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Walking speed of older people and pedestrian crossing time

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ABSTRACT

Background: Traffic lights that regulate the pedestrian crossings in Sao Paulo, Brazil are programmed to consider a standard walking speed of 1.2 m/s (m/s). However, the frequently slower walking speed of the elderly may make it difficult for them to cross the streets safely and contribute to their social seclusion.
Objectives: To assess the walking speed of older people living in the community and to compare the results with the international standards for pedestrian crossing.
Design: A cross-sectional, population-based study.
Setting and Participants: A probabilistic sample of 1191 individuals aged 60 years or more, living in the city of Sao Paulo, Brazil, in 2010.
Measurements: Walking speed was directly measured using a physical test, and was dichotomously classified using two cut-off points: 1.1 and 0.9 m/s. Interviews informed covariates on socio-demographic characteristics and health status.
Results: Vast majority (97.8%) of older adults in Sao Paulo walks at a slower pace than is currently demanded by the lights at the pedestrian crossings (1.2 m/s). This proportion remained practically unchanged (95.7%) when a standard pedestrian walking speed of 1.1 m/s is considered. Reducing the reference speed to 0.9 m/s would narrowed this proportion to 69.7%. Women, light-skinned blacks, poorly educated individuals and those with poorer health were more likely to walk at a slower pace than is required by traffic lights at the pedestrian crossings in the city.
Conclusions: Overwhelming majority of older adults living in Sao Paulo cannot cross streets at their own walking speed. Therefore, there is an urgent need for modifying the traffic environment to prevent accidents involving vulnerable pedestrians and promote urban mobility.

1. Introduction

The reduced walking speed of older people may put them at risk while crossing the streets. Crossing time allowed by the pedestrian lights may not meet the needs of these individuals, and may increase the risk of injury by accidents and foster social isolation. Although several studies have attempted to address this problem, how socio-demographic characteristics and physical factors contribute to this issue is not well understood (Asher et al., 2012; Romero-Ortuno et al., 2010; Hoxie and Rubenstein, 1994; ITF, 2012).

Mobility is an important skill for autonomous individuals (Satariano et al., 2014). For the elderly population, walking is important related for health and social interaction, and a reduced walking speed is considered a strong predictor of adverse

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outcomes such as mortality and functional decline (Abellan van Kan et al., 2009). The reduced walking speed of older people has been reported to be associated with slow decision-making, as well as visual and hearing impairments (Asher et al., 2012; Holland and Hill, 2010). Furthermore, mobility is also important for safely crossing the streets (Pooley et al., 2014).

The Sao Paulo Company of Traffic Engineer (CET-SP) regulates the crossing time for pedestrians according to the crosswalk distance. The crossing time is calculated considering a walking speed of 1.2 m/s (m/s) (Ejzenberg, 2011), an international standard adopted in several countries and cities, as England and Ireland (Asher et al., 2012; Romero-Ortuno et al., 2010), South Africa (Amosun et al., 2007) and the USA. The flashing red lights, which assumes a higher walking speed (1.4 m/s) and time to traverse half the distance of the crosswalk, allows additional crossing time. However, these standards do not address the needs of the elderly population, putting them at risk and stress (Asher et al., 2012; Romero-Ortuno et al., 2010). Taking this into consideration, the CET-SP suggested that a reduced reference walking speed of 1.1 m/s be considered in Sao Paulo, as already had been adopted in New York City (Cucci Neto et al., 2010), which allows a longer crossing time and improves safety in crosswalks. Two Spanish cities (Valencia and Barcelona) reduced the reference walking speed to 0.9 m/s, considering the importance of a longer time in crosswalks in an ageing society (Romero Ortuño, 2016). Our study focused both these parameters (1.1 and 0.9 m/s) as reference speed in crosswalks of the biggest city in Brazil, and assessed the ability of the older population in complying with these standards.

The elderly population need longer pedestrian crossing times because of a reduction in walking speed associated with aging (Bohannon, 2008). Yet, few studies have assessed the pedestrian traffic issues involving the elder population in Brazil (Freire Júnior et al., 2013; Fiorelli et al., 2015). A previous study assessed gait speed in a representative sample of older adults in Brazil (Busch et al., 2015). However, no study assessed walking speed of the elderly in relation to the time given by pedestrian lights. Thus, the objective of this study was to assess the walking speed of older people in São Paulo, in terms of their ability to comply with the two international standards that regulate pedestrian crossing lights.

