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Walking speed and home adaptations are associated with independence after stroke: a population-based prevalence study

Velocidade de marcha e adaptações no domicílio estão associadas à independência pós-acidente vascular cerebral: estudo de prevalência de base populacional

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Abstract *This study aimed at estimating the prevalence of stroke in older adults in Brazil, and at identifying the sociodemographic, health-related, health service-related, and environmental factors associated with independence in daily activities. Across-sectional, population-based study (Brazilian Longitudinal Study of Aging 2015-2016) was conducted. 536 individuals (≥ 50 years), from 9,412 participants, have had stroke and were included. Prevalence of stroke was 5.3% among individuals aged 50 years and over, increasing up to 8.0% among individuals aged 75 years and over, showing a dissimilar pattern between sex. Independence was associated with walking speed (Prevalence Ratio (PR) 2.72, 95%CI: 1.96 to 3.77), physical activity (PR 1.24; 95%CI: 1.04 to 1.47) and use of walking devices (PR 0.63; 95%CI: 0.41 to 0.96). A significant interaction was found between walking speed plus home adaptations and performance of daily living activities (PR 3.42; 95%CI: 1.04 to 11.29). The probability of independence was 40% among slow walkers (< 0.4 m/s), increasing up to 70% among fast walkers (> 0.8 m/s), and to 90% among those who also have home adaptations. Faster walking speed combined with home adaptations was the main factor associated with long-term independence after stroke.*

Key words *Activities of daily living, Cerebrovascular disease, Gait, Prevalence, Rehabilitation*

Resumo *Objetivou-se estimar a prevalência do acidente vascular cerebral (AVC) em brasileiros mais velhos, bem como identificar fatores sociodemográficos, de saúde, de serviços de saúde e ambientais associados à independência em atividades de vida diária. Trata-se de um estudo transversal de base populacional (Estudo Longitudinal da Saúde de Idosos Brasileiros 2015-2016). Dos 9.412 participantes, 536 indivíduos (≥ 50 anos) tiveram AVC e foram incluídos. A prevalência do AVC foi de 5,3% em indivíduos com 50 anos e mais, aumentando para 8% entre indivíduos com 75 anos e mais, com padrão dissimilar entre sexo. A independência foi associada à velocidade da marcha (razão de prevalência [RP] 2,72, IC95%: 1,96-3,77), atividade física (PR 1,24; IC95%: 1,04-1,47) e uso de dispositivos auxiliares de marcha (RP 0,63; IC95%: 0,41-0,96). Encontrou-se interação significativa para velocidade da marcha, adaptações no domicílio e a independência (RP 3,42; IC95%: 1.04-11.29). A probabilidade de independência foi de 40% nas velocidades mais baixas (< 0,4 m/s), e nas velocidades mais elevadas (> 0,8 m/s) foi de 70%, aumentando para 90% quando há adaptações no domicílio. A velocidade rápida da marcha e a adaptação no domicílio foram os principais fatores associados à independência a longo prazo após o AVC.*

Palavras-chave *Atividades de vida diária, Doença cerebrovascular, Marcha, Prevalência, Reabilitação*

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Introduction

Stroke is the second cause of death and a leading cause of long-term disability worldwide[1,2], with incidence rates predominantly higher among individuals aged over 50 years[3]. Stroke incidence has declined in the past four decades in high-income countries, but its incidence has doubled in older individuals living in low- and middle-income countries[4-6]. Worldwide, stroke accounted for 12% of the burden of disability-adjusted life years, in 2010[5], mainly concerning men and those aged 70 years and over[6]. As the world's population ages and the survival rates after stroke increase, a higher number of individuals is expected to experience limitations to perform activities of daily living, such as walking and bathing.

