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JAMDA xxx (2018) 1-7



JAMDA



journal homepage: www.jamda.com

Original Study

Is Neighborhood Green Space Associated With Less Frailty? Evidence From the Mr. and Ms. Os (Hong Kong) Study

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Keywords: Neighborhood green space normalized difference vegetation index frailty transitions physical activity older adults path analysis

ABSTRACT

Objectives: To examine whether neighborhood green space was related to frailty risk longitudinally and to examine the relative contributions of green space, physical activity, and individual health conditions to the frailty transitions.

Design, setting, and participants: Four thousand community-dwelling Chinese adults aged \geq 65 years participating in the Mr. and Ms. Os (Hong Kong) study in 2001-2003 were followed up for 2 years.

Methods: The percentage of green space within a 300-meter radial buffer around the participants' place of residence was derived for each participant at baseline based on the normalized difference vegetation index. Frailty status was classified according to the Fried criteria at baseline and after 2 years. Ordinal logistic regression and path analysis were used to examine associations between green space and the frailty transitions, adjusting for demographics, socioeconomic status, lifestyle factors, health conditions, and baseline frailty status.

Results: At baseline, 53.5% of the participants met the criterion for robust, 41.5% were classified as prefrailty, and 5.0% were frail. After 2 years, 3240 participants completed all the measurements. Among these, 18.6% of prefrail or frail participants improved, 66% remained in their frailty state, and 26.8% of robust or prefrail participants progressed in frailty status. In multivariable models, the frailty status of participants living in neighborhoods with more than 34.1% green space (the highest quartile) at baseline was more likely to improve at the 2-year follow-up than it was for those living in neighborhoods with 0 to 4.5% (the lowest quartile) [odds ratio (OR): 1.29, 95% confidence interval (CI): 1.04–1.60; *P* for trend: 0.022]. When men and women were analyzed separately, the association between green space and frailty remained significant in men (OR: 1.40, 95% CI: 1.03–1.90) but not in women. Path analysis showed that green space directly affects frailty transitions ($\beta = 0.041$, P < .05) and also exerts an effect through physical activity ($\beta = 0.034$, P < .05). Physical activity directly affects frailty ($\beta = 0.134$, P < .05), and also indirectly affects frailty through health conditions including number of diseases ($\beta = -0.057$, P < .05) and cognitive functions ($\beta = 0.041$, P < .05). The magnitude of the direct effect of green space on the 2-year frailty transitions is comparable to those of the indirect effect through physical activity.

Conclusion: Older people living in neighborhoods with a higher percentage of green space were associated with improvement in frailty status, independent of a wide range of individual characteristics.

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https://doi.org/10.1016/j.jamda.2017.12.015

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Frailty represents a state of decline in functional reserves, which increases the risk of adverse health outcomes such as morbidity, disability, and institutionalization after a stressor event.¹ It can be preceded by, but also occurs in the absence of, chronic disease² and has been suggested as a better predictor of health and well-being than the presence or absence of disease, representing an intermediate stage

The authors declare no conflicts of interest.

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between robust health and end of life.¹ Depending on the used definition, the prevalence of frailty at age \geq 65 years varies from 4.0% to 59.1% across various studies.^{3–5} Although frailty is common in older populations, it is a dynamic process that is neither inevitable nor irreversible as people age.^{6,7} Therefore, attempts have been made to reverse the syndrome of frailty, with physical exercise being the most widely studied, and the findings were comparatively promising.⁸

Neighborhood environments, particularly green space, are being increasingly recognized as factors that influence physical activity. Several studies in various countries have demonstrated that access to and use of green space were associated with increased levels of physical activity in older people.^{9,10} It is therefore plausible that older people living in neighborhoods with more green space are associated with better health. Various studies have examined the relationship between green space and health outcomes as well as their possible mediators, with an aim of understanding the role of green space and the underlying mechanisms of the associations. For example, in a study carried out in Adelaide. Australia, perceived neighborhood greenness was associated with physical and mental health in adults aged 20-65 years.¹¹ In the Survey of the Health of Wisconsin, higher levels of neighborhood green space were associated with lower levels of symptomology for depression, anxiety, and stress in a probability sample of Wisconsin residents aged 21-74 years.¹² In a cohort of individuals aged 45-72 carried out in Lithuania, distance to green spaces was positively associated with a higher risk of the incidence of total cardiovascular disease over 4 years.¹³ Recent reviews and studies have also indicated a relationship between a green environment and obesity,^{14,15} psychosocial well-being,¹⁶ and mortality.^{17,18} The potential mechanisms for the relationship between a green living environment and perceived general health have also been suggested,¹⁹ including that (1) the proportion of green space in the living environment could stimulate physical activity and social contacts, both of which can influence a variety of health-related outcomes and (2) exposure to green space can be psychologically restorative by promoting mental health. However, the relationship between green space and health has remained understudied in older populations. The potential effects of neighborhood green space on frailty have not been studied.

Hong Kong, a special administrative region of China situated on the Southern coast, is one of the most densely populated cities in the world. More than 7 million people occupy an area of 1,070 km², in which built-up urban areas account for less than 300 km². Within this densely populated city variations in the quantity of green space exist, which offer a natural setting in which to examine the impact of green space on frailty in older people. Using a sample of 4,000 community-dwelling Chinese men and women aged 65 years and older living in all regions of Hong Kong, we examined whether neighborhood green space was related to frailty risk longitudinally, and examined the relative contributions of green space, physical activity, and individual health conditions to the frailty transitions.

Methods and Methods

Study Design and Participants

A total of 4000 community-dwelling Chinese men and women aged 65 and older were recruited for a cohort study on osteoporosis and general health (Mr. and Ms. Os) in Hong Kong between August 2001 and December 2003 by placing recruitment notices in community centers for older adults and housing estates. The aim was to recruit a stratified sample so that approximately 33% each would be aged 65 to 69, 70 to 74, and 75 and older. Those who were unable to walk independently, had had bilateral hip replacement, or were not competent to give informed consent were excluded. A team of trained research assistants administered the study questionnaires and physical measurements for each individual on the same day. The cohort was invited to re-attend for repeat questionnaire interviews and physical measurements after 2 years. Details of the survey population have been reported elsewhere.²⁰ In the present analysis, participants without a valid address at baseline (n = 56), were not living in their baseline residence at the 2-year follow-up (n = 125), were living in



Fig. 1. Study flow chart of sample selection.

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