Aging Clinical and Experimental Research (2020) 32:1043–1048
https://doi.org/10.1007/s40520-019-01187-6

ORIGINAL ARTICLE

Factors associated with impairment in gait speed in older people with clinically normal gait. A cross-sectional study

M. A. Caballero-Mora[1,2,3] · L. Rodríguez Mañas[2,3] · M. Valdés-Aragonés[1,2] · I. García-Sánchez[2] · C. Alonso-Bouzon[1] · M. Castro Rodríguez[1] · L. Nuñez-Jimenez[1] · A. Esteban[4] · A. Rodriguez-Laso[2]

Received: 25 March 2019 / Accepted: 28 March 2019 / Published online: 12 April 2019
© Springer Nature Switzerland AG 2019

Abstract

Background Health professionals commonly use gait speed in the evaluation of functional status in older people. However, only a limited number of studies have assessed gait speed in the absence of disorders of gait, using confounding factors and exclusion criteria coming from studies conducted in younger people. Our study aims to analyse which factors are associated with gait speed in older people with normal clinical gait.

Methods An observational cross-sectional study was conducted in 119 community-dwelling residents without relevant comorbidities (Charlson index < 2), preserved function (Barthel > 85) and normal gait by visual exploration. Exclusion criteria included suffering from any illness that could modify the characteristics of gait, terminal status or the presence of an acute medical illness in the past 3 months. We used a stepwise linear regression of several variables (sociodemographic characteristics, cognition, body composition, drugs, falls, sarcopenia, frailty and physical activity) on 6-metre gait speed.

Results The mean age was 78 years (range 70–96 years) and 71.4% were women. Variables that remained associated with gait speed in the multivariate final model were age ($B = -0.020$, $p < 0.001$); gender ($B = -0.184$, $p < 0.001$); waist-to-height ratio ($B = -0.834$, $p = 0.002$); number of falls ($B = -0.049$, $p = 0.003$) and the number of Fried's frailty criteria ($B = -0.064$, $p = 0.019$).

Conclusion Falls, frailty and the waist-to-height ratio modify gait speed in older people with normal gait. Studies analysing the potential effect of several factors on gait speed should consider them as confounding factors.

Keywords Gait speed · Older people · Waist-to-height ratio · Frailty · Falls · Confounding factors

Background

Health professionals commonly use gait speed in the evaluation of functional status in older people. In addition, it is a good predictor for adverse consequences, such as disability, hospitalization or death [1]. In this context, most of the articles about gait speed focus on the differences between people suffering from diseases which cause gait disorders and people who do not [2, 3], on the effectiveness of treatments [4] or on the prediction of adverse outcomes [5]. However, there are a limited number of studies on people without gait disorders, usually focused on establishing reference parameters in healthy people with a clear underrepresentation of older people [6–11]. When correlates of usual gait speed in normal or well-functioning older adults are analysed [8–11], there is a tendency to ignore some factors that are almost exclusive to older people like the prevalence of polypharmacy, recurrent falls, sarcopenia or frailty, although they can affect gait speed.

Our study aims to analyse which factors are associated with changes in gait speed in older people without clinically evident gait disorders.

✉ M. A. Caballero-Mora
dra.caballero.mora@gmail.com

✉ A. Rodriguez-Laso
arodriguezlaso@salud.madrid.org

[1] Servicio de Geriatría, Geriatric Department, Hospital Universitario de Getafe, Ctra de Toledo Km 12.5, 28905 Getafe, Spain

[2] Fundación de Investigación Biomédica del Hospital Universitario de Getafe, Getafe, Spain