Given the heterogeneity of stroke, the "one size fits all" approach is ineffective for implementing worthwhile interventions. This means that some individuals who have had stroke may benefit from specific interventions, while some individuals may benefit from others, based upon personal and environmental characteristics. Therefore, comprehending the epidemiological characteristics in sub-groups of individuals with stroke, and identifying factors related to a long-term independence in activities of daily living can help target intervention to the patients who will most benefit[7,8]. Ideally, we would identify factors, which reliably explain the ability to perform those activities, such as walking across a room, dressing, bathing, eating, get-in and up the bed, and toileting[9]. This information would be useful to optimize rehabilitation, to improve the design and analysis of clinical trials, and to accurately inform patients of likely outcomes and prognosis[10]. There have been two systematic reviews, which examined factors associated with mobility[11] and upper limb recovery[10] after stroke, based upon small cohort studies. Most studies, however, included a limited variety of factors, had incomparable outcomes, focus on early-treatment after stroke, did not examine the influence of environmental factors, and constrained the results to a single activity (mostly walking), leading to unconvincing clinical recommendations. In addition, the sample in most exploratory studies was typically not randomly selected and may not, therefore, be fully representative of the stroke population.

The aims of the present study were to estimate the prevalence of stroke and to identify the factors associated with independence to perform activities of daily living in a nationally representative, population-based study of individuals aged 50 years and over. The specific research questions were: (1) What is the prevalence of stroke among community-dwelling individuals aged 50 years and over, and in sub-groups stratified by age and sex?; (2) Which factors are associated with long-term independence to perform activities of daily living after stroke?

Methods

Design

A cross-sectional study was conducted. Baseline data of individuals who have had a stroke was extracted from the Brazilian Longitudinal Study of Aging (ELSI-Brazil), which is a nationally representative, population-based cohort study of individuals aged 50 years and over, conducted between 2015 and 2016.

A probabilistic sample design, which applied a sampling procedure combining geographical stratification and a two- or three-stage clustering, based upon the population size, was conducted, considering 70 municipalities from the five great Brazilian geographical regions. The cities were the primary sample units, followed by census tracts and households. The 2015-2016 ELSI-Brazil followed the standards set by the Declaration of Helsinki and was approved by the ethics board of the Oswaldo Cruz Foundation, Minas Gerais (CAAE 34649814.3.0000.5091). All participants signed an informed consent form.

Participants and procedures

All residents in the selected households aged 50 years and over were eligible. Individual interviews integrated a broad range of topics related to individuals' sociodemographic characteristics, health-related characteristics, health services, house characteristics, and home adaptations. A comprehensive set of physical measurements was also carried out at the respondents' home. The standardized study procedures are detailed in the ELSI-Brazil operations manual (available at the ELSI-Brazil homepage: http://elsi.cpqrr.fiocruz.br/en/). Detailed information of the ELSI-Brazil was previously published[12]. Ten thousand individuals aged 50 years and over were identified as potential participants of the ELSI-Brazil, and 9,412 individuals agreed to participate and were used to estimate prevalence. Five hundred thirty-six (536) individuals had a medical diagnosis

of stroke and were, therefore, included in the further analyses.

Outcomes

Prevalence of stroke among individuals aged 50 years and over was estimated using the standard population at the individual-level and adjusted for age and education[5], and to allow further comparisons. Overall and age- and education-adjusted prevalence was stratified by age cut-offs (i.e., 50+ years, 60+ years, 65+ years, and 75+ years) and sex (i.e., female and male), and reported as percentages using the total population (9,412 participants). These cut-offs were used to allow comparisons with international data[4,5,13].

The combined performance in six activities of daily living(i.e., walking across a room, dressing, bathing, eating, get-in and up the bed, and toileting),derived from the previously cross-cultural adapted Katz index[9], was the outcome of interest, measured by a self-reported interview. A proxy was invited when participants were unable to answer the questions. Those measurement procedures have been widely used in epidemiological studies[14] and all activities showed sensibility higher than 85% with the observation of health-professionals[15]. The participants were asked to rate their performance on each activity using a Likert scale (1 = no difficulty, 2 = little difficulty, 3 = great difficulty or 4 = unable to perform). The outcome of interest was dichotomized into independent or dependent. Participants who reported no difficulty or little difficulty to perform all six activities were classified as independent, and participants who reported great difficulty or were unable to perform one of the six activities were classified as dependent.

