Full Length Article

The influence of aging on the spatial and temporal variables of gait during usual and fast speeds in older adults aged 60 to 102 years

Paola Errera Magnani[a],[*], Renato Campos Freire Junior[b],
Nathalia Fernanda Grecco Zanellato[c], Maiara Baena Genovez[c],
Isabella Camargo Alvarenga[c], Daniela Cristina Carvalho de Abreu[d]

[a] Postgraduate Program in Rehabilitation and Functional Performance of the Ribeirão Preto School of Medicine, University of São Paulo (USP), Ribeirão Preto. SP, Brazil
[b] Faculty of Physical Education and Physiotherapy, Federal University of Amazonas (UFAM), Manaus, AM, Brazil
[c] Physiotherapy Course, Department of Health Sciences at the Ribeirão Preto School of Medicine of the University of São Paulo (USP), Ribeirão Preto, SP, Brazil
[d] Department of Health Sciences at the Ribeirão Preto School of Medicine of the University of São Paulo (USP), Ribeirão Preto, SP, Brazil

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ABSTRACT

Background: With increases in life expectancy, it is important to understand the influence of aging on gait, given that this activity is related to the independence of older adults and may help in the development of health strategies that encourage successful aging in all phases of this process.

Research question: To compare gait parameters with usual and fast speeds for independent and autonomous older adults throughout the aging process (60 to 102 years old), and also to identify which of the gait variables are best for identifying differences across the different age groups.

Methods: Two hundred older adults aged between 60 and 102 years were evaluated. The sample was divided into 3 age groups: 60 to 79 years, 80 to 89 years and 90 years and over. The analyzed gait variables were: speed (meters/s), cadence (steps/min), stride time (seconds), step length (centimeters), double support (percentage of the gait cycle), swing (percentage of the gait cycle), step length variability (CoV%) and stride time variability (CoV%).

Results: Group comparison regarding usual gait and fast gait revealed a significant difference in all gait variables. In addition, it can be seen that variables such as gait speed and step length showed greater effect sizes in intergroup comparison (usual gait: 0.48 and 0.47; fast gait: 0.36 and 0.40; respectively), possibly showing that these variables can better detect the changes observed with increasing age.

Conclusion: There are differences in the gait performance of older adults from different age groups for usual and fast gait speeds, which is more evident regarding gait speed and step length variables. We recommend the use of usual gait for the identification of the effects of aging because, besides showing a higher effect size values it is more comfortable and requires less effort from older subjects.

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* Corresponding author at: Department of Health Sciences, University of São Paulo, School of Medicine, Address: Avenida Bandeirantes, CEP: 14049-900, 3900 Ribeirão Preto, SP, Brazil.
  E-mail address: dabreu@fmrp.usp.br (P.E. Magnani).

1. Introduction

Studies of the older population, including centenarians, are becoming increasingly necessary because it is important to better understand the aging and longevity process (Willcox, Willcox, & Poon, 2010) in order to improve the health promotion approach, the prevention of impairment, and rehabilitation strategies oriented toward older populations, thus facilitating a functional aging with a good quality of life.

The evaluation of usual gait parameters in older people is an important tool for the identification of functional capacity (Montero-Odasso et al., 2005; Studenski et al., 2003), the risk of falls (Guralnik et al., 2000; Studenski et al., 2003), the risk of dementia (Verghese, Wang, Lipton, Holtzer, & Xue, 2007), and even the risk of early death (Montero-Odasso et al., 2005; Studenski et al., 2011). In addition, maximum gait speed is an important tool for the identification of muscle weakness, decreased functional independence (Ploutz-Snyder, Manini, Ploutz-Snyder, & Wolf, 2002), and cognitive decline (Umegaki et al., 2018).

The literature filed shows that there are differences in some gait variables between young and older adults, such as a decrease in gait speed, step length and stride width (Cruz-Jentoft, et al., 2010; Cruz-Jimenez, 2017; Kim & Kim, 2014; Ko, Stenholm, Metter, & Ferrucci, 2012), a reduction in cadence and an increase of the support phase in the older population (Ko et al., 2012). However, few studies have included older adults older than 90 years, a fact that makes it impossible to extrapolate the relationship between age and changes in gait pattern in the oldest-old adults. Also, it is not clear if there is a linear relationship between aging and the measures of gait in older adults (Callisaya, Blizzard, Schmidt, McGinley, & Srikanth, 2010).