[3] CIBER de Fragilidad y Envejecimiento Saludable, Madrid, Spain

[4] CIBER de Enfermedades Respiratorias, Madrid, Spain

Methods

Setting and study design

We designed an observational cross-sectional study. Volunteers were companions of patients attending a day hospital or people reached through posters or older people's associations. Inclusion criteria were being older than 70 years, living in community dwellings and being able to walk without aids with a normal gait, as assessed by visual observation. We described "normal gait" as an independent, symmetric and upright gait, with good hip and lower limbs alternance and no dragging of the feet. A total of 235 volunteered to participate and met the inclusion criteria. However, we had to exclude 115 patients because of the presence of any of the following exclusion criteria: patients with a Mini-Mental State Exam (the Spanish version is called MEC) < 25; Barthel index < 85; terminal status (life expectancy < 6 months); acute medical illness in the past 3 months; major depression or psychiatric follow-up; neurological diseases (including Parkinson's disease, cerebellar disease or peripheral neuropathy); peripheral artery disease; and coronary heart disease. We excluded one more volunteer, because he did not have all variables measured, resulting in a final study sample of 119 persons.

Measures

Dependent variable: gait speed

We assessed gait speed using the 6-m test. We asked participants to walk 10 m in their usual way to measure the speed at which they normally walked in the street. We started the timer at the 2 m and stopped it at the 8-metre mark. We took two measurements (in metres per second—m/s) and used the best one for the analysis.

Independent variables

We limited the number of variables to have no fewer than five persons per variable in the sample [12].

Sociodemographic variables

We considered gender, age and age^2.

Morphological variables

Morphological variables such as height (cm); waist perimeter (cm); waist-to-height ratio (ratio of the waist perimeter to height); body mass index (BMI) in kg/m^2; total appendicular mass (TAM) measured through impedanciometry in kilograms (Tanita BC-418MA bioimpedanciometry); ratio TAM/BMI; press strength measured in kilograms [13] and press strength^2 were calculated. Apart from the components of sarcopenia individually, we also considered its diagnosis according to the FNIH criteria [14].

Conditions

We measured cognition through the MEC score [15]. We operationalized frailty as the number of Fried's phenotype criteria standardized to the Spanish population [16, 17]; we also introduced the number of criteria^2 in the model.

Low physical activity

We used the item of the Fried's phenotype to have a measure of the low physical activity performed by people. We considered low physical activity when men walked less than 2.5 h/week and women less than 2 h/ week. Press strength was the other Fried's item that was incorporated individually into the models.

Falls

We considered the number of falls suffered in the last year and the total number of falls^2.

Drugs

The number of drugs and number of drugs^2 were considered; we defined the consumption of four or more drugs as polypharmacy [18]. In addition, we incorporated taking psycho-drugs (participants only took antidepressants and sedative anxiolytics—subgroups N05 and N06 of the ATC classification) [19], antihypertensive, antiarrhythmic drugs or diuretics (subgroups C02, C03, C04, C07, C08 and C09 of the ATC classification).

Descriptive variables

The descriptive variables were basic activities of daily living (BADL) (measured with the Barthel index) [20], instrumental activities of daily living (IADL) (measured with the Lawton and Brody Index) [21] and comorbidity (measured with the Charlson Index) [22].

Statistical analyses

We described variables using arithmetical means and standard deviations or proportions where appropriate. We calculated bivariate linear regressions on gait speed for each variable. To obtain the best set of variables associated to gait speed, we used a stepwise regression strategy, where all variables are entered at the first step and eliminated one by one if their statistical significance is higher than 0.1. Excluded variables may re-enter the model if their significance level at inclusion is less than 0.05. We set tolerance at 0.01 [23]. We checked residuals of the final model, as well as outliers (univariate and multivariate) and influential observations. We performed all statistical tests using SPSS for Windows (13.0 version).

Results

The characteristics of the sample are presented in Table 1. The mean age was 78 years, and 71.4% were women. As expected because of the exclusion criteria, the participants were free from significant disability, cognitive impairment and comorbidity. 31.1% were obese (BMI ≥ 30), and 46.2% suffered from overweight (BMI 25–29.9). 12% suffered from sarcopenia and the mean number of Fried's criteria was 0.42. Weakness and low physical activity were the most common frailty criteria, present in one-tenth of the sample. The mean number of falls in the previous year was 0.64. Polypharmacy and consumption of psycho-drugs and cardiovascular drugs were common (27.7%, 37.8% and 62.2%, respectively). Average gait speed was 1.13 m/s; SD = 0.27 m/s, ranging from 0.32 to 1.96 m/s.

