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ORIGINAL RESEARCH

Do muscle strength, functioning, and behavioral factors have the same association with the history of falls?

Força muscular, funcionalidade e fatores comportamentais têm a mesma associação com histórico de quedas?

¿La fuerza muscular, la funcionalidad y los factores de comportamiento tienen la misma asociación con el historial de caídas?

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ABSTRACT | This study investigated the association of biological (muscle strength and functioning) and behavioral factors (level of physical activity and fear of falling) with the history of falls in community-dwelling older adults. A cross-sectional study was carried out with 173 older adults. Handgrip strength and functioning were assessed using the timed up and go (TUG) and gait speed tests. Behavioral factors were assessed by physical activity (Minnesota Leisure Time Activities Questionnaire) and fear of falling (Falls Efficacy Scale-International) instruments. The history of falls was assessed by self-reporting of falls that occurred in the last six months. Data were analyzed by the biserial point correlation test (r_b) and by a binomial regression analysis. The biological, handgrip strength (r_b=−0.282, p<0.001), gait speed test (r_b=−0.082, p=0.151) and TUG (r_b=0.167, p=0.018) and behavioral factors, fear of falling (r_b=0.098, p=0.162), physical activity (r_b=−0.149, p=0.039), were included in the regression model. Only biological factors, handgrip strength (p<0.001; OR: 0.891; 95% CI: 0.885 – 0.898) and functioning by TUG (p<0.001; OR: 1.031; 95% CI: 1.018 – 1.043) explained the history of falls. Lower values of muscle strength and worse performance in the TUG were associated with a history of falls.

Keywords | Accidental Falls; Aged; Physical Functional Performance.

RESUMO | O objetivo deste estudo foi investigar a associação de fatores biológicos (força muscular e mobilidade funcional) e comportamentais (nível de atividade física e medo de cair) com o histórico de quedas de idosos de uma comunidade. Foi realizado um estudo transversal com 173 idosos. Foram avaliadas a força de preensão manual e a mobilidade funcional por meio do *timed up and go* (TUG) e teste de velocidade de marcha. Os fatores comportamentais foram avaliados pelo escore de atividade física (*Minnesota Leisure Time Activities Questionnaire*) e medo de cair (*Falls Efficacy Scale-International*). O histórico de quedas foi avaliado

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pelo autorrelato de queda(s) ocorrida(s) nos últimos seis meses. Os dados foram analisados pelo teste de correlação por ponto bisserial (r_b) e por uma análise de regressão binomial. Os fatores biológicos, força de preensão manual (r_b=−0,282, p<0,001), teste velocidade de marcha (r_b=−0,082, p=0,151) e TUG (r_b=0,167, p=0,018), além dos fatores comportamentais, medo de cair (r_b=0,098, p=0,162) e atividade física (r_b=−0,149, p=0,039), foram incluídos no modelo de regressão. Apenas os fatores biológicos de força de preensão palmar (p<0,001; OR: 0,891; IC 95%: 0,885-0,898) e mobilidade funcional pelo TUG (p<0,001; OR: 1,031; IC 95%: 1,018-1,043) explicaram a história de quedas. Menores valores de força muscular e pior desempenho no TUG foram associados ao histórico de quedas.

Descritores | Acidentes por Quedas; Idoso; Desempenho Físico-Funcional.