Associated factors

Potential factors were grouped as follows: sociodemographic characteristics, health-related characteristics, health services, and environment assistance.

Sociodemographic factors included: sex (female or male); age (years); education (0-3, 4-7, 8 or more years of schooling); and marital status (married/living with a partner or not married (i.e. single/divorced/widowed).

Health-related factors included:time since first stroke (years);walking speed, measured using the average of two performances during the 3-meter timedwalking test (m/s)[13], which shows high test-retest reliability, similar to a 6-meter course[16]; falls in the past 12 months (yes or no); chronic conditions, e.g.,hypertension, lung disease or cancer (number of conditions); body mass index, classified according to age[17,18] (normal or altered); and physical activity, measured using the short version of the International Physical Activity Questionnaire[19] (sedentary or active, according to the time (up to 150 minutes per week) spent on walking, moderate activities and vigorous activities)[20].

Health services factors included: hospitalization in the past 12 months (no or yes); medical visits in the past 12 months (no or yes); private health plan (no or yes); and use of rehabilitation services, i.e., physical therapy, in the past 90 days (no or yes).

Environment assistance factors included: home adaptations for people with limited mobility, e.g., handrails in the bathroom or ramps (no or yes); and use of walking devices, e.g., walker, cane, or crutches (no or yes).

Statistical analysis

Age- and education-adjusted prevalence of stroke was estimated using the standard population at individual-level and stratified by sex. Categorical data were reported using percentages, and continuous variables were reported using means and standard deviation (SD). Poisson regression models were used to estimate the prevalence ratios (PR) and their 95% confidence intervals to investigate the associations between each factor and independence to perform activities of daily living. Poisson regression provides direct estimates for the prevalence ratios that can be easily interpreted by non-epidemiologists.[21]Differences by grouped factors were performed separately, setting the level of significance at0.20 to ensure that potential adjusting factors were included. Associated factors from the initial analysis were included in the fully adjusted model using forward method and the level of significance was set at 0.05.F-corrected Wald statistic goodness-of-fit test were implemented to assess model fit after fitting the Poisson regression final model.

The predicted probability of independence according to the participants' walking speed was provided, based on the fully adjusted model. The exposed–population attributable fraction to walking speed was estimated according to the cutoffs proposed by Perry *et al.*[22]: < 0.4 m/s (housebound), 0.4m/s to 0.8 m/s (limited community ambulators), and > 0.8 m/s (unlimited community ambulators). Multiplicative inter-

action between walking speed and environment assistance factors were tested to examine whether interactions modify independence to perform activities of daily living. All analyses accounted for the complex survey design, included survey weights, and correction for subsampling. Analyses were performed using Stata 13 SE (Stata-Corp., College Station, Texas, USA).

Results

Flow of participants through the study

Five hundred thirty-six (536) individuals (255 men, 48%) from the initial 9,412 participants had a medical diagnosis of stroke and were, therefore, included in the present study. They had a mean age of 69 years (SD 11) and a mean time since the onset of the first stroke of ten years (SD 11). The level of walking disability (i.e., comfortable walking speed) ranged from 0 to 1.5 m/s, covering the spectrum of walking disability. Sixty-seven participants were unable to perform the walking test and had their walking speeds registered as 0.0 m/s. Thirty-nine participants refused to perform the walking test and were, therefore, excluded from analyses. Most of the participants were classified as independent to perform the six included activities either combined (n = 359, 67%), or separately: walking across a room (n = 441, 82%), dressing (n = 394, 74%), bathing (n = 425, 79%), eating (n = 484, 90%), getting-in and up the bed (n = 403, 76%), and toileting (n = 460, 86%).

