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ORIGINAL RESEARCH

Neighborhood Disadvantage and Physical Function: The Contributions of Neighborhood-Level Perceptions of Safety From Crime and Walking for Recreation

Venurs H.Y. Loh, Jerome N. Rachele, Wendy J. Brown, Fatima Ghani, and Gavin Turrell

Background: Residents of more socioeconomically disadvantaged neighborhoods are more likely to report poorer physical function, although the reasons for this remain unknown. It is possible that neighborhood-level perceptions of safety from crime contribute to this relationship through its association with walking for recreation. **Methods**: Data were obtained from the fourth wave (collected in 2013) of the HABITAT (How Areas in Brisbane Influence HealTh and AcTivity) multilevel longitudinal study of middle- to older-aged adults (46–74 y) residing in 200 neighborhoods in Brisbane, Australia. The data were analyzed separately for men (n = 2190) and women (n = 2977) using multilevel models. **Results**: Residents of the most disadvantaged neighborhoods had poorer physical function, perceived their neighborhoods to be less safe from crime, and do less walking for recreation. These factors accounted for differences in physical function between disadvantaged and advantaged neighborhoods (24% for men and 25% for women). **Conclusion**: This study highlights the importance of contextual characteristics, through their associations with behaviors, that can have in explaining the relationship between neighborhood disadvantage and physical function. Interventions aimed at improving neighborhood safety integrated with supportive environments for physical activity may have positive impact on physical function among all socioeconomic groups.

Keywords: health inequalities, social environment, gender, physical activity

Residents of socioeconomically disadvantaged neighborhoods have significantly poorer physical function than their counterparts residing in more advantaged neighborhoods.[1] Physical function is defined as one's ability to perform various activities that require physical capacity, ranging from activities of daily living to more vigorous activities that require an increasing degree of mobility, strength, and endurance.[2] Physical function is therefore essential in performing many of the activities required for independent living.[3] From a policy perspective, it is important to know how and why neighborhood disadvantage is associated with poorer physical function, as this knowledge may provide insights about which interventions might best contribute to reducing socioeconomic inequalities in health. At present, however, current understanding of this relationship is at a nascent stage. In this paper, we test the proposition that neighborhood inequalities in physical function may be due in part to disadvantaged neighborhoods having a social environment perceived by its residents as unsafe from crime, resulting in lower levels of walking for recreation (WfR) in these areas.

Consistent with the social ecological theory, individuals' health behaviors are partly influenced by the social environment in which they live,[4] and studies have found that residents of disadvantaged neighborhoods are more likely to perceive their social environment negatively, such as increased crime and disturbance from neighbors.[5–7] These negative perceptions are a likely barrier to outdoor physical activities, such as walking, especially among women, who seem to be more sensitive to their neighborhood environments.[8–12] Walking is the most common physical activity among middle-aged Australians,[13,14] with recreational walking becoming more prevalent in postretirement.[15] Notably, WfR is also most commonly undertaken within neighborhood settings.[16] Living in a more disadvantaged neighborhood is associated with lower levels of WfR,[17,18] and lower levels of walking are associated with poorer physical function.[19–21]

The aim of this study is to examine the contribution of neighborhood-level perceptions of safety from crime (NPSC) and WfR to the relationship between neighborhood disadvantage and physical function. As previous studies have shown that relationships between neighborhood environments and physical function are likely to be different for men and women,[22] we stratified the analyses by gender. It is hypothesized that part of the association between neighborhood disadvantage and physical function will be explained by differences in NPSC and WfR in advantaged and disadvantaged neighborhoods. These findings may have implications for policy that aims to reduce neighborhood-level inequalities in physical function among middle- to older-aged adults, offering one potential point of intervention: improving perceptions of safety from crime in disadvantaged neighborhoods to support walking.

Methods

Study Population

This investigation uses data from the HABITAT (How Areas in Brisbane Influence HealTh and AcTivity) study. HABITAT is a multilevel longitudinal study of middle-aged adults living in the Brisbane local government area, Australia.[23] The primary aim of

Loh, Rachele, Ghani, and Turrell are with the Institute for Health and Ageing, Australian Catholic University, Melbourne, Australia. Rachele is also with the Centre for Health Equity, School of Population and Global Health, The University of Melbourne, Carlton, Australia. Brown is with the Centre for Research on Exercise, Physical Activity and Health, School of Human Movement and Nutrition Sciences, The University of Queensland, Brisbane, Australia. Loh (venurshuiyee.loh@myacu.edu.au) is corresponding author.

HABITAT is to examine patterns of change in health and wellbeing over the period 2007–2016 and to assess the relative contributions of environmental, social, psychological, and sociodemographic factors to these changes. This study uses data from the fourth wave (collected in 2013), where sample age ranged between 46 and 72 years. The HABITAT study received ethical clearance from the Queensland University of Technology Human Research Ethics Committee (reference numbers: 3967H and 1300000161).