RESUMEN | Este estudio tuvo el objetivo de investigar la asociación de factores biológicos (fuerza muscular y movilidad funcional) y de comportamiento (nivel de actividad física y miedo a caer) con el historial de caídas de personas mayores de una comunidad. Se realizó un estudio transversal con 173 personas mayores. Se evaluaron la fuerza de agarre manual y la movilidad funcional mediante el *timed up and go* (TUG) y la prueba de velocidad de marcha. Se evaluaron los factores de comportamiento mediante la puntuación de actividad física (*Minnesota Leisure Time Activities Questionnaire*) y el miedo a caer (*Falls Efficacy Scale-International*). Se evaluó el historial de caídas a través del autorrelato de caídas que ocurrieron en los últimos seis meses. Se analizaron los datos mediante la prueba de correlación punto-biserial (r_b) y mediante un análisis de regresión binomial. Los factores biológicos, la fuerza de agarre manual (r_b=−0.282, p<0.001), la prueba de velocidad de marcha (r_b=−0.082, p=0.151) y el TUG (r_b=0.167, p=0.018), además de los factores de comportamiento, el miedo a caer (r_b=0.098, p=0.162) y la actividad física (r_b=−0.149, p=0.039), se incluyeron en el modelo de regresión. Solamente los factores biológicos de fuerza de agarre palmar (p<0.001; OR: 0.891; IC 95%: 0.885-0.898) y movilidad funcional a través del TUG (p<0.001; OR: 1.031; IC 95%: 1.018-1.043) explicaron el historial de caídas. Valores más bajos de fuerza muscular y un peor rendimiento en el TUG se asociaron al historial de caídas.

Palabras clave | Accidentes por Caídas; Persona Mayor; Rendimiento Físico Funcional.

INTRODUCTION

Falls are a major health problem, affecting about 30% of the older population[1-3]. A history of falls is a strong indicator of future falls[1], with physical, social, and psychological consequences[1-2]. This results in higher burden to public health due to hospitalizations and deaths[1-2]. Identifying the risk of falls is a public health priority, including the assessment of individual, environmental, and behavioral factors[1-3]. The World Health Organization (WHO) categorizes risk factors for falls into four domains: biological, socioeconomic, behavioral, and environmental[3]. Muscle strength, functioning, and balance are variables of the biological domain[3]. The behavioral domain includes physical activity level and fear of falling[3]. Recognizing biological and behavioral risk factors is essential for fall prevention, which requires greater attention and investigation[3].

Biological factors encompass physical and functional characteristics of the individual[3-4]. Handgrip strength is used to identify older adults at risk[5]. According to the International Classification of Functioning (ICF), functioning involves tasks related to locomotion. Mobility, examined by timed up and go (TUG), includes several executive functions, which also involve elements of balance in habitual transfers and changes in direction during gait[6]. Habitual gait speed represents a functional marker for several negative health outcomes, such as falls, disability, hospitalization, and mortality[7-8]. Therefore, evaluating these factors enables a better understanding of falls in older adults.

The behavioral aspects reflect the importance of maintaining an adequate practice of physical activity and self-efficacy for falls[9-10]. However, the relation between physical activity and falls needs to be better explored to understand how this variable behaves in relation to the history of falls, being a risk or protective factor[9]. Fear of falling or self-efficacy for falls is characterized as a psychological concern with the possibility of falling, which may be present regardless of the history of falls[10-11]. However, once the individual falls, concerns about falling again increase, and this eventually leads to a vicious cycle of fear, reduced physical activity, deconditioning, and disuse[10-11].

The literature presents many approaches to assess muscle strength, functioning, and behavioral aspects[3-4]. However, some instruments that assess these aspects are inconsistent regarding fall prediction[4], and one must determine the most appropriate tool to assess older individuals regarding the risk of falling, considering the

profile of the target audience[4]. Knowing that the older population is heterogeneous, it is necessary to understand how these biological and behavioral aspects are related to the history of falls.

The identification of biological and behavioral factors related to the history of falls can contribute to the adoption of preventive and rehabilitation measures[3], since these factors are potentially modifiable by physical exercise and lifestyle changes[1,3]. In this sense, identifying risk or protective factors can help in the planning of intervention strategies aimed at improving older adults' physical capacities. Thus, this study aimed to investigate the association of biological factors (muscle strength and functioning) and behavioral factors (level of physical activity and fear of falling) with the history of falls in community-dwelling older adults.

