Walking for Recreation and Perceptions of the Neighborhood Environment in Older Chinese Urban Dwellers

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ABSTRACT Engagement in walking for recreation can contribute to healthy aging. Although there is growing evidence that the neighborhood environment can influence walking for recreation, the amount of such evidence in relation to older adults is scarce and limited to Western low-density urban locations. Asian urban environments are typified by distinctive environmental and cultural characteristics that may yield different patterns to those observed in Western countries. Therefore, the main aim of this study was to examine associations of perceived environmental attributes with overall and within-neighborhood walking for recreation in Chinese elders (65+ years) residing in Hong Kong, an ultradense Asian metropolis. A sample of 484 elders was recruited from 32 neighborhoods stratified by socio-economic status and walkability (dwelling and intersection densities). Validated questionnaires measuring perceived neighborhood environment and weekly minutes of overall and within-neighborhood walking for recreation were interviewer administered. Results showed that the level of recreational walking was twice to four times higher than that reported in Western adults and elders. While overall walking for recreation showed a general lack of associations with perceived environmental attributes, within-neighborhood recreational walking was positively related with proximity of recreational facilities, infrastructure for walking, indoor places for walking, and presence of bridge/overpasses connecting to services. Age and educational attainment moderated the associations with several perceived environmental attributes with older and less-educated participants showing stronger associations. Traditional cultural views on the benefits of physical activity and the high accessibility of facilities and pedestrian infrastructure of Hong Kong may explain the high levels of walking. Although specific neighborhood attributes, or their perception, may influence recreational walking within the neighborhood, the compactness and public transport affordability of ultradense metropolises such as Hong Kong may make it easy for elders to compensate for the lack of favorable neighborhood attributes by walking outside the neighborhood.

KEYWORDS Walking for recreation, Older adults, Perceived environment, Moderators

INTRODUCTION

Regular engagement in moderate- or even light-intensity physical activity is an important contributor to healthy aging.^{1,2} Walking represents a safe and affordable

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form of physical activity appropriate for elders.³ Recreational walking is particularly beneficial because, apart from conferring physical health benefits,¹ it may have an added effect on mental health as compared to walking performed in other contexts.^{4,5}

In recognition of the projected worldwide increases in proportion of elders⁶ and their distinctive vulnerability to unfavorable environmental conditions,⁷ a growing, yet still very limited, number of studies have examined neighborhood environmental correlates of recreational walking in elders.⁸ While some studies found esthetics, crime safety, and access to commercial and recreational destinations to be positively related to recreational walking,⁹⁻¹¹ others failed to detect such associations.^{12,13} Discrepant findings may be in part due to using exposure and outcome measures not specifically developed for, and/or validated in, elders.^{3,8} They may also result from not using contextually- and geographically-specific measures of walking (recreational walking within the neighborhood) that match exposure measure (neighborhood esthetics).¹⁴ While neighborhood characteristics are likely to impact walking in the neighborhood, they may not be as consistently relevant to overall walking, which may occur within and outside one's neighborhood. This is likely to be particularly the case in ultradense urban environments with a developed and affordable public transport system that allows easy access to locations outside one's neighborhood. Yet, no studies have examined differences in patterns of associations when using neighborhood-specific versus generic measures of recreational walking.

Consequently, this study examined associations of perceived neighborhood environmental attributes believed to influence walking with overall and withinneighborhood recreational walking in a sample of Chinese elders residing in an ultradense metropolis with a developed public transport system (Hong Kong). In doing so, outcome and exposure measures adapted and validated for the target population were used.^{15–17} It was hypothesized that overall recreational walking would show weaker patterns of associations with perceived neighborhood characteristics than recreational walking within the neighborhood. In line with two recent studies,^{13,18} it was also hypothesized that patterns of associations would differ by gender, age, and educational attainment, with more vulnerable elders (older and with lower educational attainment) being more strongly affected by environmental attributes. Gender differences in associations were treated in an exploratory fashion as they are likely to vary across cultures.