Sample Design

Details about HABITAT's baseline sampling design have been published elsewhere.[24] Briefly, a multistage probability sampling design was used to select a stratified random sample (n = 200) of census collector's districts (CCDs), and from within each CCD, a random sample of people aged 40–65 years (on average 85 per CCD). CCDs are embedded within a larger suburb; hence, the area corresponding to, and immediately surrounding, a CCD is likely to have meaning and significance for their residents. For this reason, we hereafter use the term "neighborhood" to refer to each CCD. The baseline HABITAT sample (2007) was broadly representative of the wider Brisbane population, although residents from disadvantaged areas, blue-collar employees, and those who did not attain a postschool educational qualification were underrepresented.[23]

Data Collection and Response Rates

A structured self-administered questionnaire was mailed to 17,000 potentially eligible participants in May 2007 using a mail-survey method developed by Dillman.[25] After excluding out-of-scope respondents (ie, deceased, no longer at the last known address, unable to participate for health-related reasons), 11,035 usable surveys were returned, yielding a baseline response rate of 68.3%: the corresponding response rates from in-scope and contactable participants in 2009, 2011, and 2013 were 72.6% (n = 7866), 67.3% (n = 6900), and 67.1% (n = 6520), respectively.

Measures

Neighborhood Socioeconomic Disadvantage. Each of the neighborhoods was assigned a socioeconomic score using the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage.[26] A neighborhood's Index of Relative Socioeconomic Disadvantage score reflects each area's overall level of disadvantage measured on the basis of 17 variables that capture a wide range of socioeconomic attributes, including education, occupation, income, unemployment, household structure, and household tenure, among others. The derived socioeconomic scores from each of the HABITAT neighborhoods were then grouped into quintiles based on their Index of Relative Socioeconomic Disadvantage scores, with Q1 denoting the 20% of most advantaged areas relative to the whole of Brisbane and Q5 denoting the 20% of most disadvantaged areas.

Neighborhood-Level Perception of Safety From Crime. Participants were asked to respond to 6 statements on a 5-item Likert scale, ranging from "strongly disagree" to "strongly agree" about the level of crime in their neighborhood and perceptions of their personal safety in parks, on the streets, and using public transport in their area. These statements were adapted for the Australian population from the Neighborhood Environment Walkability Scale questionnaire,[27] which has acceptable validity and reliability for measuring perceived neighborhood walkability.[28,29] Principal components analysis with varimax rotation revealed that the 6 items loaded on 1 "perceptions of safety from crime" factor, with a Cronbach's alpha of .81. This factor was subsequently used in an empirical Bayes exchangeable (EBE) analysis to estimate NPSC. Rather than solely use a mean neighborhood-level aggregated score, as has been done in previous studies,[30–33] the EBE approach takes into account the number of participants in each neighborhood and the variability of the exposure within and between neighborhoods.[34] Further details about the EBE approach for generating neighborhood-level exposures can be found elsewhere.[35,36] The 200 neighborhoods were subsequently grouped into quintiles based on their ranked EBE score, with Q1 denoting the 20% of neighborhoods perceived as being the least safe from crime and Q5 denoting the 20% of neighborhoods perceived as the safest from crime.

Walking for Recreation. This was measured using a single question that asks: "What do you estimate was the total time that you spent walking for recreation, leisure or exercise in the last week? When answering this question, please do not count for walking for transport." The distribution of the WfR variable was right-skewed and included outlier values which were top-coded to 840 minutes (equivalent to 2 h walking each day).[37] Level of WfR per week was categorized as none (0 min), low (1–149 min), and moderate/high (≥150 min).

Self-Reported Physical Function. This was measured using the 10-item physical functioning scale, a component of the 36-Item Short Form Health Survey.[38] The stem question of the 10-item physical functioning scale asked: "Does your health now limit you in these activities? If so, how much?" Respondents were asked to indicate: "Yes, limited a lot" or "Yes, limited a little" or "No, not limited at all" for each activity. The 10-item physical functioning scale measures a hierarchical range of difficulties, from vigorous activities such as lifting heavy objects to bathing and dressing.[39] This measure has been extensively validated among community-dwelling adults using convergent validity calculated by Pearson correlations using 3-performance-based measures: single limb stance as an indicator of balance ($r = .42$), Timed Up and Go test as a measure of mobility ($r = -.70$), and gait speed as an indicator of overall functional capacity ($r = .75$).[2] The method of data cleaning for the physical function score was adapted from Ware et al.[38] The raw physical function scores were calculated as the sum of (recoded) scale items and transformed to a 0–100 scale as follows:

$$\text{Physical function score} = \frac{\text{Raw score} - \text{Minimum possible raw score}}{\text{Possible raw score range}} \times 100.$$

A standard scoring system was used such that 0 represents minimal functioning and 100 represents maximal functioning. Although scores were somewhat negatively skewed toward maximal function, they are comparable with Australian population norms for this scale (age standardized mean = 83.6 y for men and 81.5 y for women).[40]

Covariates

Education. Respondents were asked to provide information about the highest education qualification completed. Respondents were coded as (1) bachelor degree or higher (the latter included postgraduate diploma, master's degree, or doctorate), (2) diploma (associate or undergraduate), (3) vocational (trade or business certificate or apprenticeship), and (4) no postsecondary school qualification.