The aging process is heterogeneous because the way people grow old relates to the life they have had, including morphological, functional, psychological, and social aspects and life habits that characterize people's physiological age. Studies have shown that older people from different age groups may have similarities regarding postural control and functionality (Fujita et al., 2005; Gomes, Reis, Neves, Petrella, & de Abreu, 2012), demonstrating that physiological age may be more important than chronological age, at least up to the age groups examined in these investigations (60 to 88 years). Nevertheless, according to the literature field, it is not clear whether the aging process becomes more evident at certain ages, thus causing a greater influence of chronological rather than physiological age, possibly because there are few studies that include older adults over 90 years old (Chui & Lusardi, 2010; Herssens et al., 2018; Lusardi, Pellecchia, & Schulman, 2003). This probably makes it more difficult to define at what age functional and posture balance changes become more evident.

According to a recent study (Lee et al., 2019), it is possible to observe an abrupt decline in gait speed and dynamic balance in older adults over 85 years, but the cited study had a very small sample number representing this age group ($n = 9$), an important limitation pointed out by the authors.

Given this scenario, the objective of the present study was to compare gait parameters with usual and fast speeds for independent and autonomous older adults throughout the aging process (60 to 102 years old), and also to identify which of the gait variables are best for identifying differences across the different age groups.

2. Methods

The present study was cross-sectional, and its sample consisted of older adults of both sexes ranging in age from 60 to 102 years who lived in the city of Ribeirão Preto, in the state of São Paulo, Brazil. The sample was divided into 3 age groups: 60 to 79 years, 80 to 89 years and 90 years and over.

The sample size calculation was an a-priori sample calculation from a pilot study in which we used the variable with the lowest ηp2 (eta squared) in usual gait. For this calculation we used the GPower 3.1 program, with the minimal final sample of 176 older people having a power of 0.90 and an α of 0.05.

Participants were previously informed about the procedures to be performed and all gave written informed consent to participate in the study. The study was approved by the Human Research Ethics Committee of the University Hospital, Ribeirão Preto Medical School (CAAE: 53421416.0.0000.5440).

The exclusion criteria were as follows: a score on the Mini-Mental State Examination (MMSE) lower than 26 points for older people with 8 years of education or more, lower than 18 points for older people with 1 to 8 years of education, and lower than 13 points for illiterate older people (Bertolucci, Brucki, Campacci, & Juliano, 1994) or a medical diagnosis confirming mild cognitive impairment; decompensated cardiovascular disease that contraindicates physical effort, according to self-report and without a medical diagnosis confirming such information; fractures in the 12 months prior to the study; neurological disease previously diagnosed by a neurologist; decreased protective sensitivity in the feet (it was necessary to feel at least 10 g in the sensitivity test using monofilaments) (Abbott et al., 2002); an inability to walk around or use a walker as an auxiliary device (use of canes was permitted in this study); and living in an institution, such as a nursing home or retirement home.

The age, weight, and height of the participants were recorded and the body mass index (BMI) was calculated. The level of physical activity of the participants was assessed using the International Physical Activity Questionnaire – Short Form (IPAQ – SF) (Matsudo et al., 2001; Mazo & Benedetti, 2010). The participants' history of falling was recorded by asking about the number of falls in the past six months.

The GAITRite Platinum 26' PortableWalkway System was used to evaluate the gait variables. This equipment consists of a 90 cm × 800 cm rubber electronic rug that registers footprints. During evaluation at the usual gait, the participants were asked to walk at their usual speed, and during the evaluation of fast speed, they were asked to walk at their maximum speed; the average of three attempts was recorded for each gait assessment. Before data collection, the participants executed the task once to become familiar with it. Evaluations began one meter before and ended one meter after the full extension of the GAITRite equipment to

exclude periods of acceleration and deceleration (Freire Júnior, Porto, Marques, Magnani, & Abreu, 2017). For each participant, 25–36 steps were collected in order to examine variability (Lord, Howe, Greenland, Simpson, & Rochester, 2011; Schwenk et al., 2014)

The following gait variables were analyzed: gait speed (meters/s), cadence (steps/min), stride time (seconds), step length (centimeters), double support (percentage of the gait cycle), swing (percentage of the gait cycle), Step length variability (percent coefficient of variation (CoV%), and stride time variability (CoV%) (Callisaya et al., 2010). Variability was calculated as percent coefficient of variation (CoV%) (Hausdorff, Rios, & Edelberg, 2001; Montero-Odasso et al., 2011).