2. Methods

2.1. Database

The Health, Well-being and Ageing Study (Lebrão and Laurenti, 2005) (SABE is the acronym in Portuguese) is a longitudinal study involving a home-based probabilistic sample of older adults in the city of Sao Paulo, Brazil. The initial sample was obtained in the year 2000 using a multi-stage design, which aimed to statistically analyze the urban population of 60 years of age or more. The primary and secondary sampling units were the city's census tracts and the households, respectively. All individuals over 60 years of age living in these households were eligible for the study, and the total number of participants was 2143.

This study examined the cross-sectional data gathered during the third wave of this cohort in 2010. Among those who participated in 2000, 748 survivors who were located in 2010 agreed to continue their participation. Of the 298 new participants aged 60–64 years and enrolled in 2006, 241 who were located in 2010 agreed to continue participating. Additionally, 355 new participants aged 60–64 years were included in 2010, thus the total number of participants was 1344 individuals. Sample weights applied in 2000 were reassessed in 2010 to allow statistical inferences for older adults in the city.

Information was collected using a structured questionnaire and by physical tests performed at home and monitored by a visiting health professional. The database included socio-demographic characteristics and health conditions. Further details of the procedures used for sampling and data collection have been reported previously (Albala et al., 2005). The SABE Study adhered to the international standards of ethics in research involving human subjects, and was approved by the National Committee for Ethics in Research.

2.2. Main outcome and covariates

Walking speed, defined as the speed at which individuals walk at sidewalks, was the main outcome of this study. Participants were asked to walk three meters at their normal pace (Guralnik et al., 1994). The test was not carried out if they felt it was unsafe to do so or if they needed aid to walk. The test was done twice and the results were averaged. The outcome was dichotomously categorized according to the cut-off proposed by the CET-SP as the new standard to regulate the pedestrian lights (1.1 m/s). We also used an alternative categorization (0.9 m/s), according to the standard pedestrian crossing time adopted in Barcelona and Valencia, Spain (Romero Ortuño, 2016). These cut-off points were used to assess the differences in factors associated with reduced walking speed among the elderly population.

Among the socio-demographic characteristics, gender (male/female), age (60–69, 70–79 and 80 or more years old), race/ethnicity and educational level (illiterates, one to three years of formal education, four to seven and eight or more) were assessed. The criteria established by the official agency for demographic analysis in Brazil (the Brazilian Institute for Geography and Statistics) was used for the classification of race/ethnicity and referred to the answer of participants to the direct question about their race/ethnicity (Travassos and Williams, 2004). "White" referred to population of European descent; "black" referred to those of African descent. Because of miscegenation is a prominent characteristic of the Brazilian population, the category "light-skinned" was prevalent among blacks.

Health perception was classified as very good or good, regular, and poor or very poor. Six non-communicable diseases (diabetes, arterial hypertension, pulmonary obstructive chronic disease, stroke, depression and arthrosis) were assessed according to the answer to a direct question ("have a doctor already said that you suffer from any of the following diseases?"). Participants were categorized as having no non-communicable conditions (NCC), one NCC and two or more. Functional limitation was assessed by examining the impairment in one or more Activities of Daily Life (ADL) (feeding, bathing, dressing and using the bathroom) and one or more Instrumental Activities of Daily Life (IADL) (housework, preparing meals, taking medicines, taking care of money, buying foods, and using the telephone). Grip strength, a measurement of functional ability, was parametrically assessed and subsequently dichotomized according to the mean (19.7 kg for women and 33.3 kg for men).

2.3. Statistical analysis

Statistical analysis was performed using Stata 13.0, 2013 (StataCorp, College Station, TX, USA), and considered sampling weights and the structured, complex sample design. The descriptive assessment of walking speed across covariates used the Rao-Scott Chi-square. Logistic regression models assessed unadjusted and adjusted associations between the walking speed and covariates.

3. Results

In all, the third wave of the SABE study in 2010 enrolled 1344 participants. Accounting for a sample loss of 11.4%, 91 of them refused to be visited by the health professional in their homes, and 62 preferred not to undergo the physical test. A total 1191 individuals (60.1% of them were women) fully participated in the study; i.e., they answered the questionnaire and performed the walking speed test. The mean age of participants was 70.1 years (95% Confidence Interval 68.8; 71.3). Their mean walking speed was 0.75 m/s (95%CI 0.73; 0.84) (median = 0.72 m/s).

The current regulation of the pedestrian lights was unfavorable to an overwhelming majority (97.8%) of the participants; i.e., their walking speed was below 1.2 m/s. This proportion remained practically unchanged (95.7%) when the reference speed was reduced to 1.1 m/s. Table 1 shows this proportion according to the study covariates. A significantly higher proportion of females, older individuals, those with less education and those with reduced grip strength were unable to cross the streets at their own pace in the city.