Occupation. Respondents who were employed at the time of completing the survey were asked to indicate their job title and describe the main tasks or duties they performed. This information was coded to the Australian and New Zealand Standard Classification of Occupations. For the purpose of this study, the original Australian and New Zealand Standard Classification of Occupations classification was recoded into the following categories: (1) managers/professionals, (2) white-collar employees, and (3) blue-collar employees. Respondents who were not employed were categorized as follows: (4) home duties, (5) retired, and (6) permanently unable to work.

Household Income. Respondents were asked to indicate their total annual household income (including pensions, allowances, and investments) using a 14-category measure that was subsequently recoded into 6 groups for analysis: (1) ≥AU$130,000; (2) AU$72,800–$129,999; (3) AU$52,000–$72,799; (4) AU $26,000–$51,999; (5), <AU$25,999; and (6) not classified (ie, ticked "Don't know" or "Don't want to answer this," or left the income question blank).

Statistical Analyses

We excluded respondents who changed address after 2007 (n = 1153) as moving to a different neighborhood may have been be influenced by unmeasured preferences related to both residential choice and physical function.[41] Participants with missing data for physical function (n = 82), age (n = 1), WfR (n = 103), and education (n = 14) were also excluded. This reduced the analytic sample to n = 5167 respondents. The number of participants across each of the 200 neighborhoods ranged from 1 to 34 for men and 2 to 54 for women, and the mean (SD) per neighborhood for men and women was 10.7 (6.7) and 14.5 (9.2), respectively. Sensitivity analyses (not presented here) indicated that those excluded due to missing data did not differ significantly from included respondents on neighborhood disadvantage, gender, or physical function.

Decisions about the inclusion of variables and the modeling strategy were informed by a directed acyclic graph (Figure 1), which postulated relationships between neighborhood socioeconomic disadvantage, NPSC, WfR, physical function, and potential confounders: age, education, occupation, and household income. Consistent with previous research,[1] analyses were stratified by gender as physical function scores differed for men and women.

The analyses were conducted in 7 stages. First, the relationship between neighborhood disadvantage and physical function was examined using multilevel linear regression, and the data were graphically presented as mean differences in physical function between the neighborhood quintiles, adjusted for age and individual-level socioeconomic position (SEP). Second, we used an ecologic cross-tabulation to examine the neighborhood-level relationship between socioeconomic disadvantage and perceptions of safety from crime; in particular, we focused on how advantaged and disadvantaged neighborhoods were patterned (distributed) across the quintiles of NPSC. Third, the association between NPSC and WfR was examined using multilevel multinomial logistic regression: model 1 adjusted for age, and model 2 adds individual SEP and neighborhood disadvantage. As recommended,[42] the parameters for these models—odds ratios and

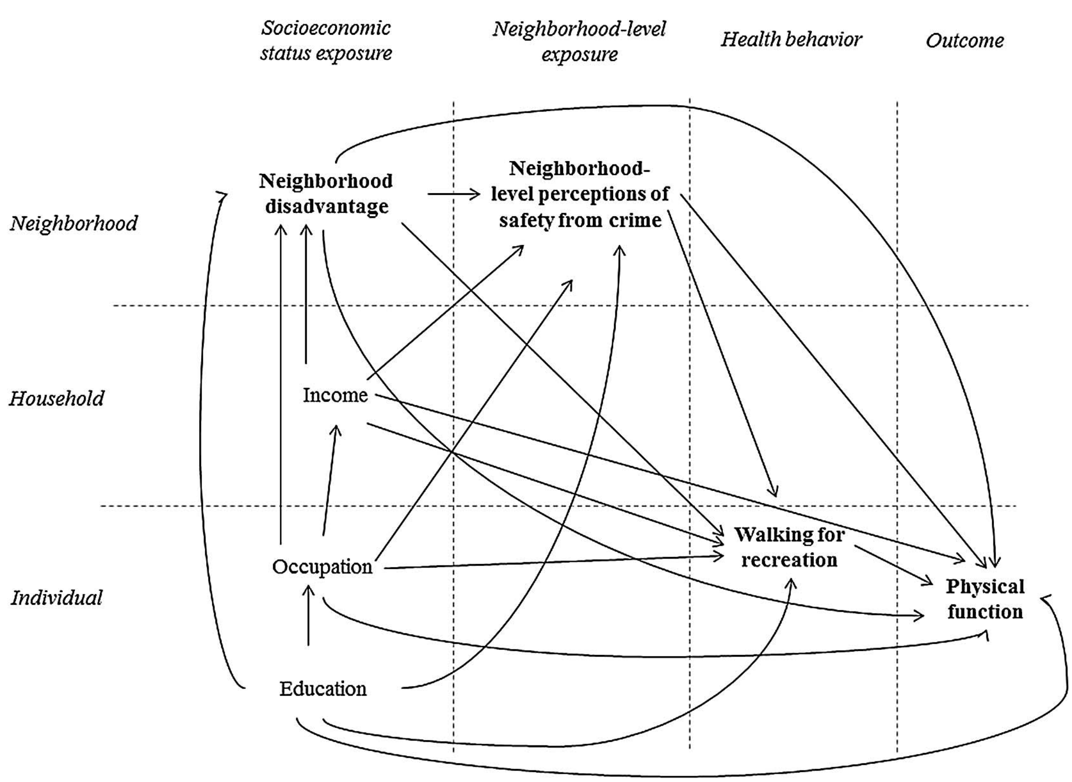

Figure 1 — Directed acyclic graph conceptualizing the relationship between neighborhood disadvantage, neighborhood-level perceptions of safety from crime, walking for recreation, and physical function adjusted for age and gender.