Importantly, apart from addressing the above methodological and substantive knowledge gaps, this is the first study to examine neighborhood environmental correlates of recreational walking in older urban dwellers of an Asian metropolis (Hong Kong, China). All previously published studies were conducted in low-density North American cities. Chinese metropolitan locations are typified by distinctive environmental (e.g., high-rise buildings and air pollution)¹⁵ and cultural characteristics (e.g., cherishing an active lifestyle)¹⁹ that may yield different patterns of associations to those observed in Western countries. It is paramount that our knowledge of environmental determinants of walking behaviors in elders be extended to other cultures and geographical locations, such as China, which is strikingly underrepresented in the current environment-physical activity literature despite being the most populous nation on the planet. Apart from generating a geographically and culturally relevant body of knowledge that can inform future environmental interventions and policies in China, research in multiple countries can also help clarify dose-response relationships and establish the level of generalizability of environmental determinants of walking behavior.

METHODS

This study used data from a project conducted in 2007–2008 on a sample of Chinese older residents of Hong Kong.^{15–17} Ethical clearance was obtained from the ethics committees of the participating institutions.

Participants and Procedures

Participants were members of four Hong Kong Elderly Health Centres (EHCs) located in catchment areas stratified by transport-related walkability (destination, dwelling, and road intersection density) and household income. Details on the four catchment areas are reported elsewhere.¹⁵ Members of the EHC are representative of the general Hong Kong elderly population in health status, socio-economic status, and age.²⁰

Participants were recruited using a two-stage sampling strategy. Eight street blocks were randomly selected without replacement in each of the four catchment areas and then 15 EHC members were recruited from each selected block. Eligibility criteria were being able to communicate in Chinese and walk unassisted, and absence of diagnosed cognitive impairment. After providing written informed consent, 484 elders (65+ years) participated in an interviewer-administered survey (response rate, 78 %) including the Neighborhood Environment Walkability Scale for Chinese Seniors (NEWS-CS),¹⁵ the Chinese version of the International Physical Activity Questionnaire-Long Form (IPAQ-LC),²¹ and the Neighborhood Walking Questionnaire—Chinese version for Seniors (NWQ-CS).¹⁶ Sociodemographic characteristics of the sample are presented in Table 1.

Instruments

The NEWS-CS¹⁵ is a questionnaire assessing perceived neighborhood environment characteristics based on the original abbreviated version of the Neighborhood Environment Walkability Scale (NEWS-A)^{22,23} adapted for Chinese elders. The NEWS-CS includes 14 subscales (residential density, land use mix—diversity and access, street connectivity, infrastructure for walking, indoor places for walking, esthetics, presence of people, crowdedness, traffic and road hazards, traffic speed, social disorder/littering, and crime), and four single items (fence separating sidewalk and traffic, bridge/overpass connecting to services, easy access of residential entrance, and sitting facilities). For the purpose of this study, perceived distance to recreational facilities (parks, swimming pools, fitness/recreational/community centers) was also examined.⁸ The NEWS-CS has moderate-to-good test–retest reliability and excellent factorial validity.¹⁵ Details about the scoring of the NEWS-CS have been provided elsewhere.¹⁵

Total minutes of recreational walking within the neighborhood (defined as an area up to a 15-min walk from home) in a usual week were assessed using the NWQ-CS,¹⁶ a self-report measure based on the Neighborhood Physical Activity Questionnaire²⁴ and adapted for Chinese elders. This measure has shown acceptable test–retest reliability (ICC=0.68) and criterion validity (associations with diary measures, r=0.68).¹⁶ The last 7-day total weekly minutes of recreational walking, irrespective of location, were assessed using the IPAQ-LC. This measure has shown excellent test–retest reliability (ICC=0.83) and relatively acceptable criterion validity (associations with diary measure: r=0.48) in this study sample.¹⁷