METHODOLOGY

This is a cross-sectional study with non-probabilistic sampling. Participants were selected via active search in health services. The following inclusion criteria were employed: being aged 60 years or older; residing in the community, and having an independent gait. The exclusion criteria were having acute disabling pain in the lower limbs that prevented the performance of the tests, decompensated neurological or cardiac condition and cognitive decline detected by the mini mental state examination (MMSE), according to educational level[12]. Clinical and sociodemographic information was obtained through a semi-structured questionnaire prepared for this study. The sample size was estimated at 101 participants, considering the analysis to be used and the number of independent variables evaluated.

Procedures

The dependent variable was the history of falls collected with the following question: "In the last six months, did you fall?". The meaning of "fall" was defined as "an unexpected event, in which the individual goes against the ground, or any level lower than the initial position"[2]. Biological factors were assessed by handgrip strength (HGS) and functioning assessed by gait speed and TUG tests. Behavioral factors were assessed by physical activity level and fear of falling.

A JAMAR®[13] dynamometer was used to assess HGS. The recommendations of the American Society of Hand Therapists were followed: the older adult was seated with their feet flat on the floor, arm adducted parallel to the trunk, elbow flexed at 90°, forearm and wrist in a neutral position. The participants were instructed to perform three measurements with the dominant hand exerting maximum isometric force for six seconds, under verbal stimulation provided by the examiner[13]. There was an interval of one minute between each repetition. The arithmetic average of the three repetitions in kilogram-force (kgf) was used for analysis.

In the gait speed test, the participants were instructed to walk a 4.6 meter route, considering two meters for acceleration and two meters for deceleration[14]. Each individual walked at their preferred speed and with their usual shoes; this analysis used meters/seconds as unit of measurement. To perform the TUG[15-16], participants were asked to get up from a chair, walk three meters, return and sit again, supporting the trunk on the chair[15-16], and were timed in seconds to perform the task. The examiners were previously trained to collect data. A single familiarization run was performed for the HGS, gait test, and TUG tests. The authors ensured that all individuals only performed the tests after certifying they had understood the execution. After familiarization, three recording measures were performed, with a rest interval of one minute and the average considered for analysis. For analysis, raw values without normalization were considered.

Physical activity was assessed using the Minnesota Leisure Time Activities Questionnaire (MLTAQ)[17]. This instrument evaluates physical activity, sports and leisure according to weekly energy expenditure (kilocalories/week). Energy expenditure was calculated based on an equation, considering the measurement of metabolic equivalent (MET) in kilocalories (Kcal), time spent in activity in minutes, and weight in kilograms[17]. Fear of falling or self-efficacy to avoid falling was measured with the Falls Efficacy Scale-International (FES-I Brasil)[18]. This scale presents questions about the concern about the possibility of falling when performing 16 activities, from basic to more complex, with respective scores from one to four. The total score can range from 16 (absence of concern) to 64 (extreme concern)[18].

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences – SPSS (version 23.0). Biserial point correlation (r_b) tests were used to identify the bivariate correlation between potential predictors and history of falls. Variables in which bivariate correlations had a $p<0.20$ significance level were included in a binomial regression

model. At the final fit, only the independent variables that were statistically significant (p<0.05) remained in the regression model. The *logit* link function was used, with adjustment for age and the probability of binomial distribution. The predictive factors obtained were expressed as odds ratio (OR) with 95% confidence intervals (95% CI).

RESULTS

A total of 173 older adults took part in the study, with mean age of 71.8 (±6.2) years. Most were female, non-fallers, with a low number of comorbidities (2.6±1.7), high percentage of visual impairment (93.1%), good perception of overall well-being (52%), good satisfaction with life (67.1%) and low prevalence of depressive symptoms (18.5%) (Table 1).