The CoV% (CoV = SD/mean *100) of step length and stride time was calculated using the mean and standard deviation of three trials in order to determine the variability of these parameters.

2.1. Statistical analysis

Data analysis was carried out using the IBM SPSS 17.0 software (SPSS Inc.). The normality of the data was tested by the Shapiro-Wilk test. Descriptive analysis included calculation of average, standard deviation, median and interquartile range. The variables for descriptive analysis included age (years), BMI (kg/m^2), MMSE score (points), number of comorbidities, number of medications, and IPAQ scores (points).

Characterization of the sample by age group category was expressed as number of cases and percentage. The variables used for characterization by category were sex, BMI (Lipschitz, 1994), years of study, number of medications, percentage of individuals using auxiliary devices, IPAQ scores (points), and number of fall episodes in the previous six months. The chi-square test was used for this analysis, with the level of significance set at 5% ($p < 0.05$).

The 3 age groups (60 to 79 years, 80 to 89 years and 90 years and over) were compared regarding the gait variables (gait speed, cadence, stride time, step length, double support, swing, step length variability and stride time variability) during usual gait and fast gait. The general univariate linear model (ANOVA) was used to identify possible differences between groups, with adjustment of the model for sex and use of an auxiliary device (cane). The Bonferroni post-hoc test was used when appropriate. Partial Eta^2 ($\eta p^2 = SS_{effect}/(SS_{effect} + SS_{error})$) was used as a measure of effect size (Becker, 1999).

3. Results

Two hundred older adults were evaluated. Descriptive data on average age, BMI, MMSE scores, IPAQ scores, number of comorbidities, and number of medications are shown in Table 1.

There were no differences between the three groups of older adults regarding number of medications or number of comorbidities. However, the group over 90 years showed significantly lower values than the group under 89 years regarding the variables related to cognitive level, physical activity level and body mass index (Table 1).

The characterization of the sample by category is presented in Table 2. The data considered were sex, BMI, years of study, IPAQ scores, medications, use of an auxiliary device (cane), and number of falls in the previous six months (Table 2).

Table 2 shows that there was no significant difference in group distribution by category regarding sex or number of medications. Regarding BMI, we observed a high percentage of obese older adults aged < 89 years (45.09% of the subjects aged 60 to 79 years and 54.90% of the subjects aged 80 to 89 years), whereas the highest percentage of malnourished older adults was detected in the group aged > 90 years (27.65%).

Categorization according to years of study revealed that 58.82% of the subjects aged < 80 years had a high educational level, while 17.02% of the subjects aged > 90 years were illiterate. In addition, among subjects aged 60 to 79 years there was a good division between sedentarism (35.29%), low physical activity (37.25%) and moderate physical activity (37.35%), whereas most of the subjects aged 80 years or more were sedentary (47.05% of subjects aged 80 to 89 years and 70.21% of subjects older than 90 years). The use of a walking aid (a cane) was more prevalent among subjects older than 90 years (29.78%), as also was the

Table 1

Characterization of the sample by age group. Data expressed as mean, standard deviation (SD), median and interquartile range (IR).

Characteristics	60 to 79-year-old (n = 102)			80 to 89-year-old (n = 51)			90 to 102-year-old (n = 47)			p value
	Mean ± SD	Median	IR	Mean ± SD	Median	IR	Mean ± SD	Median	IR	
Age (years)	69.2 ± 4.8[a,b]	69.0	7.0	83.1 ± 2.3[c]	82.0	4.0	92.9 ± 3.1	92.0	4.0	< 0.001[*]
BMI (kg/m^2)	27.1 ± 3.8[b]	26.7	4.6	27.43 ± 4.0 [c]	27.3	5.3	24.42 ± 3.5	24.7	4.9	< 0.001[*]
MMSE (points)	28.0 ± 1.4[a,b]	28.0	2.0	26.4 ± 1.7[c]	26.0	3.0	24.2 ± 3.1	25.0	5.0	< 0.001[*]
IPAQ (points)	567.3 ± 632.5[b]	518.0	834	401.8 ± 506.8[c]	132.0	800	121.4 ± 255.2	0	198	< 0.001[*]
Number of comorbidities	2.1 ± 1.0	2.0	1.0	1.8 ± 0.9	2.0	1.0	1.9 ± 1.0	2.0	2.0	0.12
Number of medications	3.2 ± 1.9	3.0	2.0	3.2 ± 2.0	3.0	3.0	3.5 ± 2.1	3.0	3.0	0.69