Prevalence of stroke

The overall prevalence of stroke among individuals aged 50 years and over was 5.3% (95%CI: 4.7 to 5.9). Prevalence increased with age, achieving 6.1% (95%CI: 5.4 to 6.9) among individuals aged 60 years and over, and 8% (95%CI: 4 to 12) among individuals aged 75 years and over. A higher age- and education-adjusted prevalence was found in men aged 50 years and over (6.1%; 95%CI: 5.2 to 6.9), compared with women aged 50 years and over (4.7%; 95%CI: 3.9 to 5.4), which was maintained up to individuals aged 65 years and over. (Table 1).

Factors associated with independence to perform activities of daily living

Overall, eight potential factors were associated with independence to perform activities of daily living, in grouped analyses: two sociodemographic factors (education and marital status), two health-related factors (walking speed and physical activity), two health services factors (hospitalizations and medical visits), and two environment assistance factors (home adaptations and use of walking devices) (Table 2). In addition, age (p = 0.25) and falls in the past 12 months (p = 0.22), which were marginally associated with independence and previously suggested as important factors associated with independence[23], were also included in the fully adjusted model.

Three factors were independently associated with independence to perform activities of daily living in the fully adjusted model. A positive association was found between performance of daily living activities with walking speed (PR 2.72, 95%CI: 1.96 to 3.77), and with physical activity (PR 1.24; 95%CI: 1.04 to 1.47). A negative association was found between performance of daily living activities and use of walking devices (PR 0.63; 95%CI: 0.41 to 0.96) (Table 3).

A significant interaction was found between walking speed plus home adaptations and performance of daily living activities (PR 3.42; 95%CI: 1.04 to 11.29, p = 0.04). This means that the predicted probability of independence significantly varied according to walking speed and home adaptations. Among individuals with

Table 1. Overall and age- and education-adjusted prevalence of stroke (95% CI), according to sex and age cut-offs. The Brazilian Longitudinal Study of Aging, 2015-2016.

	Stroke Prevalence (%). Age			
Sex	50+ years (n = 9,412)	60+ years (n = 5,164)	65+ years (n = 3,592)	75+ years (n = 1,480)
Female	4.7 (3.9 to 5.4)*	5.2 (4.3 to 6.1) *	5.3 (4.0 to 6.6) *	6.6 (3.3 to 9.9)
Male	6.1 (5.2 to 6.9)	7.3 (6.0 to 8.6)	8.6 (6.7 to 10.4)	9.8 (4.3 to 15.2)
Overall	5.3 (4.7 to 5.9)	6.1 (5.4 to 6.9)	6.8 (5.6 to 8.0)	8.0 (4.0 to 12.0)

*Statistically different from male prevalence.

Source: The Brazilian Longitudinal Study of Aging, 2015-2016.

Table 2. Prevalence ratio (95% CI) and statistical significance (*p* value) for independence in activities of daily living according to groups of factors in older individuals, who have had a stroke. The Brazilian Longitudinal Study of Aging, 2015-2016.