Table 1. Sample characterization (n=173)

Parameter	N (%)
Sex	
Female	149 (86.1)
Male	24 (13.9)
Marital Status	
Married	72 (41.6)
Widowed	61 (35.3)
Other	40 (23.1)
Skin color	
White	69 (39.9)
Mixed-race	77 (44.5)
Black	27 (15.6)
Visual impairment	
No	12 (6.9)
Yes	161 (93.1)
Overall well-being	
Regular	83 (48)
Good	90 (52)
Satisfaction with life	
Regular	57 (32.9)
Good	116 (67.1)
Depressive symptoms	
No	141 (81.5)
Yes	32 (18,5%)
Fall(s) History	
No	140 (80.9)
Yes	33 (19.1)
Continuous variables	Mean (SD)
Age, years	71.8 (6.2)
Education, years	5.2 (4.1)
Comorbidities, number	2.6 (1.7)
Medications, number	3.3 (2.4)
FES-I, score	23.9 (6.5)
MLTAQ, kilocalories/week	2822.0 (3666.1)
HGS, kg/f	23.7 (7.2)
GS, m/s	1.2 (0.3)
TUG, seconds	10.8 (3.4)

FES-I: Falls Efficacy Scale-International; MLTAQ: Minnesota Leisure Time Activities Questionnaire; HGS: handgrip strength; GS: walking speed; TUG: timed up and go; SD: standard deviation

According to the results of the bivariate correlation, the variables fear of falling (FES-I), physical activity (MLTAQ), handgrip strength (HGS), gait speed (GS), and mobility (TUG) (p<0.20) were initially included in the regression model (Table 2).

Table 2. Bivariate correlation analysis of muscle strength, functionality and behavioral variables with history of falls

Parameter	History of falls	
	r_b	p value
FES-I	0.098	0.162
MLTAQ	−0.149	0.039
HGS	−0.282	<0.001
GS	-0.082	0.151
TUG	0.167	0.018

FES-I: Falls Efficacy Scale-International; MLTAQ: Minnesota Leisure Time Activities Questionnaire; HGS: handgrip strength; GS: gait speed; TUG: timed up and go

The regression model showed that a one-unit increase (kgf) in HGS reduced the chance of falling by 10.9% (95% CI: 10.2 – 11.5%); and a one-unit increase in TUG time (seconds) increased the chance of falling by 3.1% (95% CI: 1.8 – 4.3%) (Table 3).

Table 3. Binomial regression model for the prediction of falls

Predictor variables	Coefficient	OR (95% CI)	p-value
Constant	1.555	4.735 (3.730-6.011)	<0.001
HGS	−0.115	0.891 (0.885-0.898)	<0.001
TUG	0.030	1.031 (1.018-1.043)	<0.001

HGS: handgrip strength; TUG: timed up and go; OR: odds ratio; CI: confidence interval

DISCUSSION

This study aimed to investigate the association of biological and behavioral factors with the history of falls in a sample of community-dwelling older adults. The regression results showed that the HGS and TUG biological factors explained the history of falls in the older adults. A negative association between HGS and history of falls and a positive association between time spent in TUG and history of falls was observed. Worse results in the handgrip strength and TUG tests was

associated with a history of falls in the older adults. Variables related to the behavioral factor were not selected in the regression model.

Notably, HGS was found to be the biological factor with the greatest association with the history of falls. Higher values of HGS were associated with no history of falls in the last six months. Specifically, a one-unit increase in HGS reduced the chance of the older person falling by 10.9%. Some studies that demonstrated that HGS is a strong predictor of falls in the older population corroborate our finding[19-20]. Yang et al.[19], for example, demonstrated that low HGS was the most significant risk factor for falls in the last year in older Taiwanese adults, especially in the female population. Similarly, the study sample was predominantly composed of women, so that HGS was also the predictor with the greatest strength of association. The predominant sample of women corroborates the process of feminization of old age. Moreover, the mean HGS of the evaluated sample was 23.7kgf. Considering the values attributed to the highest rate of severe falls (HGS <30 kgf in men and HGS <20 kgf in women[21]), as well as the indicators of severe sarcopenia of HGS <27 kgf for men and <16 kgf for women[22], the sample of this study does not seem to present significant levels of sarcopenia. These results indicate that HGS needs to be evaluated in older adults due to its potential predictive role for falls.

