Social Science & Medicine 182 (2017) 45–51

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Is a hilly neighborhood environment associated with diabetes mellitus among older people? Results from the JAGES 2010 study

Takeo Fujiwara [a,*], Iseki Takamoto [b], Airi Amemiya [c], Masamichi Hanazato [d], Norimichi Suzuki [d], Yuiko Nagamine [d], Yuri Sasaki [d], Yukako Tani [a], Aki Yazawa [e], Yosuke Inoue [f], Kokoro Shirai [g], Yugo Shobugawa [h], Naoki Kondo [i], Katsunori Kondo [j,k]

[a] Department of Global Health Promotion, Tokyo Medical and Dental University, Tokyo, Japan
[b] Department of Diabetes and Metabolic Diseases, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[c] Department of Social Medicine, National Research Institute for Child Health and Development, Tokyo, Japan
[d] Center for Preventive Medical Sciences, Chiba University, Chiba City, Chiba, Japan
[e] Department of Human Ecology, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[f] Carolina Population Center, The University of North Carolina at Chapel Hill, Chapel Hill, USA
[g] Department of Human Sciences, School of Law and Letters, University of the Ryukyus, Okinawa, Japan
[h] Division of International Health, Graduate School of Medical and Dental Science, Niigata University, Niigata, Japan
[i] Department of Health Education and Health Sociology, School of Public Health, The University of Tokyo, Tokyo, Japan
[j] Center for Well-being and Society, Nihon Fukushi University, Aichi, Japan
[k] Department of Gerontology and Evaluation Study, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Aichi, Japan

ARTICLE INFO

Article history:
Received 12 December 2016
Received in revised form
1 April 2017
Accepted 7 April 2017
Available online 10 April 2017

Keywords:
Diabetes
Slope
Physical environment
Steps
Neighborhood
Elderly

ABSTRACT

Background: Although living in a hilly environment may promote muscular activity in the daily lives of residents, and such activity may prevent diabetes mellitus, few studies have focused on the impact of living in a hilly environment on diabetes mellitus. The purpose of this study was to investigate the impact of a hilly neighborhood environment on DM in older people.

Methods: We used data from the Japan Gerontological Evaluation Study, a population-based, cross-sectional study of individuals aged 65 or older without long-term care needs in Japan, which was conducted in 2010. A total of 8904 participants in 46 neighborhoods had responded to the questionnaire and undergone a health check. Diabetes mellitus was diagnosed as $HbA_{1c} \geq 6.5\%$ and those undergoing treatment for diabetes mellitus. Poorly controlled diabetes mellitus was diagnosed in those without other chronic diseases who had an $HbA_{1c} > 7.5\%$, and in those with other chronic diseases if their HbA_{1c} was >8.0%. Neighborhood environment was evaluated based on the percentage of positive responses in the questionnaire and geographical information system data. A multilevel analysis was performed, adjusted for individual-level risk factors. Furthermore, sensitivity analysis was conducted for those who were undergoing treatment for diabetes mellitus ($n = 1007$).

Results: After adjustment for other physical environmental and individual covariates, a 1 interquartile range increase (1.48°) in slope in the neighborhood decreased the risk of poorly controlled diabetes mellitus by 18% (odds ratio [OR]: 0.82, 95% confidence interval [CI]: 0.70–0.97). Sensitivity analysis confirmed that larger slopes in the neighborhood showed a significant protective effect against diabetes mellitus among those who were undergoing treatment for diabetes mellitus (OR: 0.73, 95% CI: 0.59–0.90).

Conclusion: A hilly neighborhood environment was not associated with diabetes mellitus, but was protective against poorly controlled diabetes mellitus.

1. Introduction

The control of type 2 diabetes mellitus (DM) is one of the most important public health issues in our aging society (Zimmet et al., 2001). The number of patients with type 2 DM worldwide is

* Corresponding author. Department of Global Health Promotion, Tokyo Medical and Dental University (TMDU), 1-5-45, Yushima, Bunkyo-ku, Tokyo, Japan.
E-mail address: fujiwara.hlth@tmd.ac.jp (T. Fujiwara).

http://dx.doi.org/10.1016/j.socscimed.2017.04.008
0277-9536/

estimated to reach 266 million in 2030 (Qi et al., 2008), a trend that is partially attributed to the increasing older population (Charvat et al., 2015). Although several individual-level lifestyle risk factors (such as healthy diet, physical activity, and obesity (Zimmet et al., 2001; Zimmet, 1992)) have been identified, and individual-level interventions are reported to be effective (Colagiuri et al., 2010; Aguiar et al., 2016), changes to the neighborhood environments that influence lifestyle behaviors (Feng and Astell-Burt, 2013) and other such interventions might also be effective as a preventative public health strategy (Rose, 1992).

Previous studies have reported the preventive effect of changes to neighborhood environments on the development of type 2 DM, including changes to deprived neighborhoods (Muller et al., 2013; Williams et al., 2012), as well as access to exercise facilities, grocery stores (Christine et al., 2015; Auchincloss et al., 2008), and green spaces (Astell-Burt et al., 2014). It is known that the neighborhood environment related to walkability, such as the number of parks, intersection density, public transportation density, and net residential density, is associated with physical activity (Sallis et al., 2016). Moreover, perceived neighborhood walkability has shown an inverse association with sedentary behavior (Van Dyck et al., 2012). However, few studies have focused on the impact of a hilly environment on DM. A hilly environment may promote muscular activity in the daily lives of residents, and such activity may prevent DM (Minetti et al., 2002). Interestingly, Villanueva et al. reported that the rate of self-reported DM in adults living in a neighborhood with steeper slopes was lower than that of adults living in flatter areas (Villanueva et al., 2013). Studies using a more objective assessment of DM status, such as HbA_{1c} levels, rather than self-reported assessment studies, are needed to investigate the link between a hilly environment and DM.