As shown in Table 2, bivariate regression showed significant associations in the expected direction between gait speed and the following variables: age, gender, MEC, height, waist-to-height ratio, press strength, TAM, TAM to BMI index, number of drugs, polypharmacy ≥ 4, consumption of psycho-drugs, number of falls, number of frailty criteria and low physical activity. There was no significant association with waist circumference, BMI, sarcopenia, and consumption of antihypertensive drugs, diuretics or beta blockers.

The final stepwise model included age ($B = -0.020$, $p < 0.001$); gender ($B = -0.184$, $p < 0.001$); waist-to-height ratio ($B = -0.834$, $p = 0.002$); number of falls ($B = -0.049$, $p = 0.003$) and number of Fried's frailty criteria ($B = -0.064$, $p = 0.019$). These variables explained over 50% of the inter-subject variability in gait speed ($R^2 = 0.53$).

On average, being a woman or being 10 years older decreased the gait speed by 0.2 m/s ($p < 0.001$). For every unit increase of the waist-to-height ratio, gait speed decreased by 0.8 m/s ($p = 0.002$). For each two additional frailty criteria or each two more falls experienced in the previous year, gait speed decreased by 0.1 m/s ($p = 0.019$ and $p = 0.003$, respectively).

Table 1 Characteristics of the sample tested by variables

$N = 119$	Mean or %	Standard deviation or *N*
Age	77.68	5.85
Women	71.4%	92
Barthel index	99.09	1.89
Lawton index	7.37	1.22
MEC	31.79	3.23
Charlson index	0.49	0.76
BMI (kg/m^2)	28.74	3.97
Sarcopenia	12.6%	15
Recurrent falls	16.8%	20
Frailty	2.5%	3
Prefrailty	26.9%	32
1 frailty criterion	19.3%	23
2 frailty criteria	7.6%	9
3 frailty criteria	2.5%	3
Weight loss	7.6%	9
Low physical activity	10.1%	12
Exhaustion	5.0%	6
Slowness	0.8%	1
Weakness	18.5%	22
Gait speed	1.13	0.27

MEC mini examen cognoscitivo, *BMI* body mass index

Discussion

The aim of this study was to assess the relationship between gait speed and the factors that theoretically could affect it in older patients with clinically normal gait, including some that are almost exclusive to older people. Age, gender, waist-to-height ratio, number of frailty criteria and number of falls were the factors we found to be associated with gait speed.

Age, gender and waist circumference and height are classical factors that have been reported to be associated with gait in older and younger people [11]. However, there are just a few studies that analysed the waist-to-height ratio, even though this ratio has proven to be one of the best cardiovascular assessment index for the older people [24]. In the line of these results, the waist-to-height ratio was the only morphological one that remained associated with gait speed in the multivariate model.

Frailty is a pathologic status of older people and its prevalence increases with age [25]. We operationalized it with the Fried's phenotype. We considered its individual components that could theoretically be related to gait speed, such as press strength and low physical activity, but we also wanted to explore the association of the index as a whole. The more frailty criteria an individual had, the lower his/her gait speed was. Of note, only one person in the sample met the Fried's slowness criterion, so the association cannot be attributed to