IR: Interquartil range; BMI: Body Mass Index; MMSE: Mini-Mental State Examination; IPAQ: International Physical Activity Questionnaire.

[*] p < 0.05.

[a] p < 0.05 (Group of 60 to 79 years vesus 80 to 89 years).

[b] p < 0.05 (Group of 60 to 79 years vesus 90 to 102 years).

[c] p < 0.05 (Group of 80 to 89 years vesus 90 to 102 years).

Table 2

Characterization of the sample by category in age groups. Data expressed as number of cases (n) and percentage (%).

Characteristics		60 to 79 year old (n = 102)	80 to 89 year old (n = 51)	90 to 102 year old (n = 47)	p value
Sex	Woman (n (%))	80 (78.43%)	40 (78.43%)	37 (78.73%)	0.99
	Men (n (%))	22 (21.57%)	11 (21.57%)	10 (21.27%)	
Body Mass Index	Malnutrition (n (%))	6 (5.88%)	4 (7.84%)	13 (27.65%)	< 0.001*
	Eutrophia (n (%))	50 (49.01%)	19 (37.25%)	23 (48.93%)	
	Obesity (n (%))	46 (45.09%)	28 (54.90%)	11 (23.40%)	
Years of study	Illiterate (n (%))	0 (0%)	2 (3.92%)	8 (17.02%)	< 0.001*
	1 to 8 years (n (%))	42 (41.17%)	35 (68.62%)	27 (57.44%)	
	+ 9 years (n (%))	60 (58.82%)	14 (27.45%)	12 (25.53%)	
IPAQ	Sedentary (n (%))	36 (35.29%)	24 (47.05%)	33 (70.21%)	< 0.001*
	Low (n (%))	27 (26.47%)	12 (23.52%)	11 (23.40%)	
	Moderate (n (%))	38 (37.25%)	15 (29.41)	3 (6.38%)	
	High (n (%))	1 (0.98%)	0 (0%)	0 (0%)	
Medications	No medications (n (%))	7 (6.86%)	3 (5.88%)	2 (4.25%)	0.53
	1 to 4 medications (n (%))	50 (49.01%)	22 (43.13%)	17 (36.17%)	
	More than 4 medications (n (%))	45 (44.11%)	26 (50.98%)	28 (59.57%)	
Auxiliary device	Cane (n (%))	1 (0.98%)	1 (1.97%)	14 (29.78%)	< 0.001*
	No cane (n (%))	101 (99.02%)	50 (98.03)	33 (70.20%)	
Falls	No falls (n (%))	77 (75.49%)	34 (66.66%)	21 (44.58%)	< 0.001*
	One fall (n (%))	16 (15.68%)	14 (27.45%)	9 (19.14%)	
	2 or + falls (n (%))	9 (8.82%)	3 (5.88%)	17 (36.17%)	

IPAQ: International Physical Activity Questionnaire.

* $p < 0.05$. The chi-square test was used for this analysis.

occurrence of one or more falls in the last 6 months (55.31%).

3.1. Usual gait

Group comparison by univariate analysis regarding usual gait revealed a significant difference in gait speed even when the model was adjusted for important confounding covariables (sex and use of an auxiliary device). This same behavior was observed for all other gait variables, demonstrating that the groups differed in a statistically significant manner (Table 3). In addition, variables such as gait speed and step length showed greater effect sizes in intergroup comparison, possibly showing that these variables can better detect the changes observed with increasing age.

Also, usual gait speed was reduced by 18.18% among subjects aged 80 to 89 years compared to those aged < 80 years, and by 26.26% among subjects older than 90 years compared to subjects aged 80 to 89 years. Step length during the usual gait was reduced by 12.74% among subjects aged 80 to 89 years compared to those younger than 80 years and by 22.65% among subjects older than 90 years compared to those aged 80 to 89 years.