In older people, the control of DM is important to the prevention of complications (The effect of intensive t, 1993; Intensive blood-glucose c, 1998; Ohkubo et al., 1995) such as diabetic nephropathy, retinopathy, neuropathy, and microvascular problems (Zimmet, 1999). Management of these complications involves significant medical costs (Liebl et al., 2015). Furthermore, intensive glycemic control to prevent the onset or deterioration of DM may be harmful in frail older people who are more likely to have other diseases (Lipska et al., 2015; Vijan et al., 2014). Therefore, close attention should be paid to those with poorly controlled DM, which is defined as HbA_{1c} levels of 7.5% or greater in healthy individuals with no comorbidities other than DM, or 8.0% or greater in elderly people with chronic disease, mild cognitive impairment, or an inability to perform two or more daily tasks (Kirkman et al., 2012). To our knowledge, however, no study has focused on the association between the neighborhood environment and poorly controlled DM in older people.

In this study, we used large population-based data on older people (i.e., 65 years or over) without long-term care needs to investigate the link between the neighborhood physical environment—assessed by both survey-based and geographic information system (GIS)-based data—and DM, which was assessed by HbA_{1c} levels obtained from community-based health checks. We hypothesized that older people living in a hilly environment, that is, living in an area with steep slopes, may be less likely to have DM, especially poorly controlled DM, after accounting for potential lifestyle and other such factors in the neighborhood physical environment.

2. Methods

2.1. Sample

We used part of the data from the Japan Gerontological Evaluation Study (JAGES) project, a large, ongoing, prospective epidemiological study of the Japanese population aged 65 years or older from 31 municipalities across all areas of Japan without long-term care needs (n = 112,123; response rate, 66.3%). For the current study, we used data from individuals in six municipalities in the Chita peninsula, Aichi, for whom we had health check data (n = 9893). The data were collected in August 2010 to January 2012. We excluded individuals for whom information on HbA1c levels (n = 393) and neighborhood code (n = 7) were missing. After further limiting the sample to those who had lived in the same city for 10 years or more, a total of 8904 participants were included in analyses to determine the impact of living in a hilly environment on DM. The JAGES protocol was approved by the Ethics Committee for Research of Human Subjects at Nihon Fukushi University (No. 10-05).

2.2. HbA_{1c} measurement and blood glucose level

HbA_{1c} was measured at community health centers or registered hospitals in health checks organized by the municipality and analyzed by local hospital laboratories using the latex agglutination method, and reported by the Japan Diabetes Society (JDS). The measured ratio was converted to a National Glycohemoglobin Standardization Program (NGSP) value based on the transform equation (Geistanger et al., 2008). Fasting blood glucose level was also measured in around half of the participants (N = 4623, 51.9%), and casual blood glucose level was measured in another one-fifth of participants (N = 1960, 20.2%).

DM was diagnosed if HbA_{1c} was ≥6.5%, fasting glucose level was ≥126 mg/dl, or casual glucose level was ≥200 mg/dl, or if the patient was undergoing treatment for DM regardless of the level of HbA1c. Poorly controlled DM was defined as HbA_{1c} > 7.5% for those without other diseases or >8.0% for those with other chronic diseases, including cancer, heart disease, stroke, hypertension, or dyslipidemia, based on the latest consensus report on DM among older people from American Diabetes Association (Kirkman et al., 2012).

2.3. Objective neighborhood environment (slope, population density, and land value)

We used the ArcGIS 10.1 software to assess the neighborhood physical environment as a special calculation, and included the presence of slopes, grocery stores, and parks. In accordance to a previous study using JAGES data (Takagi et al., 2013a), we used the elementary school district as the neighborhood unit, which is a proxy for a geographical area that is easy for elderly people to navigate (Hanibuchi et al., 2008). The average area of an elementary school district was 6.34 km^2 (SD = 3.86).

The average land slope of school districts was calculated using the Elevation, Degree of Slope 5th Mesh Data (as of 2011) of the National Land Numerical Information from the Ministry of Land, Infrastructure, Transport and Tourism in Japan, based on the Digital Map 50 m Grid (Elevation) from the Geospatial Information Authority of Japan (GSI) (Ministry of Land I and Transport and Tourism, 2016a). The range of slopes was from 0.95 to 9.79°, with a mean of 3.03 (SD = 1.82).

The number of grocery stores in each school district was calculated using the 500-m mesh data from the Census of Commerce of 2007 conducted by the Ministry of Economy, Trade and Industry. In this study, a grocery store was defined as a department store, general merchandise store, specialized supermarket, daily commodities store, or convenience store. The average count of parks was calculated using the City Park Data (as of 2011) of National Land Numerical Information from the Ministry of Land, Infrastructure, Transport and Tourism in Japan, from GSI. The city park parameter included open spaces, athletic grounds, and ball parks that were built based on the Urban Park Act across the country (Ministry of Land I and Transport and Tourism, 2016b). Similarly, the number of hospitals in each school district was