95% credible intervals—were estimated using Markov chain Monte Carlo simulation. This procedure was implemented using the Metropolis–Hastings algorithm with standard noninformative prior distributions on all parameters. To achieve convergence of the simulated chains for the variance parameters (assessed using the Raftery–Lewis and Brooks–Draper diagnostics), the Metropolis–Hastings algorithm was implemented for 50,000 iterations.[42] Fourth, the association between neighborhood disadvantage and WfR was examined using multilevel multinomial logistic regression, using the same procedure as outlined in stage 3. Fifth, the association between NPSC and physical function was examined using multilevel linear regression: model 1 presents mean differences in physical function across the quintiles of NPSC adjusted for age, and model 2 adds individual SEP and neighborhood disadvantage. Sixth, the association between WfR and physical function was examined using the same procedure as outlined in stage 5. Seventh, the contribution of NPSC and WfR to the association between neighborhood disadvantage and physical function was examined using multilevel linear regression: model 1 presents mean differences in physical function across the quintiles of neighborhood disadvantage adjusted for age, education, occupation, and household income; model 2 adds NPSC; model 3 adds WfR (excluding NPSC); and model 4 adjusts for both NPSC and WfR. All data were prepared in Stata SE 13,[43] and the analyses were undertaken using MLwiN version 2.35.[44]

Results

Bivariate associations between physical function, neighborhood disadvantage, respondents' sociodemographic characteristics, NPSC, and WfR are presented in Table 1. Mean physical function scores were lowest among residents of disadvantaged neighborhoods, the least educated, those who were permanently unable to work, members of low-income households, and those in the oldest age group. Physical function scores were also lowest for those who strongly perceived their neighborhood as being the least safe from crime and those who did no WfR in the previous week.

Neighborhood Disadvantage and Physical Function

After adjusting for age and individual-level SEP, there was a significant graded association between neighborhood disadvantage and physical function for both men and women (Figure 2). Residents from more disadvantaged neighborhoods (Q4 and Q5) had significantly lower physical function scores than their counterparts from more advantaged neighborhoods (Q1 and Q2).

Neighborhood Disadvantage and NPSC

The data in Table 2 show that more disadvantaged neighborhoods were perceived as having lower levels of safety from crime than more advantaged neighborhoods. Among men, for example, 30% (n = 12) of the most disadvantaged neighborhoods were categorized in the lowest quintile of NPSC, compared with 2.5% (n = 1) of the least disadvantaged neighborhoods: the corresponding percentages for women were 52.5% (n = 21) and 7.5% (n = 3).

NPSC and WfR

Among men, the age-adjusted odds of WfR at low levels were significantly higher among those living in neighborhoods that were perceived as being the safest from crime (Table 3). However, after further adjustment for individual-level SEP and neighborhood disadvantage, the association attenuated to the null. Among women, the age-adjusted odds of WfR at low and moderate/high levels were significantly greater for those living in neighborhoods perceived as safer from crime than those living in neighborhoods perceived as the least safe from crime. While the association attenuated after adjustment for individual-level SEP and neighborhood disadvantage (model 2), the odds of WfR at moderate/high levels remained significant for women living in neighborhoods that were perceived as the safest from crime (Q1; Table 3).

Neighborhood Disadvantage and WfR

Among men, the age-adjusted odds of WfR at low and moderate/high levels were significantly greater in less disadvantaged neighborhoods than in the most disadvantaged neighborhoods (Table 3); however, after further adjustment for individual-level SEP, none of the associations reached statistical significance. Among women, the odds of WfR at low and moderate/high levels were significantly higher in less disadvantaged neighborhoods than the most disadvantaged neighborhoods, before and after adjustment for individual-level SEP (Table 3).

NPSC and Physical Function

After adjusting for age (model 1), living in a neighborhood perceived as being less safe from crime (Q1, Q2, and Q3) was associated with lower physical function scores for both men and women (Table 4). These associations were attenuated after further adjustment for individual-level SEP and neighborhood disadvantage, and remained statistically significant only for women (model 2).

WfR and Physical Function

WfR was positively associated with physical function for both men and women before and after adjustment for individual-level SEP and neighborhood disadvantage (Table 4). Men who walked for 150 minutes or more in the previous week had a mean physical function score approximately 4 points higher than those who reported no walking: the corresponding mean difference for women was approximately 10 points.

