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Built urban environment and functional incapacity: Enabling healthy aging☆

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ABSTRACT

Background: This study aimed to assess the associations among neighborhood walkability and functional disability in older adults.
Methods: The study included a community-based, random sample of 410 community-dwelling adults aged ≥60 years old in Viçosa, Minas Gerais, Brazil. The dependent variable was functional disability, which was assessed by investigating the difficulty in performing or the requirement of help to perform the activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Older adults with functional disability were those who reported difficulty in performing six or more activities or a complete inability to perform at least three activities. The environmental are also evaluated. Confounding variables were selected using directed acyclic graphs, and multilevel logistic regression models were used to test the associations between the variables.
Results: Older adults living in areas with higher walkability had lower odds ratios for functional disability, even after adjustment for possible confounding variables.
Conclusions: While additional research is required to evaluate these neighborhood features in more detail and determine the causality, promoting simple changes in the built environment may be more effective in minimizing disability as the population ages than the efforts to change risk factors at the individual level.

1. Introduction

The World Health Organization (WHO) defines "healthy aging" as a dynamic process that facilitates wellbeing in old age, and it considers functional capacity as one of the essential components for the health of the older adults (World Health Organization (WHO), 2015). The preservation, improvement, and rehabilitation of the functional capacity of the older adults assures them of their permanence in the environment and society in which they live, independently performing their activities even in the presence of health problems (Beard et al., 2016).

The rate of decline of functional capacity can be influenced and reversed at any age through individual and environmental interventions (Organização Mundial da Saúde (OMS), 2004; Verbrugge and Jette, 1994). However, from a political perspective,

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environmental elements have a more significant effect on the health and functionality of older people, since they are more sensitive to the home environment than the other age groups (Plouffe and Kalache, 2010; Yen et al., 2009). A comfortable environment for older adults may further reduce the extent and severity of the adverse effects of functional disability.

One way in which the physical environment can exert such effects on functionality is through its influence on physical activity and mobility. Neighborhood characteristics, such as walkability (an estimate of how well the environment is built for moving on foot or by bike), have often been associated with higher levels of physical activity among older people, particularly at the international level (Barnett et al., 2017; Talen and Koschinsky, 2013; Van Holle et al., 2014; Villanueva et al., 2014).

However, despite the close relationship between physical activity and disability there is little evidence of the effects of the walkability of neighborhoods on disability (Beard et al., 2009; Freedman et al., 2008). In addition, there have been no studies that have evaluated the index of walkability, but proxies of how walkable an area can be. Moreover, almost all the evidence relating to that proxies is obtained from a small number of cities in high-income countries. Considering the differences in the characteristics of the urban environment, the extrapolation of international results to Brazilian cities, especially small and medium-sized cities, may not be appropriate. Thus, it is important to validate these results for other countries (Frank et al., 2010).

A relevant challenge for urban health is to measure the impact of environmental characteristics on individual and collective health, with a focus on healthy aging. To this end, the present study aimed to examine the role of walkability in the functional disability of the older adults.

2. Methodology

2.1. Place of study

The city of Viçosa is in the southeast Brazilian "Zona da Mata" region in the State of Minas Gerais (20°45′S and 42°55′W). In 2009, the municipality had in a population of approximately 71,885 inhabitants, distributed in an area of 299 km ^{2}. Among them, 7719 were older adults, 55.5% female and 54.8% aged 60–69 years old (DATASUS, 2014).

2.2. Data collection and study variables

2.2.1. Individual level

Individual-level data were acquired from the survey "Conditions of health, nutrition and medication use by the older individuals in the municipality of Viçosa (MG): a population-based survey", a population-based cross-sectional study in the municipality of Viçosa, Minas Gerais, conducted during 2009, with 621 non-institutionalized older individuals. In the present study, we evaluated the mobility of 410 older individuals residing at addresses that were in urban census tracts that had spatial continuity. Additional details of the methodology can be obtained from our previous publication (Nascimento et al., 2012). Of the total number of individuals in the original study (621), only 410 older adults living in urban census tracts, with at least two sampled residents who had assessed functional capacity, were included in the study. This strategy was adopted so that statistical analyses could be performed.

Data collection was performed by conducting home interviews by applying a semi-structured questionnaire with variables related to sociodemographic conditions, health and nutrition, and medication use. At the time of the interview, the households were georeferenced using a global positioning system (GPS).