Factors, by groups	Performance on activities of daily living (n = 536)		Prevalence ratio (95% CI); p value
	Independent (n = 353)	Dependent (n = 183)	
Sociodemographic characteristics			
Sex, %			
Female	48	50	Reference
Male	52	50	1.00 (0.84 to 1.18); $p = 0.99$
Age (years), mean (SD)	66 (12)	70 (16)	1.00 (0.99 to 1.00); $p = 0.25$
Education, %			
0 to 3 years	42	53	Reference
4 to 7 years	32	24	1.16 (1.00 to 1.36); $p = 0.05$
≥ 8 years	26	23	1.10 (0.94 to 1.28); $p = 0.25$
Marital status, %			
Married	61	52	Reference
Not married	39	48	0.90 (0.77 to 1.05); $p = 0.18$
Health-related characteristics			
Time since stroke (years), mean (SD)	10 (11)	10 (13)	1.00 (0.99 to 1.00); $p = 0.42$
Walking speed (m/s), mean (SD)	0.61 (0.37)	0.29 (0.37)	2.11 (1.58 to 2.82); $p < 0.01$
Falls in the past 12 months, %			
No	70	52	Reference
Yes	30	48	0.91 (0.78 to 1.06); $p = 0.22$
Chronic conditions (number), mean (SD)	2 (2)	2 (2)	0.98 (0.94 to 1.03); $p = 0.46$
Body mass index, %			
Normal	33	22	Reference
Altered	67	78	0.95 (0.84 to 1.08); $p = 0.45$
Physical activity, %			
Sedentary	33	74	Reference
Active	67	26	1.18 (1.00 to 1.40); $p = 0.06$
Health services			
Hospitalizations in the past 12 months, %			
No	79	64	Reference
Yes	21	36	0.70 (0.55 to 0.90); $p < 0.01$
Medical visits in the past 12 months, %			
No	26	33	Reference
Yes	74	67	1.17 (0.99 to 1.40); $p = 0.07$
Private health plan, %			
No	82	80	Reference
Yes	18	20	0.99 (0.84 to 1.17); $p = 0.93$
Use of physical rehabilitation services, %			
No	97	95	Reference
Yes	3	5	0.83 (0.50 to 1.39); $p = 0.48$
Environment assistance			
Home adaptations, %			
No	91	76	Reference
Yes	9	24	0.75 (0.56 to 1.00); $p = 0.05$
Use of walking devices, %			
No	92	55	Reference
Yes	8	45	0.35 (0.25 to 0.50); $p < 0.01$

The provided percentages are weighted according to the sampling parameters. The number of participants is not weighted according to the sampling parameters. Independent: participants who reported no difficulty or little difficulty to perform six activities of daily living i.e., walking across the room, dressing, bathing, eating, bed mobility and transfers, and toileting.

Source: The Brazilian Longitudinal Study of Aging, 2015-2016.

Table 3. Fully adjusted model with prevalence ratio (95%CI) of independence to perform activities of daily living in older individuals, who have had a stroke. The Brazilian Longitudinal Study of Aging, 2015-2016.

Factors	Fully adjusted model (n = 407)	
	Prevalence ratio	95% CI
Age (years)	1.00	0.99 to 1.01
Education		
0 to 3 years	Reference	
4 to 7 years	1.05	0.91 to 1.22
≥ 8 years	0.99	0.83 to 1.18
Marital status		
Married	Reference	
Not married	0.97	0.83 to 1.12
Walking speed (m/s)	2.72*	1.96 to 3.77
Falls in the past 12 months		
No	Reference	
Yes	0.91	0.76 to 1.08
Physical Activity		
Sedentary	Reference	
Active	1.24*	1.04 to 1.47
Hospitalizations in the past 12 months		
No	Reference	
Yes	0.88	0.73 to 1.07
Medical visits in the past 12 months		
No	Reference	
Yes	1.01	0.87 to 1.16
Home adaptations		
No	Reference	
Yes	0.98	0.80 to 1.20
Use of walking devices		
No	Reference	
Yes	0.63*	0.41 to 0.96

*$p < 0.05$; F-corrected Wald statistic goodness-of-fit test: 1.63, $p = 1.00$.

Source: The Brazilian Longitudinal Study of Aging, 2015-2016.

walking speed > 0.8 m/s, the predicted probability was significantly higher among those with home adaptations (93%; 95%CI: 83 to 100), in comparison with those with no home adaptations (72%; 95%CI: 66 to 79). Among individuals with walking speeds between 0.4 and 0.8 m/s, the predicted probability was 53% (95%CI: 51 to 56), and among individuals with walking speeds < 0.4 m/s, the predicted probability was 39% (95%CI: 33 to 44), regardless of home adaptations. Detailed information in Figure 1.