	Statistic
Socio-demographic characteristics, %	
Gender, male	42
Age	
65–74 years	67
75+ years	33
Educational attainment	
Secondary or above	39
Primary	48
No formal education	13
Weekly minutes of recreational walking, M (SD); median (IQR)	
Within neighborhood	244 (331), 120 (420)
Overall	331 (380), 210 (375)
Participation in recreational walking, %	
Within neighborhood	65.4
Overall	77.9
Perceived neighborhood attributes (range), M (SD)	
Residential density (263–1,026)	680 (108)
Land use mix—diversity (1–5)	3.8 (0.6)
Land use mix—access to shops (1–4)	3.8 (0.6)
Proximity of recreational destinations (1–5)	2.8 (1.0)
Street connectivity (1–4)	3.7 (0.5)
Infrastructure for walking (1–4)	3.8 (0.3)
Indoor places for walking (1–4)	2.7 (1.0)
Esthetics (1–4)	2.1 (0.6)
Presence of people (1–4)	3.7 (0.5)
Crowdedness (1–4)	1.6 (0.8)
Traffic and road hazards (1–4)	1.7 (0.6)
Traffic speed (1–4)	1.9 (0.8)
Social disorder/littering (1–4)	1.8 (0.7)
Crime (1–4)	1.3 (0.6)
Fence separating sidewalks from traffic (1–4)	3.3 (1.1)
Bridge/overpass connecting to services (1-4)	2.0 (1.2)
Easy access of residential entrance (1–4)	3.5 (1.0)
Sitting facilities (1–4)	2.8 (1.1)

TABLE 1 Descriptive statistics for sociodemographic characteristics, perceived neighborhood attributes and recreational walking (*N*=484)

M mean, SD standard deviation, IQR interquartile range

Data Analysis

Descriptive statistics were computed for all variables. Generalized additive mixed models with negative binomial and logarithmic link functions were used to estimate the strength and shape of the associations of perceived environmental attributes with weekly minutes of recreational walking.²⁵ Random intercepts were specified to account for clustering arising from the two-stage sampling procedure. A first set of models estimated the dose–response relationships of single perceived environmental attributes with the outcomes, adjusting for sociodemographic covariates. Separate models estimated main effects and two-way gender, age, and educational attainment by environmental attributes interactions. All perceived environmental attributes that yielded main and/or interaction effects significant at a 0.05 probability level were

included in multiple-predictor models of recreational walking. All variables and interaction terms that remained significant were retained in a final model. Analyses were conducted in R²⁶ using the package "mgcv".²⁵

RESULTS

High levels of recreational walking were reported (Table 1). While no gender and age differences were found in levels of walking, participants with a higher educational attainment tended to engage in more walking than their less educated counterparts. Respondents with secondary or higher education had 471 % (95 % CI, 235 and 876 %) more weekly minutes of within-neighborhood recreational walking (as measured by the NWQ-CS) and 228 % (95 % CI, 28 and 371 %) more weekly minutes of overall recreational walking (as measured by the IPAQ-LC) than those with no formal education. Respondents with primary education reported 196 % (95 % CI, 76 and 396 %) more within-neighborhood walking than those with no formal education. Respondents reported high levels of perceived residential density, land use mix—diversity, land use mix access, infrastructure for walking, street connectivity, and presence of people, and low levels of crime (Table 1).

Associations of Perceived Environmental Attributes with Recreational Walking

Only one perceived environmental characteristic (bridge/overpass connecting to services) was significantly associated with overall recreational walking as measured by the IPAQ-LC (e^b =1.159; 95 % CI, 1.062, 1.265; p<.001). In contrast, in the single-predictor models, seven perceived neighborhood attributes showed a significant main effect on within-neighborhood recreational walking (Table 2). Proximity to recreational facilities, infrastructure for walking, indoor places for walking, and the presence of bridges/overpasses connecting to services were independently positively associated with within-neighborhood walking after accounting for other predictors.

Moderating Effects of Gender, Age, and Educational Attainment

Several significant moderating effects of age and educational attainment on withinneighborhood recreational walking were observed (Table 3). Significant positive associations of within-neighborhood walking with presence of sitting facilities and indoor places for walking, and negative associations with physical barriers to walking and traffic speed, were observed only in older respondents. In general, for those environmental attributes showing significant interaction effects with educational attainment, the effects of perceived neighborhood attributes on withinneighborhood recreational walking were stronger in less educated respondents than their counterparts (Table 3). Only one moderating effect of educational attainment on overall recreation walking was observed. Namely, infrastructure for walking showed a positive association in respondents with no formal education (e^b =4.314; 95 % CI, 2.286, 8.142; p<0.001) and primary education (e^b =1.840; 95 % CI, 1.010, 3.353; p<0.05) but not in those with secondary or higher education (e^b = 0.985; 95 % CI, 0.618, 1.571; p>0.05). No significant moderating effects of gender were found.