The dependent variable was functional disability, which was assessed by the investigation of the difficulty in performing or the requirement of help to perform the activities of daily living (ADLs) and instrumental activities of daily living (IADLs). ADLs included self-feeding, bathing, dressing, walking from one room to another in the home, and getting up from the bed to a chair. IADLs included preparing meals, using the telephone, leaving the house or taking a bus, taking prescribed medications alone, managing money, shopping, cleaning and maintaining the house, doing household chores, and washing and ironing clothing. Older adults with functional disability were those who reported some difficulty in performing six or more activities or total inability to perform at least three activities of the Katz et al. (1970) and Lawton e Brody (Lawton and Brody, 1969), as proposed by Fielder and Peres (Fiedler and Peres, 2008).

Information was collected on sex (male or female), age (years), individual income (median), cohabitation (yes or no), smoking (yes, no, ex-smoker), physical exercise, use of medications (up to 4, or 5 or more), self-reported morbidities (up to 4, or 5 or more) and number of hospitalizations. The presence of obesity and the quality of the diet of the older adults were also investigated. Older adults individuals who had a body mass index (BMI), $\geq 30.0\,kg/m^2$, according to the criteria of the Pan American Health Organization (PAHO), were considered obese (Organização Pan-Americana de Saúde (OPAS, 2001)).

The quality of the diet was evaluated using the Revised Healthy Eating Index for the Brazilian population (HEI-R) proposed by Previdelli et al. (2011) and validated by Andrade et al. (2013). More details can be obtained from previous publications (Fernandes, 2016).

Later, around each residence of the older adults interviewed, circles were built with radius of 500, 750 and 1000 m and the data were related to these areas.

2.2.2. Environmental level

We used information relating to walkability and the Social Vulnerability Index (SVI) to investigate the environmental variables (neighborhood data).

To this end, we calculated the walkability index for each census tract as defined by the 2010 census (Instituto Brasileiro de

Geografia e Estatística (IBGE), 2010) using the following formula: (z-score intersection density) + (z-score commercial density) + (residential density z-score) + (% presence of sidewalks z-score) + (% presence of street lighting z-score).

We obtained the street network of the municipality of Viçosa through the project OpenStreetMap (OSM) (OpenStreetMap, 2018), a free global community-based digital mapping application. For the creation of variable street length, we excluded express roads, rural roads, and other paths not suitable for walking. Subsequently, we calculated the sum of the length of the streets (in meters) within each census tract.

From the OSM, we counted the total number of connections between the streets with real nodes (3- or 4-way intersections, not including dead ends). We then divided this count by the length of the streets (kilometer) of each census tract to obtain a measure of street connectivity.

Residential density and commercial density were calculated by dividing the number of residences and the number of commercial establishments by the total street length of each census tract.

Finally, we used the data from the residential environment of the georeferenced database at the Instituto Brasileiro de Geografia e Estatística (IBGE) to determine the presence of sidewalks, public lighting, and urban afforestation. This information was included for the first time in the 2010 census, in the pre-collection phase, through direct observations made by IBGE technicians. The census researchers assessed whether there were sidewalks/walkways, defined as footpaths, or paved roads intended for pedestrians, in front of the residence. In addition, they observed whether there was at least one public street light on the same side of the street or across the street. They also verified whether there was urban afforestation along the sidewalks/walkways and/or on the medians. Census officials also noted afforestation when it existed in unpaved areas or areas without sidewalks/walkways. The presence of these three attributes (%) in the sector was determined by dividing the total number of households with the attribute, by the total number of households in the sector, and then multiplying by 100.

To evaluate the presence of sidewalks and street lighting, we verified that there was a sidewalk/walkway intended for pedestrians and at least one fixed point (light pole) for each block of residences. Subsequently, the presence in the sector (%) was determined by dividing the number of households with the attribute by the total number of households in the sector tract, and then multiplying by 100.

Subsequently, each component of the walkability index was transformed into a z-score; the components were then summed to obtain the final index. The mean value for each census tract covered by the buffers constructed around the residence of the older adults was then obtained.

With respect to the socioeconomic condition of the neighborhood, the Social Vulnerability Index (SVI) for each census sector was calculated using data from the IBGE Demographic Census 2010, according to the methodology suggested by Medeiros and Albuquerque (Medeiros et al., 2014). The authors operationalized the IVS from the arithmetic mean of fifteen indicators grouped in the following four classes: housing and sanitation, income, education, and social situation.

All data were processed in the Projected Coordinate System, Universal Transverse Mercator System (UTM), zone 23 S, SIRGAS 2000.

2.3. Theoretical model and data analysis

In order to analyze the effect of the independent variables of interest of the study on the functional incapacity of the older adults, a theoretical model was created with Directed Acyclic Graphs (DAG), generated using DAGitty software version 3.0.15 (http://www.dagitty.net/) (Textor et al., 2011). DAGs are causal diagrams that allow the researcher to visualize the study question, establish causal assumptions among variables, define a minimum set of variables to estimate the effect of exposure on the outcome, control the confounding factors, and avoid unnecessary adjustments (Fleischer and Roux, 2008).