3.2. Fast gait

Univariate analysis revealed a significant difference in fast gait speed between age groups even when the model was adjusted for important confounding covariables (sex and use of an auxiliary device). This same behavior was observed for all other gait variables, demonstrating that the groups differed in a statistically significant manner (Table 3). In addition, we observed that, similar to the

Table 3

Comparison of usual and fast gait performance between groups. Data expressed as mean, standard deviation.

Types of gait	Variables	60 to 79 year old n = 102	80 to 89 year old n = 51	90 to 102 year old n = 47		Between-group effects (p value)	
		Mean ± SD	Mean ± SD	Mean ± SD	η_p^2	Unadjusted	Adjustment
Usual gait	Gait speed (m/s)	1.21 ± 0.2[a,b]	0.99 ± 0.2[c]	0.73 ± 0.2	0.48	< 0.001*	< 0.001*
	Cadence (step/min)	116.90 ± 9.3[a,b]	110.0 ± 10.6[c]	103.27 ± 13.9	0.17	< 0.001*	< 0.001*
	Stride time (sec)	1.03 ± 0.1[a,b]	1.10 ± 0.1[c]	1.18 ± 0.2	0.16	< 0.001*	< 0.001*
	Step length (cm)	62.38 ± 7.3[a,b]	54.43 ± 8.3[c]	42.10 ± 9.0	0.47	< 0.001*	< 0.001*
	Double support (%CT)	25.40 ± 3.3[a,b]	27.98 ± 3.5[c]	33.01 ± 7.4	0.22	< 0.001*	< 0.001*
	Swing (%CT)	37.50 ± 1.7[a,b]	35.67 ± 2.0[c]	33.14 ± 4.5	0.22	< 0.001*	< 0.001*
	Step length variability (CoV%)	4.80 ± 1.6[b]	5.72 ± 2.5[c]	9.56 ± 7.2	0.15	< 0.001*	< 0.001*
	Stride time variability (CoV%)	3.47 ± 1.9[a,b]	4.62 ± 2.8	6.11 ± 3.5	0.11	< 0.001*	< 0.001*
Fast gait	Gait speed (m/s)	1.68 ± 0.2[a,b]	1.40 ± 0.3[c]	1.05 ± 0.4	0.36	< 0.001*	< 0.001*
	Cadence (step/min)	142.61 ± 14.7[b]	136.08 ± 15.9[c]	129.12 ± 22.3	0.08	< 0.001*	0.001*
	Stride time (Sec)	0.84 ± 0.8[b]	0.89 ± 0.1	0.95 ± 0.1	0.09	< 0.001*	0.001*
	Step length (cm)	70.91 ± 8.3[a,b]	61.93 ± 10.7[c]	47.71 ± 12.8	0.40	< 0.001*	< 0.001*
	Double support (%CT)	20.41 ± 3.8[a,b]	23.15 ± 4.0[c]	27.33 ± 8.3	0.16	< 0.001*	< 0.001*
	Swing (%CT)	39.83 ± 1.8[a,b]	38.19 ± 2.3[c]	36.04 ± 4.9	0.16	< 0.001*	< 0.001*
	Step length variability (CoV%)	5.15 ± 2.0 [a,b]	6.71 ± 2.8[c]	9.15 ± 5.2	0.15	< 0.001*	< 0.001*
	Stride time variability (CoV%)	4.84 ± 2.1[a]	6.28 ± 3.5	5.55 ± 2.7	0.04	0.03*	0.03*

Adjustment: Sex and use of auxiliary device.

η_p^2: eta squared.

* p < 0.05.

a p < 0.05 (Group of 60 to 79 years vesus 80 to 89 years).

b p < 0.05 (Group of 60 to 79 years vesus 90 to 102 years).

c p < 0.05 (Group of 80 to 89 years vesus 90 to 102 years).

usual gait results, gait speed and step length showed greater effect sizes in intergroup comparison.