Table 2 Variables could associate on gait

N = 119	Descriptive		Bivariate			Multivariate		
	Mean or %	SD or *N*	*B*	*p*	95% CI for *B*	*B*	*p*	95% CI for *B*
Age	77.68	5.85	**– 0.023**	**< 0.001**	**(– 0.030; – 0.015)**	**– 0.020**	**< 0.001**	**(– 0.026; – 0.013)**
Women	71.4%	92	**– 0.204**	**< 0.001**	**(– 0.311; – 0.104)**	**– 0.184**	**< 0.001**	**(– 0.262; – 0.103)**
MEC	31.79	3.23	**0.035**	**< 0.001**	(0.022; 0.050)			
Height (m)	1.54	0.09	**1.023**	**< 0.001**	**(0.499; 1.590)**			
Waist circumference (cm)	95.98	9.34	– 0.002	0.537	(– 0.007; 0.003)			
Waist-to-height ratio (cm/cm)	0.62	0.07	**– 1.210**	**0.001**	**(– 1.978; – 0.545)**	**– 0.834**	**0.002**	**(– 1.371; – 0.311)**
BMI (kg/m^2)	28.74	3.97	– 0.012	0.061	(– 0.025; – 0.001)			
Press strength (kg)	18.40	6.08	**0.022**	**< 0.001**	**(0.015; 0.029)**			
TAM (kg)	19.02	3.91	**0.016**	**0.008**	**(0.004; 0.028)**			
TAM to BMI index (kg/m^2)	0.68	0.17	**0.477**	**0.001**	**(0.196; 0.759)**			
Sarcopenia	12.6%	15	– 0.098	0.193	(– 0.246; 0.050)			
Number of drugs	4.23	3.29	**– 0.032**	**< 0.001**	**(– 0.047; – 0.019)**			
Polypharmacy ≥ 4	27.7%	33	**– 0.195**	**< 0.001**	**(– 0.287; – 0.102)**			
Psycho-drugs	37.8%	45	**– 0.136**	**0.008**	**(– 0.241; – 0.044)**			
Antihypertensives, diuretics or beta blockers	62.2%	74	– 0.097	0.059	(– 0.202; – 0.001)			
Number of falls	0.64	1.17	**– 0.093**	**< 0.001**	**(– 0.134; – 0.057)**	**– 0.049**	**0.003**	**(– 0.080; – 0.018)**
Number of frailty criteria	0.42	0.74	**– 0.178**	**< 0.001**	**(– 0.232; – 0.119)**	**– 0.064**	**0.019**	**(– 0.119; – 0.017)**
Low physical activity	10.1%	12	**– 0.306**	**< 0.001**	**(– 0.464; – 0.166)**			

Statistically significance values are in bold ($p < 0.05$)

BMI body mass index, *CI* confidence interval, *MEC* mini examen cognoscitivo, a measure of cognitive function, *TAM* total appendicular mass

the presence of this component that is based on a measure of gait speed.

We found an association between an increasing number of falls and a decrease in gait speed. Other studies support these results [26]. Fear to fall produced by previous falls could reduce gait speed [27]. In any case, with our cross-sectional design, it is impossible to determine if falls are the cause or the consequence of a low gait speed. We found that patients with two or more falls experienced a reduction of gait speed above 0.1 m/s. This is an important change that has shown predictive power of adverse events [1, 5].

Prevalence of falls increases with age and frailty level [28]. Though it is clear that frailty and recurrent falls cannot be considered as factors associated to a healthy population [26, 28], other authors do not include them among their exclusion criteria when choosing their sample [8–11]. Using the same exclusion criteria, we have found patients who suffer from both conditions.

We have found a very weak association between muscle mass or sarcopenia and gait speed. It must be said that in the stepwise regression, sarcopenia remained in the model until frailty was introduced, suggesting that the presence of frailty explains all the effects of sarcopenia on gait speed. Supporting this explanation, several authors have found a strong association between this phenotype and sarcopenia [29].

Polypharmacy and psycho-drugs variables lost their significance in the multivariate model when we adjusted by age, gender and the number of frailty criteria. Confounding factors could also play a role in the loss of significance. Alternatively, the effect of drugs could be mediated by frailty [28]. In relation to the consumption of antihypertensive drugs, diuretics or beta blockers, they did not show an association even in the bivariate model. This could be due to the fact that what conditions gait speed is changes in these medications, not just their usage [30]. The use of absence of clinical instability in the last 3 months as an inclusion criteria in our study and the review of patients' clinical records suggest that this circumstance did not happen in our sample.