	Unadjusted	Adjusted ^a
Perceived neighborhood attribute	e ^b (95 % CI)	<i>e^b</i> (95 % CI)
Residential density	0.931 (0.798, 1.087)	-
Land use mix—diversity	0.985 (0.848, 1.145)	-
Land use mix—access to shops	0.985 (0.839, 1.158)	-
Proximity to recreational facilities	1.306 [*] (1.099, 1.551)	1.236** (1.032, 1.480)
Street connectivity	1.308 ^{**} (1.005, 1.705)	-
Physical barriers to walking	0.769 ^{**} (0.600, 0.986)	-
Infrastructure for walking	1.559 ^{**} (1.025, 2.372)	1.487** (1.014, 2.179)
Indoor places for walking	1.243 ^{**} (1.049, 1.473)	1.233 [*] (1.060, 1.435)
Esthetics	1.291** (1.023, 1.627)	-
Presence of people	0.854 (0.647, 1.129)	-
Crowdedness	1.035 (0.846, 1.267)	-
Traffic and road hazards	0.907 (0.698, 1.179)	-
Traffic speed	1.012 (0.835, 1.228)	-
Social disorder/littering	1.000 (0.807, 1.238)	-
Crime	1.117 (0.854, 1.462)	-
Fence separating sidewalks from traffic	0.957 (0.839, 1.092)	-
Bridge/overpass connecting to services	1.176 ^{**} (1.031, 1.340)	1.129** (1.005, 1.267)
Easy access of residential entrance	1.040 (0.899, 1.202)	-
Sitting facilities	1.018 (0.892, 1.161)	-

TABLE 2	Associations of perceived	neighborhood	attributes	with	weekly	minutes	of	within-
neighborh	ood recreational walking							

The antilogarithms of the regression coefficients represent the proportional increase (if $e^b > 1.00$) or decrease (if $e^b < 1.00$) in weekly minutes of walking associated with a unit increase in a perceived neighborhood attribute. All models were adjusted for gender, educational attainment, and age

e^b antilogarithm of regression coefficient, 95 % CI 95 % confidence intervals

p*<0.01, *p*<0.05

^aAdjusted for other perceived environmental attributes statistically significantly related to walking

DISCUSSION

This study examined associations of perceived characteristics of the neighborhood environment with recreational walking in Chinese older urban dwellers, a previously unstudied population. In doing so, we used outcome and exposure measures specifically adapted and validated for the target population^{16,17} and assessed both overall and within-neighborhood recreational walking.

The observed level of recreational walking was twice to four times higher than that reported in Western adults and elders with no mobility problems.^{10,23} Importantly, over 60 % of the sample exceeded the minimal recommended amount of physical activity (150 min/week) through recreational walking alone. Similar high levels of walking have been observed in a large representative sample of Chinese elders.²⁷ These unusually large amounts of walking may be attributable to environmental and cultural factors. Chinese elders value an active lifestyle, which they traditionally consider a key contributor to good health and social ties.^{19,28} Thus, a large proportion of them engage in regular morning walks or tai-chi sessions.^{19,29}

With regards to environmental factors, we found uniformly higher ratings of perceived access to shops, street connectivity, crime safety, and infrastructure for walking than studies conducted in Western countries.^{13,22,23} These features have been identified as facilitators of recreational^{10,11,13} and overall walking in