Table 3 shows that gait speed and step length are the gait variables which the greatest effect size. Also, fast gait speed was reduced by 16.66% among subjects older than 80 to 89 years compared to those younger than 80 years and was reduced by 25% among subjects older than 90 years compared to those aged 80 to 89 years. Step length during fast gait was reduced by 12.66% among subjects aged 80 to89 years compared to subjects younger than 80 years and was reduced by 22.96% among subjects older than 90 years compared to those aged 80 to 89 years.

4. Discussion

Several physiological changes are caused by the aging process, such as alterations in postural control (Woollacott & Shumway-Cook, 2002), a decrease in muscle strength (Bean, Kiely, LaRose, Alian, & Frontera, 2007), and changes in the pattern of muscle activation (Laughton et al., 2003), which interfere with the functional performance of older adults, as illustrated by gait alterations.

The present findings revealed that the profile of oldest-old adults differed from that of youngest-old adults since the former group included a larger number of malnourished subjects, with lower educational level, mostly sedentary and with a larger number of falls. However, despite these limitations, these older adults are independent and autonomous, showing that it is extremely important to conduct further studies on this population in order to learn about its limitations and thus propose better strategies for their inclusion in society with a better quality of life.

In addition, the results of the present study corroborate the findings reported in previous investigations (Callisaya et al., 2010; Chui & Lusardi, 2010; Herssens et al., 2018) because they demonstrate the relationship between an increase in age and changes in gait variables, mainly in terms of gait speed and step length. However, the study by Callisaya et al. (2010) did not include older adults over 90 years old, which hinders the understanding of the behavior of gait parameters in the oldest population. The investigation by Chui and Lusardi (2010) only included 72–98-year-old subjects, a fact that did not permit the understanding of the behavior of the aging process as a whole on gait parameters since the authors did not include younger older adults (those under 70 years of age).

The study by Chui and Lusardi (2010), conducted on 72–98-year-old American subjects, also revealed a relationship between aging and worsening of gait parameters, but the average values of gait speed, cadence, step length, and swing were higher than those obtained in the present study. Similarly, the older adults evaluated in the investigation by Chui and Lusardi (2010) had a lower average value for the variable percentage of time spent on double support compared to the sample examined in the present study. These differences observed between average values may be related to the fact that the aging process is influenced by social and cultural factors (Freire Junior, Fernandes, Borges, Guerra, & de Abreu, 2018; Freire, Pieruccini-Faria, & Montero-Odasso, 2018; Mendes, Gusmão, Mancussi e Faro, & Leite, 2005), which emphasize the relevance of the present study in the identification of gait values observed in the Brazilian population, allowing reference values to be established for Brazilian research and clinical practice.

In a Brazilian study that evaluated gait variables, the sample was divided into five-year age groups (65–69, 70–74, 75–79, and > 80 years old), but the objective of the investigation was not to find out what gait parameter had the greatest correlation with aging (Kirkwood, Gomes, Sampaio, Furtado, & Moreira, 2016). Also, the participants older than 80 years were allocated to the same

group (Kirkwood et al., 2016). Conversely, the present study identified that the variables gait speed and step length seem to be the factors most influenced by the aging process, both in the assessment of usual gait and in the assessment of fast gait, unlike other investigations which did not intend to examine this aspect. This finding is relevant, given that gait speed is an important clinical parameter because it is easily assessed in clinical practice. In addition to involving a simple and fast evaluation, it can be readily measured using a stopwatch (Verghese, Holtzer, Lipton, & Wang, 2009).

Gait speed is mainly determined by spatiotemporal variables of step cadence and length. Thus, a person can change his gait speed by changing one of these variables separately or both of them combined (Howard, Wallace, & Stokic, 2013). According to the present findings, increased age had a greater influence on gait speed and step length, suggesting that the reduced gait speed during the aging process can be mainy attributed to a reduction of step length (spatial variable). Thus, it is plausible to consider that the strategy of increasing step length may be more effective than increased cadence in improving gait speed in the older population.

