenia (Borges, 2019; Figueiredo et al., 2014), and increased risk of falls (Gadelha et al., 2018;Yeung et al., 2019), which corroborates the results achieved in the present study. Therefore, we are facing a multifactorial phenomenon that is self-complementing and that should be considered in a multidimensional approach, where physical activity should assume a central role in the control and prevention of sarcopenia (Steffl et al., 2017) and consequently decrease the risk of falling (Bertoni et al., 2018). Overall, our results strengthen the understanding of relationships between the modifiable behavioral variables under analysis, and support the design of public health policies that help to reduce sarcopenia and the risk of falls, and consequently health care costs in the Amazon region.

Some limitations must be recognized when interpreting the results of the present study. First, the results were obtained from a cross-sectional survey, which prevents the establishment of cause-effect relationships. Second, muscle mass measurements were obtained through anthropometric measurements, due to the lack of more sophisticated methods. However, Landi et al. (2014) demonstrated that calf circumference predicts performance and survival in older people. As such, calf circumference measurements can be used as a diagnostic proxy in older people (Cruz-Jentoft et al., 2019). Regarding the strengths of the present study, it is important to mention that, as far as we know, this is the first study on relationships between the risk of falls, sarcopenia, and physical activity in the state of Amazonas. Additionally, it is the first study in the context of Amazonas to estimate the prevalence of sarcopenia using the diagnostic algorithm proposed by EWGSOP2, and to objectively quantify the role of age, sex, sarcopenia status and physical activity for the likelihood that participants present risk of falls. The current definition of sarcopenia (EWGSOP2) recommends simple and accessible methods to assess muscle strength to early identify people with probable sarcopenia (Cruz-Jentoft et al., 2019). This data is essential to early detection of people at high risk for sarcopenia, and all the consequences arising from this status, such as the increased risk of falls proven in the present study.

Conclusions

To conclude, this study shows that independently of sex and age, physical activity, and sarcopenia status, are key factors for the prevention of risk of falling in older people. However, with regard to policy implications to combat vulnerable aging, longitudinal and experimental studies with well-defined physical activity programs at the community are recommended to better clarify the relationship between sarcopenia, and the risk of falls in older people.

Acknowledgements

The authors would like to thank the field team (Bárbara Patriarca, Floramara Machado, Angeany Odim) for technical assistance in data collection and management. We are especially grateful to the older people for their participation and interest. Andreas Ihle and Matthias Kliegel belong to the Swiss National Center of Competences in Research LIVES – Overcoming vulnerability: life course perspectives, which is financed by the Swiss National Science Foundation (grant No. 51NF40-160590). The authors are grateful to the Swiss

National Science Foundation for its financial assistance. Finally, Élvio Rúbio Gouveia, Bruna Gouveia e Pedro Campos belonging to Interactive Technologies Institute (Portugal), acknowledge support from LARSyS – Portuguese National Funding Agency for Science, Research and Technology (FCT) Pluriannual funding 2020–2023 (Reference: UIDB/50009/2020).

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