Regarding cognitive function, even in our sample with no cognitive impairment, we found a bivariate relation of MEC with gait speed. This effect disappeared when we adjusted our model by age, gender and number of frailty criteria. Again, confounding by these variables which are associated with cognitive impairment [28] could be the reason.

According to our results, health professionals should consider age and gender, waist-to-height ratio, number of falls and the number of Fried's frailty criteria as adjustment factors when studying other variables associated with gait speed and falls. Other studies did not take into account frailty and falls in their designs, and their findings can be biased.

The main strength of this study is that it allowed studying a wide number of variables in people without disability and with a normal gait. This also acts as a limitation because our volunteers were relatively healthy and had a low prevalence of factors that might be associated with gait, such as sarcopenia, physical inactivity or depression; this circumstance may also limit the external validity of the study. However, the need of excluding patients with any disturbance of gait precludes the inclusion of people with other conditions that produce abnormal clinical gait. The main drawback is the cross-sectional nature of the design that prevents us from establishing causal relationships.

Conclusion

There is a lack of information about factors associated with gait speed in older people without gait abnormalities, which forces the scientific and clinical community to use thresholds for "normal" gait speed and consider factors associated with changes in gait speed from studies in younger people. This raises the possibility of bias. This work proposes new factors that should be considered as potential confounders in the study of variations of gait speed in older people with clinically normal gait.

Funding Funding was provided by ISCIII PI11/01068, and CIBERFES CB16/10/00464 and co-funding was by Feder.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval All procedures performed in the studies involving-human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all participants.

References

1. Freiberger E, de Vreede P, Schoene D et al (2012) Performance-based physical function in older community-dwelling persons: a systematic review of instruments. Age Ageing. 41:712–721. https://doi.org/10.1093/ageing/afs099
2. Chisholm AE, Makepeace S, Inness EL et al (2014) Spatial-temporal gait variability poststroke: variations in measurement and implications for measuring change. Arch Phys Med Rehabil. 95:1335–1341. https://doi.org/10.1016/j.apmr.2014.02.014
3. Ornetti P, Maillefert JF, Laroche D et al (2010) Gait analysis as a quantifiable outcome measure in hip or knee osteoarthritis: a systematic review. Jt Bone Spine. 77:421–425. https://doi.org/10.1016/j.jbspin.2009.12.009
4. Van Abbema R, De Greef M, Crajé C et al (2015) What type, or combination of exercise can improve preferred gait speed in older adults? A meta-analysis. BMC Geriatr 15:72. https://doi.org/10.1186/s12877-015-0061-9
5. Abellan van KG, Rolland Y, Andrieu S et al (2009) Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. J Nutr Health Aging 13:881–889
6. Frimenko R, Goodyear C, Bruening D (2015) Interactions of sex and aging on spatiotemporal metrics in non-pathological gait: a descriptive meta-analysis. Physiotherapy 101:266–272. https://doi.org/10.1016/j.physio.2015.01.003
7. Cesari M, Kritchevsky SB, Penninx BWHJ et al (2005) Prognostic value of usual gait speed in well-functioning older people—results from the health, aging and body composition study. J Am Geriatr Soc 53:1675–1680
8. Hollman JH, Mcdade EM, Petersen RC (2011) Normative Spatiotemporal gait parameters in older adults. Gait Posture. 34:111–118. https://doi.org/10.1016/j.gaitpost.2011.03.024
9. Oberg T, Karsznia A, Oberg K (1993) Basic gait parameters: reference data for normal subjects, 10–79 years of age. J Rehabil Res Dev 30:210–223
10. Oh-Park M, Holtzer R, Xue X et al (2010) Conventional and robust quantitative gait norms in community-dwelling older adults. J Am Geriatr Soc 58:1512–1518
11. Samson MM, Crowe A, de Vreede PL et al (2001) Differences in gait parameters at a preferred walking speed in healthy subjects due to age, height and body weight. Aging Clin Exp Res 13:16–21
12. Austin PC, Steyerberg EW (2015) The number of subjects per variable required in linear regression analyses. J Clin Epidemiol 68:627–636. https://doi.org/10.1016/j.jclinepi.2014.12.014
13. Arnold CM, Warkentin KD, Chilibeck PD et al (2010) The reliability and validity of handheld dynamometry for the measurement of lower-extremity muscle strength in older adults. J Strength Cond Res 24:815–824. https://doi.org/10.1519/JSC.0b013e3181aa36b8
14. Studenski S, Peters K, Alley D et al (2014) The FNIH sarcopenia project: Rationale, study description, conference recommendations, and final estimates. J Gerontol A Biol Sci Med Sci 69:547–558. https://doi.org/10.1093/gerona/glu010
15. Lobo A, Ezquerra J, Gómez Burgada F et al (1979) Cognocitive mini-test (a simple practical test to detect intellectual changes in medical patients). Actas Luso Esp Neurol Psiquiatr Cienc Afines 7:189–202
16. Fried LP, Tangen CM, Walston J et al (2001) Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 56:M146–M156
17. Alonso Bouzón C, Carnicero JA, Turín JG et al (2017) The standardization of frailty phenotype criteria improves its predictive ability: the Toledo study for healthy aging. J Am Med Dir Assoc 18:402–408. https://doi.org/10.1016/j.jamda.2016.11.003
18. Seppala LJ, van de Glind EMM, Daams JG et al (2018) Fall-risk-increasing drugs: a systematic review and meta-analysis: III Others. J Am Med Dir Assoc 19:372.e1–372.e8. https://doi.org/10.1016/j.jamda.2017.12.099
19. The Anatomical Therapeutic Chemical Classification System with Defined Daily Doses (ATC/DDD) (2003) ATC Index with DDDs 2003. Guidelines for ATC classification and DDD assignment 2003. https://www.whocc.no/filearchive/publications/1_2013guidelines.pdf. Accessed Jan 2013
20. Mahoney FI, Barthel DW (1965) Functional evaluation: Barthel index. Md State Med J 14:61–65