Additionally, data in Table 1 shows that the walking speed of those who reported difficulties in ADL (15.1%) was lower than is demanded by the pedestrian lights. Walking speed that allowed pedestrian crossing was less prevalent among seniors with a reduced grip strength (48.9%) and those with difficulties in IADL (40.3%).

When a new cut-off (0.9 m/s) was considered as reference the same covariates were found significantly associated with a slower walking speed for pedestrian crossing. However, the slower speed requirement allowed a higher cross-section of the participants to fall in the safe category (30.3%) (Table 1).

Tables 2 and 3 shows the unadjusted and adjusted assessment of associations, respectively, for different cut-off values of walking speed. The unadjusted assessment of associations depicted socio-demographic factors that significantly influenced the prevalence of slower speed for both the cut-off values. Irrespective of the standard adopted in the comparison; i.e., 1.1 or 0.9 m/s, women, older subjects and less instructed individuals tended to walk at a slower speed than their respective counterparts (Table 2).

Among the covariates assessing health status, the number of NCC, self-reported difficulties in ADL and in IADL, and a decreased grip strength were significantly associated with reduced walking speed, independently of the cut-off adopted for comparison (Table 2).

When a standard walking speed of 1.1 m/s was considered to regulate the pedestrian lights, the multiple regression model revealed conditions that jointly contributed to a slower walking speed: poor education and reduced grip strength (Table 3). When the alternative standard walking speed (0.9 m/s) was considered, the same covariates were significantly associated with a poorer outcome. In addition, women, light-skinned blacks, and those reporting two or more NCC also showed higher odds of being unable to cross streets safely (Table 3). Age was not significantly associated with the outcome after adjusting for the remaining factors.

4. Discussion

This study revealed that even when considering the new, slower standard walking speed (1.1 m/s) in the crosswalks proposed to the city, older people are unable to cross streets at safe in Sao Paulo, Brazil. As has been previously reported (Asher et al., 2012; Romero-Ortuno et al., 2010; Amosun et al., 2007; Langlois et al., 1997), this standard is insensitive to aging-associated characteristics, such as reduced walking speed, shorter step size, slower decision-making processes, postural instability, and visual and hearing impairment (Zito et al., 2015). In addition to the risk of accidents, difficulties at crosswalks may contribute to the seclusion and restricted social interaction of older individuals.

Independent of socio-demographic or health characteristics, vast majority of older people residing in the city were

Table 1
Distribution of older people according to walking speed and socio-demographic characteristics, behavior and health status (n= 1119). São Paulo, 2010.

	Percentage	Walking speed < 1.1 m/s	P-value	Walking speed < 0.9 m/s	P-value
Total		95.7		69.7	
Socio-Demographic Characteristics					
Gender					
Male	39.9	93.6	0.019	63.4	0.001
Female	60.1	97.1		73.8	
Race/ethnicity					
White	58.0	94.4	0.097	67.3	0.003
Light-skinned black	36.2	97.3		75.2	
Dark-skinned black	5.8	98.3		59.1	
Age groups					
60–69	55.1	94.2	0.029	64.5	0.001
70–79	30.5	96.7		74.4	
80+	14.4	98.9		78.3	
Educational level					
8 years or more	27.1	90.5	< 0.001	53.7	< 0.001
4–7 years	38.4	97.1		73.0	
1–3 years	23.0	97.3		77.6	
Illiterates	11.5	99.6		80.1	
Health Status					
Health perception					
Very good or good	49.6	93.1	0.002	62.9	< 0.001
Regular	42.9	97.9		77.6	
Poor	7.5	99.0		73.4	
Number of Non-Communicable Diseases					
None	16.2	94.1	0.003	57.1	< 0.001
One	28.0	91.9		64.7	
Two or more	55.8	98.0		75.9	
Difficulties in ADL					
None	84.9	94.9	0.035	68.2	0.010
One or more	15.1	100.0		76.5	
Difficulty in IADL					
None	59.7	93.8	< 0.001	62	< 0.001
One or more	40.3	98.5		80.6	
Grip strength					
Average or higher	51.5	93.0	< 0.001	58.9	< 0.001
Lower than the average	48.9	98.6		82.4	

P-values assessed by the Rao-Scott test.

unable to walk at the standard speeds used (1.2 m/s) or at the newly proposed standard (1.1 m/s) that determine the time allowed by the traffic lights for pedestrian crossing. A study conducted by Asher et al. (2012) in the UK, where pedestrian crossings are also regulated by the speed of 1.2 m/s, had arrived at similar conclusions. A separate study conducted in Spain (Romero Ortuño, 2016), which assessed individuals aged 75 or more, concluded that 0.7 m/s would be a more reasonable standard. However, the authors concluded that nearly three quarters of women and two thirds of men would not meet this standard.