Neighborhood Disadvantage and Physical Function Adjusting for NPSC and WfR

Men and women residing in the most disadvantaged neighborhoods had a significantly lower physical function score than their counterparts living in the least disadvantaged neighborhoods (Table 5). These associations remained significant after adjustment for NPSC, but attenuated by 20% for men and 21% for women. After adjusting for WfR, these associations remained significant but attenuated by 4% for men and 10% for women. After simultaneous adjustment for NPSC and WfR, these associations were further attenuated: these factors explained 24% and 25% of the association between neighborhood disadvantage and physical function for men and women, respectively; although, in both men and women, physical function scores remained significantly lower for residents of the most disadvantaged neighborhoods.

Table 1 Sociodemographic Characteristics and Mean (95% CI) Physical Function Scores for the HABITAT Analytic Sample in 2013[a]

	Men (n = 2190)		Women (n = 2977)	
	%	Mean (95% CI)	%	Mean (95% CI)
Overall	42.3	87.7 (86.9 to 88.4)	57.7	83.4 (82.7 to 84.1)
Neighborhood disadvantage				
Q1 (least disadvantaged)	20.9	91.8 (90.6 to 92.8)	20.8	87.8 (86.5 to 89.1)
Q2	27.1	90.2 (88.9 to 91.3)	26.9	85.5 (84.3 to 86.8)
Q3	20.5	87.5 (86.0 to 89.0)	19.4	83.7 (82.1 to 85.2)
Q3	18.4	85.3 (83.4 to 87.1)	19.1	80.8 (79.2 to 82.5)
Q5 (most disadvantaged)	13.1	79.9 (77.1 to 82.6)	13.8	75.7 (73.2 to 78.2)
Age, y				
45–49	20.9	92.3 (91.1 to 93.5)	18.9	89.7 (88.4 to 91.1)
50–54	21.9	89.3 (87.8 to 90.7)	21.9	86.4 (85.0 to 87.9)
55–59	20.5	87.0 (85.4 to 88.6)	20.2	84.5 (83.0 to 85.9)
60–65	19.4	85.8 (84.0 to 87.6)	20.5	80.7 (79.0 to 82.3)
≥66	17.3	83.2 (81.2 to 85.1)	18.5	75.1 (73.2 to 77.1)
Education				
Bachelor degree or higher	36.2	91.1 (90.2 to 92.0)	33.6	86.6 (85.6 to 87.7)
Diploma/associate degree	12.4	89.4 (87.7 to 91.1)	11.5	83.8 (81.7 to 85.9)
Certificate	21.1	86.5 (84.7 to 88.3)	14.2	83.8 (81.9 to 85.6)
No postschool qualification	30.2	83.8 (82.3 to 85.4)	40.7	80.5 (79.2 to 87.7)
Occupation				
Professional	36.1	91.7 (90.9 to 92.6)	29.5	89.4 (88.4 to 90.3)
White collar	13.0	91.0 (89.7 to 92.4)	25.2	86.5 (85.3 to 87.7)
Blue collar	19.0	88.1 (86.5 to 89.7)	4.8	85.7 (82.7 to 88.7)
Home duties	0.7	81.2 (68.7 to 93.8)	8.2	83.8 (81.2 to 86.2)
Retired	20.4	82.9 (81.1 to 84.7)	23.6	76.3 (74.6 to 77.9)
Permanently unable to work	2.4	57.1 (49.4 to 64.8)	1.8	38.1 (30.4 to 45.8)
Not easily classifiable[b]	8.4	85.3 (82.2 to 88.3)	6.8	80.7 (77.9 to 83.5)
Income				
≥$130,000	25.7	92.9 (92.0 to 93.8)	16.7	90.7 (89.5 to 91.9)
$72,800–$129,999	24.8	89.6 (88.4 to 90.8)	22.6	86.7 (85.4 to 88.0)
$52,000–$72,799	13.0	87.8 (85.9 to 89.6)	11.8	84.1 (82.2 to 86.1)
$26,000–$51,599	18.0	83.8 (81.9 to 85.7)	19.2	78.5 (76.8 to 80.3)
<$25,999	8.4	74.8 (71.1 to 78.4)	11.8	73.5 (70.9 to 76.0)
Not classified[c]	10.1	87.4 (84.9 to 89.8)	17.9	83.6 (81.8 to 85.4)
Neighborhood-level perceptions of safety from crime[d]				
Q1 (50.7–100)	20.0	83.8 (81.9 to 85.7)	19.9	79.3 (77.4 to 81.2)
Q2 (39.5–50.6)	19.7	84.9 (83.0 to 86.7)	18.8	81.2 (79.5 to 82.9)
Q3 (33.3–39.4)	20.2	88.3 (86.8 to 89.9)	21.0	82.6 (80.9 to 84.2)
Q4 (25.1–33.2)	20.0	90.4 (88.9 to 91.7)	19.5	85.5 (84.1 to 86.9)
Q5 (0–25.0)	20.1	91.1 (89.9 to 92.3)	20.8	88.1 (86.8 to 89.3)
Walking for recreation in the previous week, min				
Moderate/high (≥150 min)	30.7	88.8 (87.6 to 89.9)	34.4	87.5 (86.6 to 88.6)
Low (1–149 min)	35.0	89.4 (88.3 to 90.4)	35.3	84.9 (83.9 to 86.0)
None (0 min)	34.3	85.0 (83.6 to 86.5)	30.3	76.8 (75.3 to 78.4)

Abbreviations: CI, confidence interval; HABITAT, How Areas in Brisbane Influence HealTh and AcTivity.
[a]Physical function score ranged from 0 to 100, where 0 represents minimal functioning and 100 represents maximal functioning.
[b]Students, unemployed, or other classifiable.
[c]Those who reported “Don’t know” or “Don’t want to answer this,” or left the income question blank.
[d]Neighborhood-level perceptions of safety from crime score ranged from 0 to 100: Q1 represents neighborhoods perceived as the least safe from crime and Q5 represents neighborhoods perceived as the safest from crime.