Perceived neighborhood attribute	e ^b (95 % Cl)
Education-specific associations	
Physical barriers to walking	
No formal education	0.190 [*] (0.096, 0.375)
Primary	1.108 (0.746, 1.647)
Secondary and over	1.115 (0.734, 1.694)
Infrastructure for walking	
No formal education	4.097 [*] (1.837, 0.139)
Primary	2.181** (1.228, 3.874)
Secondary and over	1.042 (0.528, 2.060)
Indoor places for walking	
No formal education	2.500 [*] (1.553, 3.863)
Primary	1.408** (1.101, 1.801)
Secondary and over	1.022 (0.793, 1.317)
Fence separating sidewalks from traffic	
No formal education	0.339 [*] (0.229, 0.501)
Primary	0.961 (0.806, 1.146)
Secondary and over	1.000 (0.819, 1.221)
Age-specific associations	
Physical barriers to walking	
65–74 years	1.157 (0.850, 1.574)
≥75 years	0.309 [*] (0.198, 0.480)
Indoor places for walking	
65–74 years	1.063 (0.870, 1.300)
≥75 years	1.958 [*] (1.483, 2.544)
Traffic speed	
65–74 years	1.125 (0.897, 1.412)
≥75 years	0.705**** (0.515, 0.965)
Sitting facilities	
65–74 years	0.933 (0.804, 1.082)
≥75 years	1.408** (1.133, 1.749)

TABLE 3 Education- and age-specific associations of perceived neighborhood attributes with weekly minutes of within-neighborhood recreational walking (only significant interaction effects shown)

The antilogarithms of the regression coefficients represent the proportional increase (if $e^b > 1.00$) or decrease (if $e^b < 1.00$) in weekly minutes of walking associated with a unit increase in a perceived neighborhood attribute. All models were adjusted for gender, educational attainment, age, and perceived environmental attributes statistically significantly related to walking

 e^b antilogarithm of regression coefficient, 95 % CI 95 % confidence intervals $^*p{<}0.001,~^{**}p{<}0.01,~^{***}p{<}0.05$

elders.^{30,31} Thus, it is possible that their widespread prevalence in Hong Kong contributed to the high levels of recreational walking found in this study. At the same time, the lack of variability in some of these environmental features (e.g., access to shops) may have impeded the detection of significant associations with walking.

This study found positive associations of perceived infrastructure for walking with both measures of recreational walking in the whole sample or educational subgroups, emphasizing the importance of having access to sidewalks, street lights, and safe crosswalks as facilitators of walking in elders.³¹ The same held true for perceived presence of bridges/overpasses connecting to services, a feature typical of

Hong Kong that likely helps elders overcome difficulties with walking on steeply graded paths and high-traffic areas.

As postulated, within-neighborhood measures of recreational walking showed a greater number of associations with perceived environmental attributes than did a general, location-unspecific measure (IPAQ-LC). Obviously, neighborhood characteristics are in the main expected to influence walking behavior that occurs within the neighborhood.²⁴ The comparatively weaker associations with overall recreational walking suggest that a proportion of respondents living in less-walkable neighborhoods walked for recreation outside their neighborhoods. In fact, 12.5 % of respondents reported participating in recreational walking, but not within their neighborhood. Due to its compactness and affordable public transport system, Hong Kong provides relatively easy access to walkable areas so that its dwellers can compensate for the lack of a suitable neighborhood environment by walking elsewhere. This is less likely to be the case in less-dense Western urban areas with poorer inter-area accessibility.

Only perceived proximity of recreational facilities and bridges/overpasses connecting to services were predictive of within-neighborhood recreational walking across all sociodemographic groups, the former finding being in line with previous studies.^{9,11,19} Several other neighborhood attributes were associated with walking in the less educated and "older" elders only. As noted earlier, older age is accompanied by greater vulnerability to unfavorable environmental conditions due to increased functional limitations. This study identified traffic speed and physical barriers to walking as deterrents of recreational walking in "older" elders, while indoor places for walking and sitting facilities emerged as important facilitators.