Based on the literature, the model used in the present study proposes to graphically represent the influence of walkability on the functional incapacity of the older adults, as shown in Fig. 1.

The set of variables necessary for the minimum adjustment for confounding bias for walkability were as follows: the practice of physical exercise, age, number of diseases, income, sex, obesity, and SVI (Fig. 1).

After defining the DAGs, a descriptive analysis was performed, and the bivariate relationships between the variables of interest and the functional disability were examined by calculating the appropriate association measures. For categorical variables, the chi-square test and the linear trend chi-square test were used; these were used in the comparison of 3 or more independent groups of interest in the study.

The association between the built environment with the dichotomous outcome and functional disability was analyzed through the construction of multilevel logistic regression models. The following two hierarchical levels of data were used in the analysis: the first related to the specific characteristics of each older person evaluated and the second related to the aspects of the urban area where the dwellings of the interviewees were located, as represented by the census tracts. Odds ratio (OR) estimates and respective 95% confidence intervals were obtained for the association between the independent variables of interest of the study and the functional disability. A level of statistical significance of 5% was considered for all tests. The analyzes were performed with Stata® program, version 13.0.

3. Results

The final study group consisted of 499 older individuals aged between 60 and 96 years. The majority, 53.82% (n = 268) were female with a mean age of 70.53 years. The median income was R$700.00. The HEI score ranged from 21.95 to 90.56, with a median

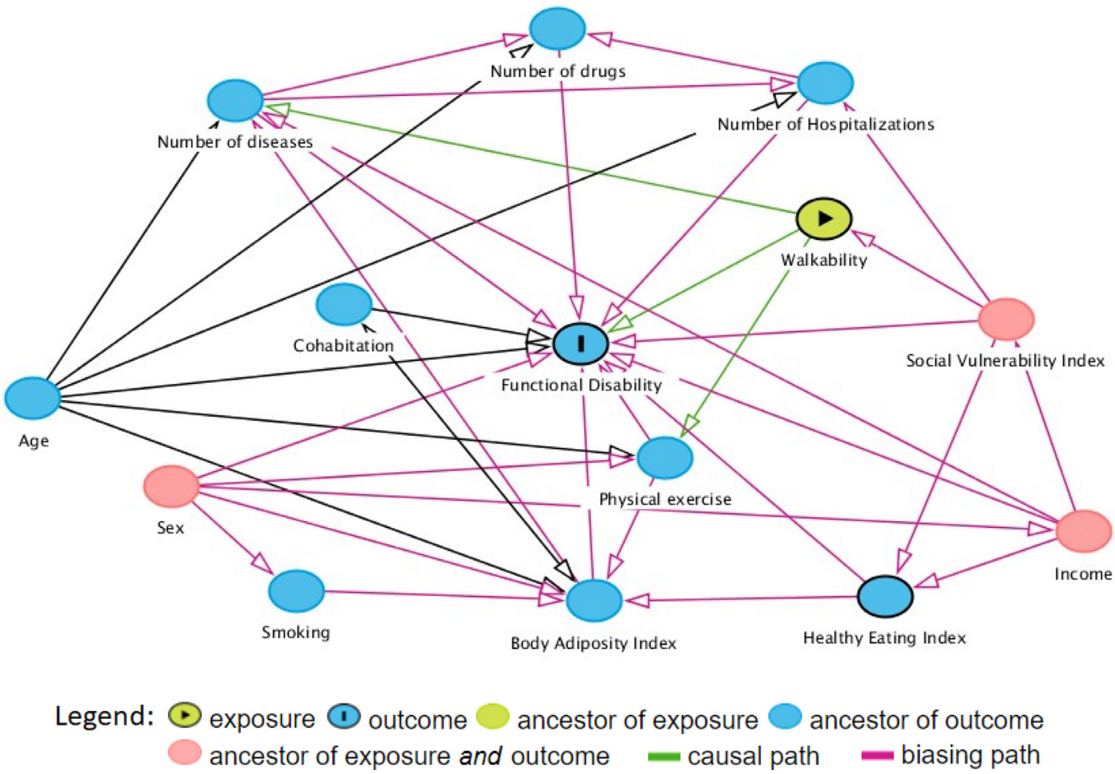

Fig. 1. Acyclic graph aimed at assessing the association between walkability and functional disability.

Table 1
Bivariate analysis of the association between the individual variables and the functional disability of the older adults. .