The time to perform the TUG was another biological factor identified as a predictor for history of falls. Longer time spent performing the test (i.e., worse performance) was associated with a 3.1% greater chance of having a history of falls in the last six months. Similarly, our results are in agreement with data from the literature associating TUG with adverse outcomes including falls, hospitalization, institutionalization, and death[23]. Ansai et al.[24], for example, demonstrated an association between TUG and risk of falls with a 1.13 OR (95% CI: 1.02 – 1.24). However, a systematic review with meta-analysis indicates that the TUG has limited capacity to assess community-dwelling older adults at risk of falling, demonstrating low sensitivity and specificity values[25]. The OR observed in this study indicates that, although the strength of association was not high, TUG must be included in older adults' evaluation, since it is one of the most reported instruments in the literature, with low cost and easy applicability[4].

There was no association of gait speed with the history of falls. The literature shows that this measure is considered a predictor of falls and suggests a cutoff point of 1m/s[8]. One factor that may have influenced the result of this study is related to participants' profile. The sample of this study had a mean age of 71.8 years and presented low self-report of falls (19.1%). This percentage is considered low when compared to the literature[26]. Moreover, it was observed that the average walking speed was 1.2m/s, which is above the cutoff point suggested by the literature[8]. Thus, gait speed may not be the most appropriate measure to predict falls in more robust and independent older adults, with a few comorbidities and high weekly energy expenditure. The results of this study suggest that, for samples with this profile, the TUG test may be more indicated to identify older adults with a greater chance of falling.

Regarding behavioral factors, no association was identified between the level of physical activity and fear of falling with the history of falls. Based on literature data on the association of high levels of physical activity with lower occurrence of falls[27], the benefits of physical activity for the health of older adults are evident, and great public efforts aim at keeping the older population active[27]. Fear of falling was not associated with the history of falls in the sample studied, which differs from other studies[10-11]. It has been shown that older adults who reported falling were twice as likely to be afraid of falling[28]. Moreover, the fear of falling influences the balance and gait of the individual and may predict limitations in mobility and self-care[29]. Possibly, the low fear of falling found in this study may be due to less concern about the consequences of a fall, since most participants are independent, with low fall reports, and those who fell did not have serious injuries. This perception of non-seriousness of the fall can impact the psychological and behavioral aspect, consequently, the fear of falling. The results may indicate that the relationship between fear and falls is not linear and that, in a sample of older adults with little or moderate concern about the history of falls, the factors may not be associated.

A first limitation of the study is the predominance of females in the sample. However, we identified that gender was not significantly associated with the history of falls (p=0.680) and, therefore, was not included in the regression model for adjustment. The model was age-adjusted as described. In addition, the use of self-report for a history of falls may involve memory bias. However, this is the most common way to explore this phenomenon. It is believed that when considering the information of the last six months and being careful to exclude those with possible cognitive deficits, this bias has been minimized. Another limitation is the absence

of anthropometric data related to height, body weight, and body mass index.

This study findings have implications for clinical practice. Biological and behavioral risk factors are determinant for the evaluation and rehabilitation process of older adults with a history of falls[1-3] and represent modifiable factors through intervention with exercise and health education[1]. Although behavioral factors have not been associated with a history of falls in this study, they are often established in the management of falls[1-3]. We consider that the sample profile may have influenced these outcomes. The sample evaluated presented low self-report of falls, few comorbidities, moderate fear of falling, and a good physical activity level. Thus, the understanding of the predictors (HGS and TUG) associated with the history of falls and absence of association of behavioral factors should be considered in the light of an independent, active sample of older adults with few comorbidities. In this sense, it is possible that in more debilitated and frail older adults, other variables may also be associated with the history of falls. The results reinforce the importance of HGS assessment and the application of the TUG test in community-dwelling older adults. Considering that general muscle strength and mobility are risk factors that can be modified, fall prevention strategies should consider interventions aimed at improving these aspects. It is expected that the improvement in overall muscle strength associated with mobility exercises may reduce the chance of falling.