Hong Kong elders with no formal education appeared to be particularly affected by neighborhood environmental conditions. They were the only educational group to show significant associations of neighborhood walking with physical barriers to walking, fences separating sidewalks from traffic, and infrastructure for walking. In contrast, elders with secondary or higher education were the only group not to show significant associations with infrastructure and indoor places for walking. Individuals with a higher educational attainment are usually more aware of the health benefits associated with an active lifestyle,³² which may contribute to them becoming more intrinsically motivated to engage in regular exercise and, consequently, be less affected by adverse environmental conditions. There is also some evidence that higher educational attainment is associated with higher levels of social support from family and friends, which may also protect from the effects of negative environmental influences.³²

In conclusion, this study suggests that Hong Kong elders with no mobility problems engage in much higher levels of recreational walking than their Western counterparts. This may be attributable to traditional cultural views on the benefits of an active lifestyle as well as environmental factors. More disadvantaged and older elders are the ones likely to be most affected by adverse environmental conditions. The provision of a good infrastructure and indoor/covered places for walking, recreational destinations, adequate levels of traffic safety, and escalators in hilly areas has the potential to reduce socio-economic differential in health status among Chinese Hong Kong elders by facilitating recreational walking in the less educated. It may also help elders maintain their functional independence for longer. This is particularly important given that the proportion of older adults is rapidly increasing in Hong Kong and China overall.³³

Although informative and novel in several ways, this study has limitations that would need to be addressed in future investigations. These include the cross-sectional nature of the study, exclusive reliance on self-report measures, the lack of a comprehensive assessment of the participants' health status (apart from cognitive impairment and mobility), and the exclusion of participants with mobility problems. Given that adverse environmental conditions may contribute to the loss of mobility, the inclusion of participants with mobility problems may result in a more accurate assessment of the dose-response relationships between walking and aspects of the neighborhood environment.¹² Regular walkers may be more aware of their neighborhood environment and thus be more likely to report the presence of certain attributes in their neighborhood. This would yield higher associations with walking than those observed when using objective measures of the environment. Yet, the fact that associations were found only for specific environmental characteristics suggests that the observed effects are likely to be in part due to environmental influences on walking behavior and cannot be entirely attributed to differences in awareness.

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REFERENCES

- 1. Vogel T, Brechat PH, Lepretre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *Int J Clin Pract.* 2009; 63: 303–320.
- 2. Buman MP, Hekler EB, Haskell WL, et al. Objective light-intensity physical activity associations with rated health in older adults. *Am J Epidemiol*. 2010; 172: 1155–1165.
- 3. Cunningham GO, Michael YL. Concepts guiding the study of the impact of the built environment on physical activity for older adults: a review of the literature. *Am J Health Promot.* 2004; 18: 435–443.
- 4. Cerin E, Leslie E, Sugiyama T, Owen N. Associations of multiple physical activity domains with mental well-being. *Ment Health Phys Act*. 2009; 2: 55–64.
- 5. Teychenne M, Ball K, Salmon J. Associations between physical activity and depressive symptoms in women. *Int J Behav Nutr Phys Act.* 2008; 5: 27.
- Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc.* 2007; 39: 1435–1445.
- Forsyth A, Oakes JM, Schmitz KH. Test-retest reliability of the Twin Cities Walking Survey. J Phys Act Health. 2009; 6: 119–131.
- 8. Van Cauwenberg J, De Bourdeaudhuij I, De Meester F, et al. Relationship between the physical environment and physical activity in older adults: a systematic review. *Health Place*. 2011; 17: 458–469.
- Li F, Fisher KJ, Brownson RC, Bosworth M. Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. J Epidemiol Community Health. 2005; 59: 558–564.
- Nagel CL, Carlson NE, Bosworth M, Michael YL. The relation between neighborhood built environment and walking activity among older adults. *Am J Epidemiol.* 2008; 168: 461–468.