Ageing has an impact on the proportion of older adults in large urban centers, and there is increasing financial and human costs associated with traffic accidents involving older pedestrians (ITF, 2012; O'Hern et al., 2015). Many older individuals are able to pick up their pace in crosswalks, and they may count on the benevolence of drivers, who would not run over instantly after the traffic lights have changed. However, it is not sensible to rely on these factors exclusively and leave the majority of the elderly, as well as children and disabled unable to cross the streets at their usual pace.

The additional time given by flashing red lights contributes to safety in crosswalks. However, flashing red lights are regulated considering accelerated pacing and insufficient time to traverse the crosswalk. Rantakokko et al. (2009) observed that slow walking speed and unfavorable street conditions enhanced the fear of older people in moving outdoors, limiting their functioning. Notwithstanding the contribution of flashing red lights, they are also a source of anxiety and stress. We argue that the time given by the green light to pedestrian crossing should be more considerate of the ability of older individuals living in the city.

The results reported here corroborate previous studies and strongly argue in favor of the need for reforming the traffic system, specifically regarding the regulation of time allowed by traffic lights at pedestrian crossings (Asher et al., 2012; Amosun et al., 2007; O'Hern et al., 2015). This study also identified socio-demographic characteristics and health conditions that are associated with slower walking speed, providing important information regarding those groups who are at a higher risk of accidents when crossing the streets.

The odds of having a slower walking speed increased with age in the unadjusted assessment of association. When the associations were adjusted for covariates assessing health status (number of NCC and grip strength), the association

Table 2
Unadjusted assessment of association between walking speed and socio-demographic characteristics, behavior and health status of older people. São Paulo, 2010.

	Walking speed < 1.1 m/s		**Walking speed < 0.9 m/s**	
	Unadjusted OR	95% Conf. Interval	Unadjusted OR	95% Conf. Interval
Socio-demographic Characteristics				
Gender				
Male	1		1	
Female	2.29	1.13;4.63	1.63	1.29;2.07
Race/ethnicity				
White	1		1	
Light-skinned black	2.15	0.92;5.03	1.47	1.12;1.94
Dark-skinned black	3.39	0.43;26.6	0.70	0.42;1.16
Age groups				
60–69	1		1	
70–79	1.93	0.81;4.59	1.60	1.12;2.27
80+	5.42	1.63;18.0	1.99	1.46;2.71
Educational level				
8 years or more	1		1	
5–7 years	3.53	1.51;8.23	2.33	1.61;3.39
1–4 years	3.82	1.44;10.1	2.99	1.93;4.61
Illiterates	25.37	3.40;189.1	3.48	2.28;5.30
Health Status				
General Health				
Very good or good	1		1	
Regular	3.51	1.40;8.79	2.05	1.53;2.74
Poor	6.95	0.87;55.58	1.63	1.03;2.58
Number of Non-Communicable Diseases				
None	1		1	
One	0.71	0.24;2.09	1.38	0.92;2.05
Two or more	3.12	1.20;8.08	2.36	1.59;3.50
Difficulty in ADL				
None	1		1	
One or more	–	–	1.52	1.11;2.08
Difficulty in IADL				
None	1		1	
One or more	4.34	1.83;10.32	2.54	1.94;3.33
Grip strength				
Average or higher	1		1	
Lower than the average	5.33	2.28;12.47	3.78	2.38;4.51

Odds ratios and confidence intervals directly assessing the association between the outcome (lower walking speed of older adults living in São Paulo) and each selected characteristic, as not adjusted for the remaining covariates.

between age and walking speed became statistically non-significant. This finding suggests that the effect of age on walking speed depended on the fading of physical conditions that affects older individuals. This is in agreement with the study by Asher et al. (2012), who concluded that walking difficulties affect individuals with a reduced functional ability to a greater extent.

The odds of having a slower walking speed were higher for women; it also differed among ethnic and educational strata. The lower walking speed of light-skinned blacks may reflect the socioeconomic disparities affecting health rather than the biological differences between individuals of different ethnic background, particularly because it has been reported that older black individuals live in poorer neighborhoods in the city of Sao Paulo (Avineri et al., 2012). Socio-demographic characteristics are not modifiable conditions (Avineri et al., 2012); however, their association with health outcomes is relevant to the prevention programs. Understanding which groups mostly face difficulties to maintain outdoor mobility in the urban environment is important for the safety education of pedestrians and may help promote practices that reduce the risk of road-related injury (Duperrex et al., 2002).