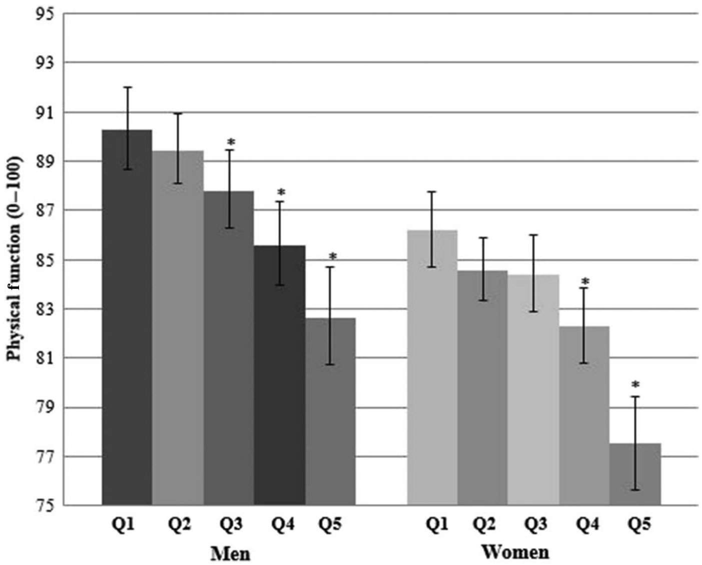

Figure 2 — Relationship between neighborhood disadvantage and physical function (0–100) for men and women. Model adjusted for within-neighborhood variation in age, education, occupation, and household income. Q5 represents the most disadvantage neighborhood and is also the reference group. *Significance at $P < .001$.

Discussion

This study found that living in more socioeconomically disadvantaged neighborhoods was significantly associated with poorer physical function, which is consistent with previous research.[1,6,45–47] In an effort to move beyond the descriptive nature of previous studies and explore possible mechanistic pathways, we examined the contribution of NPSC and WfR to this relationship. Residents of more disadvantaged neighborhoods perceived their neighborhoods to be less safe from crime, and women in these neighborhoods did less WfR than those in advantaged neighborhoods. These 2 factors partly accounted for the observed differences in physical function between disadvantaged and advantaged neighborhoods.

Our finding that residents of more disadvantaged neighborhoods reported lower levels of NPSC is consistent with previous research.[5–7] For example, a study in London[5] found that participants living in more disadvantaged neighborhoods were more likely to report negative social features, such as crime, disturbance by neighbors, and vandalism. This finding is important because lower perceptions of safety from crime within neighborhoods have previously been shown to have implications for walking behaviors. A systematic review[8] reported that high levels of neighborhood crime were a barrier to walking in the neighborhood: this effect was found to be stronger among women and older adults.[48] We found greater levels of WfR among residents of neighborhoods with higher perceptions of safety from crime, but this relationship was only statistically significant among women. The gender difference in the relationship between NPSC on both physical function and WfR could be explained by research indicating that women are more "ecologically vulnerable" than men and more sensitive to their immediate surroundings.[49,50] Mark,[51] for example, found an interaction between gender and risk, where equal exposure to risk resulted in greater fear among women than men. Men, on the other hand, were found to have lower levels of fear and often perceived themselves as invulnerable, leading them to discount risk. In our study, gender-specific findings were also observed in the relationship between neighborhood disadvantage and WfR; after adjusting for age and individual-level SEP, the association remained for women only. The gender differences observed in this study highlight the importance of conducting analyses separately for men and women, to improve understanding of the effects of NPSC on WfR and physical function.

Consistent with other studies using self-report measures of crime,[52–57] we found a significant association between NPSC and physical function. However, after adjusting for individual- and neighborhood-level socioeconomic factors, the association remained only among women. Despite evidence that physical function differs for men and women, and the social aspects of the

Table 2 Association Between Neighborhood Disadvantage and Neighborhood-Level Perceptions of Safety From Crime for Men and Women

	Neighborhood-level perceptions of safety from crime[a]					
N = 200 neighborhoods	**Q1, %**	**Q2, %**	**Q3, %**	**Q4, %**	**Q5, %**	**Total N**
Neighborhood disadvantage						
Men						
Q1 (least disadvantaged)	2.5	10.0	17.5	27.5	42.5	40
Q2	0.0	15.0	22.5	27.5	35.0	40
Q3	15.0	25.0	22.5	20.0	17.5	40
Q4	22.5	30.0	30.0	17.5	0.0	40
Q5 (most disadvantaged)	30.0	20.0	7.5	7.5	5.0	40
Women						
Q1 (least disadvantaged)	7.5	5.0	15.0	25.0	47.5	40
Q2	0.0	20.0	22.5	30.0	27.5	40
Q3	12.5	17.5	25.0	25.0	20.0	40
Q4	27.5	32.5	20.0	20.0	0.0	40
Q5 (most disadvantaged)	52.5	25.0	17.5	0.0	5.0	40

[a]Q1 represents neighborhoods perceived as the least safe from crime and Q5 represents neighborhoods perceived as the safest from crime.