- Michael Y, Beard T, Choi D, Farquhar S, Carlson N. Measuring the influence of built neighborhood environments on walking in older adults. *J Aging Phys Act.* 2006; 14: 302– 312.
- 12. de Leon CFM, Cagney KA, Bienias JL, et al. Neighborhood social cohesion and disorder in relation to walking in community-dwelling older adults: a multilevel analysis. *J Aging Health*. 2009; 21: 155–171.
- 13. Shigematsu R, Sallis JF, Conway TL, et al. Age differences in the relation of perceived neighborhood environment to walking. *Med Sci Sports Exerc.* 2009; 41: 314–321.
- Giles-Corti B, Timperio A, Bull F, Pikora T. Understanding physical activity environmental correlates: increased specificity for ecological models. *Exerc Sport Sci Rev.* 2005; 33: 175–181.
- 15. Cerin E, Sit CH, Cheung MC, Ho SY, Lee LC, Chan WM. Reliable and valid NEWS for Chinese seniors: measuring perceived neighborhood attributes related to walking. *Int J Behav Nutr Phys Act.* 2010; 7: 84.
- Cerin E, Barnett A, Sit CH, et al. Measuring walking within and outside the neighborhood in Chinese elders: reliability and validity. *BMC Public Health*. 2011; 11: 851.
- 17. Cerin E, Barnett A, Cheung MC, Sit CPH, Macfarlane DJ, Chan WM (2012) Reliability and validity of the International Physical Activity Questionnaire-Long Form in a sample of Hong Kong urban elders: does neighborhood of residence matter? *J Aging Phys Act* (in press).
- 18. Berke EM, Ackermann RT, Lin EH, et al. Distance as a barrier to using a fitness-program benefit for managed Medicare enrollees. *J Aging Phys Act.* 2006; 14: 313–324.
- 19. Belza B, Walwick J, Shiu-Thornton S, Schwartz S, Taylor M, LoGerfo J. Older adult perspectives on physical activity and exercise: voices from multiple cultures. *Prev Chronic Dis.* 2004; 1: A09.
- 20. Schooling CM, Lam TH, Li ZB, et al. Obesity, physical activity, and mortality in a prospective chinese elderly cohort. *Arch Intern Med.* 2006; 166: 1498–1504.
- Macfarlane D, Chan A, Cerin E. Examining the validity and reliability of the Chinese version of the International Physical Activity Questionnaire, Long Form (IPAQ-LC). *Public Health Nutr.* 2010:1–8.
- Cerin E, Leslie E, Owen N, Bauman A. An Australian version of the Neighborhood Environment Walkability Scale: validity eveidence. *Meas Phys Educ Exerc Sci.* 2008; 12: 31–52.
- 23. Cerin E, Saelens BE, Sallis JF, Frank LD. Neighborhood Environment Walkability Scale: validity and development of a short form. *Med Sci Sports Exerc.* 2006; 38: 1682–1691.
- 24. Giles-Corti B, Timperio A, Cutt H, et al. Development of a reliable measure of walking within and outside the local neighborhood: RESIDE's Neighborhood Physical Activity Questionnaire. *Prev Med.* 2006; 42: 455–459.
- 25. Wood SN. *Generalized additive models: an introduction with R*. Boca Raton: Chapman & Hall; 2006.
- R Development Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing http://www.R-project.org/; 2011.
- Deng HB, Macfarlane DJ, Thomas GN, et al. Reliability and validity of the IPAQ-Chinese: the Guangzhou Biobank Cohort study. *Med Sci Sports Exerc.* 2008; 40: 303– 307.
- 28. Tan J, Ward L, Ziaian T. Experiences of Chinese immigrants and Anglo-Australians ageing in Australia: a cross-cultural perspective on successful ageing. *J Health Psychol.* 2010; 15: 697–706.
- 29. Lee SA, Xu WH, Zheng W, et al. Physical activity patterns and their correlates among Chinese men in Shanghai. *Med Sci Sports Exerc.* 2007; 39: 1700–1707.

- Hall KS, McAuley E. Individual, social environmental and physical environmental barriers to achieving 10,000 steps per day among older women. *Health Educ Res.* 2010; 25: 478–488.
- 31. Wang Z, Lee C. Site and neighborhood environments for walking among older adults. *Health Place*. 2010; 16: 1268–1279.
- 32. Cerin E, Leslie E. How socio-economic status contributes to participation in leisure-time physical activity. *Soc Sci Med.* 2008; 66: 2596–2609.
- 33. Li Q, Reuser M, Kraus C, Alho J. Aging of a giant: a stochastic population forecast for China, 2006–2060. *J Popul Res.* 2009; 26: 21–50.