21. Lawton MP, Brody EM (1969) Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 9:179–186
22. Charlson M, Pompei P, Ales KL et al (1987) A new method of classyfing prognostic comorbidity in longitudinal studies: development and validation. J Chron Dis 40:373–383
23. Doménech JM (2001) Análisis multivariante: modelos de regresión. UD 5. Construcción de un modelo de regresión múltiple con fines predictivos. Selección de la mejor ecuación. Signo, Barcelona
24. Ashwell M, Gunn P, Gibson S (2012) Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev 13:275–286. https://doi.org/10.1111/j.1467-789X.2011.00952.x
25. Collard RM, Boter H, Schoevers RA et al (2012) Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 60:1487–1492. https://doi.org/10.1111/j.1532-5415.2012.04054.x
26. World Health Organization (2007) WHO global report on falls prevention in older age. https://www.who.int/ageing/publications/Falls_prevention7March.pdf
27. Ayoubi F, Launay CP, Kabeshova A et al (2014) The influence of fear of falling on gait variability: results from a large elderly population-based cross-sectional study. J Neuroeng Rehabil 11:128. https://doi.org/10.1186/1743-0003-11-128
28. Yang F, Chen QW (2018) Evaluation of frailty and influencing factors in old people in hospital institution: Evidence for a phenotype of frailty. Med (Baltimore) 97:e9634. https://doi.org/10.1097/MD.0000000000009634
29. Buch A, Carmeli E, Boker LK et al (2016) Muscle function and fat content in relation to sarcopenia, obesity and frailty of old age—an overview. Exp Gerontol 76:25–32. https://doi.org/10.1016/j.exger.2016.01.008
30. Kahlaee HR, Latt MD, Schneider CR (2018) Association between chronic or acute use of antihypertensive class of medications and falls in older adults. A systematic review and meta-analysis. Am J Hypertens 31:467–479. https://doi.org/10.1093/ajh/hpx189

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.