Discussion

This study aimed at estimating the prevalence of stroke among older adults and identifying the factors associated with independence to perform activities of daily living, based upon a cohort with 9,412 individuals. Overall, prevalence of stroke was 5.3% among individuals aged 50 years and over, increasing up to8% among individuals aged 75years and over, in 2015-2016. Faster walking speed combined with home adaptations enhance the probability of long-term independence after stroke.

This study examined stroke prevalence among older individuals, since90% of strokes occur among people over 50 years.[24] The findings are in accordance with previous studies[6,24], which demonstrated that stroke prevalence increases with advancing age in both men and women. In addition, the results highlighted that stroke prevalence among older adults aged 65 years and over was one of the highest across low- and middle-income countries[4]. According to the Prospective Studies Collaboration meta-analyses, occurrence of stroke is considerably reduced when systolic blood pressure is controlled[25]. Brazil demonstrates relatively high levels of prevention and monitoring of older people with hypertension due to a continuum of care from primary health teams (i.e. home visits, groups of physical activity, and free medication supply). However, blood pressure control is negatively influenced by low levels of schooling [26], poor health behaviors, such as sedentary lifestyle and alcohol consumption[27], and non-compliance to medication treatment[28].

An important finding of this study was that the age-related percentage increase on stroke prevalence had a dissimilar pattern between men and women. Prevalence linearly increased with aging among men but was roughly stabilized among women. Men are more likely to experience a stroke than women because of unhealth habits, such as alcoholism and smoking, which are risk factors for cardiovasculardiseases[24] and ineffective blood pressure control[26]. On the other hand, among individuals aged 75 years and over, prevalence was at the highest level, and became similar in men and women. Because in Brazil, the current life expectancy is 80 years for women and 72 years for men (www.ibge.gov.br), there are more women with stroke living in later

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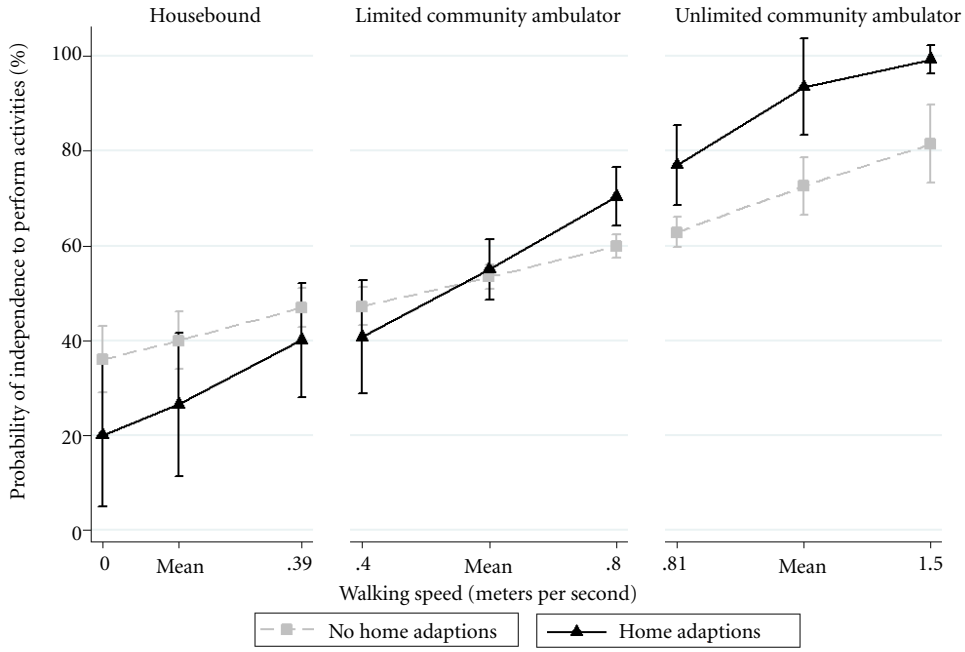

Figure 1. Predicted probability of independence to perform activities of daily living according to walking speed cut-offs (housebound, limited community ambulators, and unlimited community ambulators) and home adaptations, in older individuals who have had stroke. The Brazilian Longitudinal Study of Aging, 2015-2016.