Gait speed is easily measurable and a potentially modifiable risk factor (Dickstein, 2008). According to Middleton, Fritz, and Lusardi (2015), the assessment of gait speed is so important that this variable can be considered to be the sixth vital sign. Oh-Park, Holtzer, Xue, and Verghese (2010) suggested reference values for the usual gait of adults older than 70 years, New York residents, but did not include older subjects at the onset of aging (before age 70). The suggested values were approximately 1.1 m/s for men and women aged 70–74 years, 1.1 m/s for men aged 75–79 years, 1.0 m/s for women aged 75–79 years, and approximately 1.0 m/s for both sexes starting at 80 years of age. However, our findings did not confirm these values since we detected greater gait speed values among subjects under 80 years of age (1.21 m/s) and lower values among subjects older than 80 years (80 to 89 years: 0.99 m/s and 90 years or more: 0.73 m/s), a fact possibly suggesting that Brazilian older subjects suffer a greater negative influence on gait speed after 80 years of age than older adults living in New York. In addition, Oh-Park et al. (2010) did not intend to evaluate gait with fast speed.

Bohannon (1997) suggested reference values for maximum gait speed for persons aged up to 79 years, with a value of 1.93 m/s for men aged 60 to 69 years and a value of 2.07 m/s for men aged 70 to 79 years. In contrast, the value for women aged 60 to 79 years was 1.7 m/s. The fast gait values reported by Bohannon for women are similar to those obtained in the present study (1.68 m/s). This may have been because most of our sample consisted of women. In contrast to the study by Bohannon, our results also suggest reference values of fast gait speed for subjects older than 80 years which could be used during the evaluation of the oldest-older adults in clinical practice.

The comparison of older adults of different age groups, including oldest older, is extremely important since, even though we know that increasing age negatively affects the gait of older adults (Callisaya et al., 2010; Chui & Lusardi, 2010; Herssens et al., 2018), the aging process is heterogeneous. Thus, understanding the chronologic influence of age on the gait parameters can guide the health professionals in a more specific manner when they consider each phase of aging.

One of the reasons for a short step length during gait (usual or fast gait) among older adults over 80 years could be an increase in the eccentric activity of the femoral quadriceps muscle during the final phase of double support, or an increase in the eccentric activity of the hamstring muscles during the final balance phase which occurs with increasing age (Abreu & Caldas, 2008). Another hypothesis for this finding is that older adults tend to fatigue the dorsiflexor muscles faster and, since this is an important marker of impairment of motor function in older adults, it may adversely affect gait performance (Justice, Mani, Pierpoint, & Enoka, 2014).

Step by step variability, measured by the coefficient of variation (CoV), is a measure of the reproducibility of the coordinated movements of the limbs from one stride to the next during gait. Gait is one of the most repetitive actions performed by a person during daily life, and the normal fluctuation of the variability of stride time is usually < 3% among healthy adults (Beauchet et al., 2009; Hausdorff, 2004). In the present study, walking at usual gait speed, older adults aged 60 to 79 years showed 3.47 ± 1.9% fluctuation in the variability of stride time, whereas older adults aged 80 to 89 years and 90 and 102 years showed values of 4.62 ± 2.8% and 6.11 ± 3.5%, respectively. Higher variability has been shown to be associated with increased risk of falls (Toebes, Hoozemans, Furrer, Dekker, & van Dieen, 2012; Verghese et al., 2009) and with some diseases (Herman, Mirelman, Giladi, Schweiger, & Hausdorff, 2010). However, when the gait with fast speed was evaluated, all groups showed increased fluctuation in the variability of stride time, greater than usual gait, except for the group of 90 years old and over. Regarding the fluctuation of stride time, the group of older adults aged under 80 years showed values of 4.84 ± 2.1%, the group of older adults aged 80 to 89 years showed increased values of 6.28 ± 3.5%, and older adults over 90 showed a value of 5.55 ± 2.7%.

The present study provides more information about the aging process in oldest people (those over 80 years), including centenarians. However, the study has some limitations: older people using a walker as an auxiliary device or who were institutionalized were not evaluated. In addition, the study sample included a lower number of males because they had difficulty participating in the study and following the study design.

5. Conclusion

The findings of the present study showed that there are differences in the gait performance of older adults from different age groups for usual gait speed and fast gait speed which allow the identification of the damage that age can cause to gait, which is more evident regarding gait speed and step length variables. However, usual gait showed higher effect size values than those for fast gait speed in all variables analyzed. Therefore, we recommend the use of usual gait for the identification of the effects of aging because it is more comfortable and requires less effort from older subjects, especially older and debilitated subjects who have a higher risk of falling. Therefore, usual gait may be used preferentially in clinical practice.

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