This study also found that a larger proportion of the older individuals would be able to safely cross the streets if the standard speed that regulate the traffic lights was 0.9 m/s. This condition would provide additional time for pedestrian crossings and allow nearly 30% of the older individuals to walk at their usual pace in crosswalks. According to an NGO that promotes walkability in Sao Paulo, in addition to older citizens, disabled individuals and parents carrying a child also need extra time to cross the streets (Cidadeapé, 2015). The new standard would benefit these groups. This is supported by other studies that considered children and older pedestrians as vulnerable road users (ITF, 2012; Zito et al., 2015; Eid and Abu-Zidan, 2015).

Although the international (WHO, 2015) and national (Brasil, 2008) statutes of traffic regulation clearly state that pedestrians must be respected and privileged over any other means of transport, several studies concluded that the walking speed of older people and the pedestrian crossing time do not match (Asher et al., 2012; Romero-Ortuno et al., 2010; Hoxie

Table 3
Associated factors with walk speed lower according to estimated pedestrian crossing time in Brazilian older. São Paulo, 2010.

	Walking speed < 1.1 m/s		**Walking speed < 0.9 m/s**	
	Adjusted OR	95% Conf. Interval	Adjusted OR	95% Conf. Interval
Socio-demographic characteristics				
Gender				
Male	–		1	
Female	–		1.39	1.05; 1.85
Race/ethnicity				
White	–		1	
Light-skinned black	–		1.38	1.02; 1.86
Dark-skinned black	–		0.73	0.40; 1.33
Age groups				
60–69	1		1	
70–79	1.05	0.43; 2.56	1.09	0.77; 1.54
80+	1.34	0.40; 4.52	1.15	0.74; 1.78
Educational level				
8 years or more	1		1	
5–7 years	2.91	1.26; 6.87	1.96	1.30; 2.95
1–4 years	2.47	1.00; 6.10	2.07	1.30; 3.29
Illiterates	8.46	1.08; 66.35	2.16	1.35; 3.46
Health Status				
Number of non-communicable diseases				
None			1	
One			1.33	0.83; 2.14
Two or more			1.86	1.20; 2.89
Grip strength				
Average or higher	1		1	
Lower than the average	3.35	1.50; 7.51	3.25	2.26; 4.69

Odds ratios and confidence intervals assessed by multivariable models, which adjusted the association between the outcome (lower walking speed of older adults living in São Paulo) and each selected characteristic for the remaining covariates included in the model.

and Rubenstein, 1994; Dommes et al., 2012; Arango and Montufar, 2008). Martin et al. (2010) and Oxley and Fields (Oxley and Fildes, 1999) have pointed out the high fatality rate of road traffic accidents involving older pedestrians. That most of these accidents occurred in daylight, with good visibility and favorable weather conditions suggests that prevention strategies must target the whole traffic environment.

Some measures aimed at protecting the pedestrians are already being implemented in Brazil and other countries. These measures include reduced speed limits for cars, law enforcement and penalties (WHO, 2015; Brasil, 2008; Diretoria de Planejamento Projetos e Segurança de Trânsito de São Paulo, 2015); educational policies targeting specific age-groups have also been recommended (ITF, 2012; Rus et al., 2015). Hong Kong has adopted an innovative measure: sensors installed in traffic lights recognizes the "smart card" carried by the aged and disabled and extend the crossing time (Ng, 2016).

Assessment of a probabilistic sample of older people living in the community of a large Brazilian city is the main strength of this study. The absence of a consensus on how to measure the walking speed of older people is its main limitation. Earlier studies conducted with a similar objective asked individuals to walk different distances to evaluate their waking speed. However, Bohannon (Romero Ortuño, 2016) reported a strong correlation ($r=0.933$; $p<0.001$) between walking speed measured at short (8 feet) and long distances (20 feet).

In summary, currently, the time allowed by pedestrian lights in São Paulo does not insure the safety of the older individuals while crossing streets at their usual pace. In addition to initiatives such as the revised reduced speed limits for vehicles already being implemented by the municipal authorities, the results reported here urge for further modifications in the traffic system. Implementation of an appropriate slower standard walking speed to regulate the pedestrian lights will help promote mobility and social inclusion of older individuals living in the community.

Conflicts of interest

None declared.

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