Source: The Brazilian Longitudinal Study of Aging, 2015-2016.

years. Overall, these results suggest that additional health strategies should be used for preventing stroke among men, and for increasing health monitoring and rehabilitation of older men and women, who have had a stroke.

The results indicated that individuals who walk faster, without assistive devices and are physically active might have less limitation to perform activities of daily living. All those factors have the potential to be enhanced even at chronic stages after stroke. Rehabilitation and exercise programs at Primary Health Care could focus on improving walking speed, as it showed to be the strongest factor for long-term independence after stroke. Relatively low-cost strategies such as walking training, and circuit training, which could be delivered individually or in groups, have positive effects on walking speed after stroke[29-31]. Unless the paretic upper limb is severely disabled, it is reasonable to believe that walking independence potentially increases the number of activities performed either at home or in the community. In addition, clinical measures of walking speed may be used for developing early interventions to help reduce the risk and burden of limitations on activities of daily living in older adults[32]. In our sample, the probability of independence in activities of daily living was around 40% among individuals categorized as housebound (walking speed < 0.4 m/s). This probability increased to about 70% among individuals who walk at faster speeds, and to around 90% among those who also have home adaptations. In addition, evidence suggests that individuals who walk faster tend to improve levels of physical activity and reject walking assistive devices[33,34]. Therefore, health public strategies aiming at motivating able-bodied older adults to increase walking speed and levels of physical activity should be adopted for prevention of stroke and rehabilitation of disabilities related to stroke.

In Brazil, the National Health Promotion Policy and the Active Aging Policy[35] have included physical activity as one of the public priority axes for promoting social participation and preventing chronic diseases, but a comprehen-

sive long-term care policy for older adults is still needed[36]. The results of this study suggested that a combination of faster walking speed and home adaptations might potentialize independence to perform daily living activities. Therefore, further health public strategies should include not only rehabilitation of physical disabilities, but also promote evaluations and modifications of the living environment, easily implemented by professionals from primary health care. Previous studies[37] have indicated that home environment adaptations positively impact functioning at older ages, but they have been used as a treatment rather than a preventive approach[38].

Study strengths and limitations

The current study has strengths and limitations. A major strength was a population-based, nationally representative sample derived from seventy municipalities from the five regions of Brazil. This ensures the external validity to the Brazilian community-dwelling older adults who have had a stroke and help guiding policymaking. Furthermore, this is the first nationally representative Brazilian study with older adults that included direct measures of walking speed and measures of environmental factors. On the other hand, this study only used baseline data, which did not allow causal relationships, and walking speed was not normalized by participants' length of lower limb or height. In addition, although self-reported information is the most valid method to access attitudes[39], there are potential biases inherent to the method, that could have influenced individuals' responses regarding performance ofactivities of daily living and level of physical activity.

Conclusion

In conclusion, this study revealed that prevalence of stroke was 5.3% among individuals aged 50 years and over, increasing up to 9.9% among individuals aged 75 years and over. Prevalence of stroke gradually increased with aging among men, but quickly increased among women aged 75 years and over. Faster walking speed combined with home adaptations was the main factor associated with long-term independence after stroke. Health public strategies should focus on improving walking activity and home environment aiming at long-term independence after stroke.

Collaborations

JL Torres and LR Nascimento: conceptualization, methodology, statistical analysis and first draft preparation. MF Lima-Costa and FB Andrade: funding acquisition, edited and wrote the final version. All authors critical reviewed, commented on subsequent drafts and approved the final manuscript.

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