Table 3 Associations Between Neighborhood-Level Perceptions of Safety From Crime, Neighborhood Disadvantage, and Walking for Recreation for Men and Women

	Walking for recreation in the previous week, min					
	Model 1[a]			Model 2[b]		
N = 200 neighborhoods	None (0 min)	Low (1–149 min), OR (95% CrI)	Moderate/High (≥150 min), OR (95% CrI)	None (0 min)	Low (1–149 min), OR (95% CrI)	Moderate/High (≥150 min), OR (95% CrI)
Neighborhood-level perceptions of safety from crime						
Men (n = 2190)						
Q1 (least safe from crime)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.00	1.05 (0.73 to 1.51)	1.21 (0.84 to 1.76)	1.00	0.95 (0.65 to 1.37)	1.13 (0.76 to 1.67)
Q3	1.00	1.01(0.72 to 1.44)	1.02 (0.71 to 1.49)	1.00	0.82 (0.55 to 1.21)	0.87 (0.57 to 1.34)
Q4	1.00	1.41 (0.99 to 2.01)	1.42 (0.98 to 2.07)	1.00	1.05 (0.68 to 1.59)	1.18 (0.75 to 1.85)
Q5 (safest from crime)	1.00	1.42 (1.01 to 2.03)*	1.41 (0.97 to 2.05)	1.00	1.00 (0.64 to 1.52)	1.13 (0.71 to 1.78)
Women (n = 2977)						
Q1 (least safe from crime)	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.00	0.84 (0.60 to 1.17)	0.89 (0.63 to 1.26)	1.00	0.71 (0.50 to 1.01)	0.82 (0.57 to 1.20)
Q3	1.00	1.03 (0.74 to 1.42)	1.19 (0.85 to 1.67)	1.00	0.83 (0.58 to 1.20)	1.09 (0.74 to 1.61)
Q4	1.00	1.23 (0.87 to 1.71)	1.61 (1.13 to 2.28)*	1.00	0.95 (0.64 to 1.40)	1.47 (0.98 to 2.23)
Q5 (safest from crime)	1.00	1.41 (1.01 to 1.99)*	2.02 (1.43 to 2.89)**	1.00	0.96 (0.62 to 1.50)	1.64 (1.04 to 2.63)*
Neighborhood disadvantage						
Men (n = 2190)						
Q5 (most disadvantaged)	1.00	1.00	1.00	1.00	1.00	1.00
Q4	1.00	1.24 (0.82 to 1.86)	1.13 (0.75 to 1.72)	1.00	1.18 (0.78 to 1.77)	1.17 (0.77 to 1.79)
Q3	1.00	1.34 (0.89 to 1.99)	1.26 (0.82 to 1.91)	1.00	1.22 (0.81 to 1.84)	1.27 (0.83 to 1.93)
Q2	1.00	1.51 (1.02 to 2.79)*	1.37 (0.92 to 2.05)	1.00	1.28 (0.87 to 1.91)	1.30 (0.86 to 1.96)
Q1 (least disadvantaged)	1.00	1.13 (0.75 to 1.71)	1.59 (1.04 to 2.41)*	1.00	1.49 (0.99 to 2.28)	1.44 (0.91 to 2.26)
Women (n = 2977)						
Q5 (most disadvantaged)	1.00	1.00	1.00	1.00	1.00	1.00
Q4	1.00	1.27 (0.88 to 1.82)	1.28 (0.87 to 1.87)	1.00	1.20 (0.82 to 1.76)	1.26 (0.86 to 1.89)
Q3	1.00	1.49 (1.03 to 2.14)*	1.42 (0.97 to 2.08)*	1.00	1.35 (0.93 to 1.97)	1.37 (0.92 to 2.04)
Q2	1.00	1.46 (1.04 to 2.09)*	1.51 (1.06 to 2.16)*	1.00	1.24 (0.86 to 1.77)	1.42 (0.96 to 2.09)
Q1 (least disadvantaged)	1.00	1.83 (1.28 to 2.62)**	2.06 (1.40 to 3.03)***	1.00	1.44 (0.97 to 2.14)	1.78 (1.19 to 2.69)**

Abbreviations: CrI, credible interval; OR, odds ratio.
[a]Model adjusted for age.
[b]Model 1 + adjustment for education, occupation, household income, and neighborhood disadvantage.
$^{*}P < .05$. $^{**}P < .01$. $^{***}P < .001$.