	Functional disability				p
	No		Yes		
	n	%	n	%	
Sex					
Male	201	88.55	26	11.45	0.009
Female	209	79.77	53	20.23	
Renda					
≤R$700.00	155	77.11	46	22.89	0.000
> R$700.00	221	90.95	22	9.05	
Diseases					
≤4	256	92.09	22	7.91	0.000
> 4	154	72.99	57	27.01	
Cohabitation					
No	364	83.68	71	16.32	0.777
Yes	46	85.19	8	14.81	
Physical exercise					
No	264	79.28	69	20.72	0.000
Yes	146	93.59	10	6.41	
Obesity					
No	304	89.41	36	10.59	0.025
Yes	81	81.00	19	19.00	
Healthy Eating Index					
1° tercile	133	85.81	22	14.19	0.334[a]
2° tercile	137	84.05	26	15.95	
3° tercile	140	81.87	31	18.13	

[a] Linear trend chi-square test.

Table 2
Multivariate analysis of the association between environmental variables of each circle radius and functional disability of the older adults. Viçosa (MG). 2009.

	500 m		750 m		1000 m	
	OR	CI 95%	OR	CI 95%	OR	CI 95%
Model 1						
Walkability	0.93	0.86–1.01	**0.91**	**0.84–0.99**	**0.89**	**0.81–0.98**
Model 2[a]						
Walkability	**0.89**	**0.80–0.99**	**0.86**	**0.76–0.98**	**0.83**	**0.72–0.95**

[a] Model adjusted by physical exercise, age, number of diseases, income, sex, Body Mass Index and Social Vulnerability Index.

of 64.98. The prevalence of functional disability was 16.1% (95% CI, 13.0%–19.4%). It was found that 43.9% (95% CI, 39.6%–48.3%) of the older adults had some difficulty in performing at least one ADL and 49.9% (95% CI 45.5%–54.3%) had some difficulty in performing at least one IADL.

Table 1 shows the significance of the bivariate relationships between the individual variables and functional disability. A higher prevalence of functional disability was observed among women, those below the median income, those with five or more diseases, those who did not exercise, and those who were obese.

Table 2 presents the results of the multilevel logistic regression analysis with the walkability exposure. The values of the adjusted model (Model 2) showed that older individuals living in areas with greater walkability had a lower chance of having functional disability in buffers from 500 m. It was verified that the OR decreased with the increase of the distance of the buffers and that the values of the adjusted model were smaller than those of the unadjusted model.

4. Discussion

The results of this study suggest that the environment plays an important role in maintaining the functional capacity of the older adults. We found that older adults living in places with better walkability were less likely to present with functional disability. Understanding how the environment influences health maintenance is critical in making decisions relating to urban planning and public health in the promotion of healthy aging.

To the best of our knowledge, no other study has evaluated the effects of walkability on functional disability. We believe that the associations observed in the current study were due to the outcome being closely related to the physical activity, which in turn, is related to the environmental characteristics that favor walkability. It is well established that the functional results of the older adults improve as the frequency of walking increases (Kalachea and Kickbusch, 1997). In addition to this direct effect on healthy individuals, environmental characteristics may still help individuals with functional limitations to better utilize the space in which they live (Xue et al., 2007).

A global goal is to keep urban environments as quality places, easily accessible to all individuals, regardless of their age (World Health Organization, 2007). When considering the ways to minimize disability as the population ages, simple changes in the built environment may be easier to implement than efforts to change risk factors at the individual level. Thus, interventions in urban infrastructure, such as the construction of sidewalks, the organized opening of new businesses, and the improvement of public street lighting, can enable people to walk in the neighborhood, or even make it more pleasant, and thus increase the frequency of walking (Kalachea and Kickbusch, 1997). In addition, although walkability accounts for a rather small proportion of variation in outcomes, its contribution to population health is important because environmental changes have the potential to affect entire populations over a long period of time (Owen, N., Humpel, N., Leslie, E., Bauman, A., Sallis et al., 2004).

While the results of this study are limited due to its cross-sectional design, which impedes any consideration of causality or even the temporal nature of associations, there are important implications for the promotion of public health in the older adults. Environmental interventions, especially those that increase walkability, can play an important role in the functional capacity of the older adults, helping them to preserve their mobility, independence, and quality of life.

Considering the relevance of this theme, future research should consider the longitudinal design in the evaluation of the influence of neighborhood factors on the functionality of the older adults. This study should also be conducted among several populations of the older people living in different locations in Brazil and other countries of the world.

5. Conclusions

Our results reveal that adequate and suitable walking environments contribute to the functional capacity of the older adults. Such evidence is in addition to previous literature, supporting international recommendations for changes in the built environment to create more accessible neighborhoods that promote active and healthy aging. These changes should be the subject of urban planning and public health policies, including the development of interventions for the construction, reformulation, and maintenance of public roads and the urban environment.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2019.100574.

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