CONCLUSION

Biological factors, handgrip strength, and functioning assessed via TUG were predictors of the history of falls. Worse results in handgrip strength and TUG were associated with a history of falls in older adults. There was no association between behavioral factors (physical activity level and fear of falling) and a history of falls.

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REFERENCES

1. Montero-Odasso M, Van der Velde N, Martin FC, Petrovic M, Tan MP, et al. World guidelines for falls prevention and management for older adults: a global initiative. Age Ageing. 2022;51(9):afac205. doi: 10.1093/ageing/afac205. Erratum in: Age Ageing. 2023;52(9):afad188. doi: 10.1093/ageing/afad188. Erratum in: Age Ageing. 2023;52(10):afad199. doi: 10.1093/ageing/afad199
2. World Health Organization. Step Safely: Strategies for Preventing and Managing Falls across the Life-Course. Geneva: WHO; 2021.
3. Qian XX, Chau PH, Kwan CW, Lou VWQ, Leung AYM, et al. Investigating risk factors for falls Among community-dwelling older adults according to WHO's risk factor model for falls. J Nutr Health Aging. 2021;25(4):425-32. doi: 10.1007/s12603-020-1539-5
4. Beck Jepsen D, Robinson K, Ogliari G, Montero-Odasso M, Kamkar N, et al. Predicting falls in older adults: an umbrella review of instruments assessing gait, balance, and functional mobility. BMC Geriatr. 2022;22(1):615. doi: 10.1186/s12877-022-03271-5
5. Bohannon RW. Grip strength: An indispensable biomarker for older adults. Clin Interv Aging. 2019;14:1681-91. doi: 10.2147/CIA.S194543
6. Wang L, Song P, Cheng C, Han P, Fu L, et al. The Added Value of Combined timed up and go test, walking speed, and grip strength on predicting recurrent falls in Chinese community-dwelling elderly. Clin Interv Aging. 2021;16:1801-12. doi: 10.2147/CIA.S325930
7. Quach L, Galica AM, Jones RN, Procter-Gray E, Manor B, Hannan, MT, et al. The nonlinear relationship between gait speed and falls: The maintenance of balance, independent living, intellect, and zest in the elderly of Boston Study. J Am Geriatr Soc. 2011;59(6):1069-73. doi: 10.1111/j.1532- 5415.2011.03408.x
8. Kyrdalen IL, Thingstad P, Sandvik L, Ormstad H. Associations between gait speed and well-known fall risk factors among community-dwelling older adults. Physiother Res Int. 2019;24(1):e1743. doi: 10.1002/pri.1743
9. Van Gameren M, Hoogendijk EO, van Schoor NM, Bossen D, Visser B, et al. Physical activity as a risk or protective factor for falls and fall-related fractures in non-frail and frail older adults: a longitudinal study. BMC Geriatr. 2022;22(1):695. doi: 10.1186/s12877-022-03383-y
10. Hull SL, Kneebone II, Farquharson L. Anxiety, depression, and fall-related psychological concerns in Community-dwelling older people. Am J Geriatr Psychiatry. 2013;21(12):1287-91. doi: 10.1016/j.jagp.2013.01.038
11. Young WR, Mark WA. How fear of falling can increase fall-risk in older adults: applying psychological theory to practical observations. Gait Posture. 2015;41(1):7-12. doi: 10.1016/j.gaitpost.2014.09.006
12. Bertolucci PH, Brucki SM, Campacci SR, Juliano Y. The Mini-Mental State Examination in a general population: impact of schooling. Arq Neuropsiq. 1994;52(1):1-7. doi: 10.1590/S0004-282X1994000100001

13. Figueiredo IM, Sampaio RF, Mancini MC, Silva FCM, Souza MAP. Test of grip strength using the Jamar dynamometer. Acta Fisiatr. 2007;14(2):104-10. doi: 10.5935/0104-7795.20070002

14. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56(3):M146-56. doi: 10.1093/gerona/56.3.m146

15. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8. doi: 10.1111/j.1532-5415.1991.tb01616.x

16. Dutra MC, Cabral ALL, Carvalho GA. Brazilian version of Timed Up and Go test. Interfaces. 2016;3(9):81-8. doi: 10.16891/2317-434X.430

17. Lustosa LP, Silva SLA, Marra TA, Dias JMD, Pereira LSM, et al. Factor analysis of the Minnesota Leisure Time Activities questionnaire – Brazilian-portuguese. Rev Bras Med Esporte. 2018;24(3):220-4. doi: 10.1590/1517-869220182403156284

18. Camargos FFO, Dias RC, Dias JMD, Freire MTF. Cross-cultural adaptation and evaluation of the psychometric properties of the Falls Efficacy Scale – International Among Elderly Brazilians (FES-I-BRAZIL). Braz J Phys Ther. 2010;14(3). doi: 10.1590/S1413-35552010000300010

19. Yang NP, Hsu NW, Lin CH, Chen HC, Tsao HM, et al. Relationship between muscle strength and fall episodes among the elderly: the Yilan study, Taiwan. BMC Geriatr. 2018;13;18(1):90. doi: 10.1186/s12877-018-0779-2

20. Cöster ME, Karlsson M, Ohlsson C, Mellström D, Lorentzon M, et al. Physical function tests predict incident falls: A prospective study of 2969 men in the Swedish Osteoporotic Fractures in Men study. Scand J Public Health. 2020;48(4):436-41. doi: 10.1177/1403494818801628

21. Pham T, McNeil JJ, Barker AL, Orchard SG, Newman AB, et al. Longitudinal association between handgrip strength, gait speed and risk of serious falls in a community-dwelling older population. PLoS ONE. 2023;18(5):e0285530. doi: 10.1371/journal. pone.0285530

22. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31. doi: 10.1093/ageing/afy169

23. Batko-Szwaczka A, Wilczyński K, Hornik B, Janusz-Jenczeń M, Włodarczyk I, et al. Predicting adverse outcomes in healthy aging community-dwelling early-old adults with the timed up and go test. Clin Interv Aging. 2020;15:1263-70. doi: 10.2147/CIA.S256312

24. Asai T, Oshima K, Fukumoto Y, Yonezawa Y, Matsuo A, et al. Association of fall history with the Timed Up and Go test score and the dual task cost: A cross-sectional study among independent community-dwelling older adults. Geriatr Gerontol Int. 2018;18(8):1189-93. doi: 10.1111/ggi.13439

25. Barry E, Galvin R, Keogh C, Horgan F, Fahey T. Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: A systematic review and meta- analysis. BMC Geriatr. 2014;14:14. doi: 10.1186/1471-2318-14-14

26. Filho JE, Borel WP, Mata Diz JB, Carvalho Barbosa AW, Britto RR, Felício DC. Prevalence of falls and associated factors in community-dwelling older Brazilians: A systematic review and meta-analysis. Cad Saude Publica. 2019;35(8):e00115718. doi: 10.1590/0102-311X00115718

27. Moreira NB, Rodacki ALF, Pereira G, Bento PCB. Does functional capacity, fall risk awareness and physical activity level predict falls in older adults in different age groups? Arch Gerontol Geriatr. 2018;77:57-63. doi: 10.1016/j.archger.2018.04.002

28. Lavedán A, Viladrosa M, Jurschik P, Botigueá T, Masot O, Lavedán R. Fear of falling in community-dwelling older adults: A cause of falls, a consequence, or both? PLoS ONE. 2018;13(3):e0194967. doi: 10.1371/journal.pone.0194967

29. Asai T, Oshima K, Fukumoto Y, Yonezawa Y, Matsuo A, Misu S. The association between fear of falling and occurrence of falls: a one-year cohort study. BMC Geriatr. 2022;22(1):393. doi: 10.1186/s12877-022-03018-2