Table 4 Associations Between Neighborhood-Level Perceptions of Safety From Crime, Walking for Recreation, and Physical Function in Men and Women

	Physical function[a]	
N = 200 neighborhoods	Model 1,[b] β (95% CI)	Model 2,[c] β (95% CI)
Neighborhood-level perceptions of safety from crime		
Men (n = 2190)		
Q5 (safest from crime)	–	–
Q4	−0.73 (−3.40 to 1.94)	0.34 (−1.87 to 2.56)
Q3	−2.82 (−5.47 to −0.18)*	−0.57 (−2.90 to 1.75)
Q2	−6.39 (−9.02 to −3.77)***	−2.21 (−4.62 to 0.18)
Q1 (least safe from crime)	−7.45 (−10.07 to −4.82)***	−1.56 (−4.21 to 1.08)
Women (n = 2977)		
Q5 (safest from crime)	–	–
Q4	−2.46 (−4.74 to −0.19)*	−1.10 (−3.39 to 1.17)
Q3	−5.04 (−7.27 to −2.81)***	−3.01 (−5.19 to −0.83)**
Q2	−6.32 (−8.61 to −4.02)***	−3.18 (−5.63 to −0.73)*
Q1 (least safe from crime)	−8.26 (−10.52 to −5.99)***	−2.32 (−4.90 to 0.25)
Walking for recreation		
Men (n = 2190)		
None (0 min)	–	–
Low (1–149 min)	4.06 (2.39 to 5.74)***	3.11 (1.52 to 4.69)***
Moderate/high (≥150 min)	4.21 (2.47 to 5.98)***	4.12 (2.48 to 5.77)***
Women (n = 2977)		
None (0 min)	–	–
Low (1–149 min)	7.37 (5.69 to 9.05)***	5.85 (4.28 to 7.42)***
Moderate/high (≥150 min)	10.54 (8.84 to 12.23)***	9.31 (7.73 to 10.89)***

Abbreviation: CI, confidence interval.
[a]Physical function score ranged from 0 to 100, where 0 represents minimal functioning and 100 represents maximal functioning.
[b]Model adjusted for age.
[c]Model 1 + adjustment for education, occupation, household income, and neighborhood disadvantage.
*$P < .05$. **$P < .01$. ***$P < .001$.

neighborhood environment have larger effects for women than men, only one study[47] stratified data by gender and found negligible differences for men and women. The results from our study, however, and those of Freedman et al[47] may not be comparable, due to differences in the measure used to assess safety from crime (self-report vs objective) and the different country contexts (Australia vs United States). Furthermore, it is well established that participation in regular, moderate physical activity (including walking) is beneficial for physical function.[3,20,21,58] The relative risk of older adults losing functional independence may be reduced by up to 30% through engagement in 150–180 minutes per week of moderate to vigorous physical activity, such as brisk walking.[20] Our results showed that WfR was positively associated with physical function, and previous longitudinal analyses have shown that moderate-intensity activity, such as walking, prevents functional decline.[59]

Bringing together the pathways tested in the current study, both NPSC and WfR explained part of the relationship between neighborhood disadvantage and physical function for men and women. NPCS, however, explained a larger part of this relationship: 20% and 21% for men and women, compared with 4% for men and 10% for women explained by WfR. A similar study by Feldman and Steptoe[6] in London found that residents living in more disadvantaged neighborhoods perceived greater neighborhood strain (measured by levels of social cohesion, neighborhood problems, and vigilance for threat) that, in turn, were associated with poorer physical functioning. To the best of our knowledge, few studies have examined the mechanistic pathways between neighborhood disadvantage and physical function. Our findings and those of Feldman and Steptoe[6] suggest that the relationships between neighborhood disadvantage, NPSC, WfR, and physical function are complex and, at present, not well understood. Nevertheless, the current study makes an important contribution to advancing understanding of why residents of more disadvantaged neighborhoods have poorer physical function: it seems in part because they are more concerned about safety from crime in their local environment, and hence, they are less likely to walk for recreation. Although other factors are likely to contribute to the relationship between neighborhood disadvantage and physical function, our study adds to the nascent understanding of potential mechanisms.

Table 5 Relationship Between Neighborhood Disadvantage and Physical Function Adjusting for Individual-Level Socioeconomic Position (Model 1), Neighborhood-Level Perceptions of Safety From Crime (Model 2), Walking for Recreation (Model 3), and the Fully Adjusted Model (Model 4)

	Physical function[a]			
	Model 1,[b] β (95% CI)	Model 2,[c] β (95% CI)	Model 3,[d] β (95% CI)	Model 4,[e] β (95% CI)
Neighborhood disadvantage				
Men (n = 2190)				
Q1 (least disadvantage)	–	–	–	–
Q2	−0.55 (−2.61 to 1.50)	−0.28 (−2.37 to 1.81)	−0.52 (−2.58 to 1.53)	−0.23 (−2.32 to 1.85)
Q3	−2.33 (−4.55 to −0.11)*	−1.56 (−3.92 to 0.79)	−2.23 (−4.45 to −0.01)*	−1.49 (−3.85 to 0.86)
Q4	−4.47 (−6.76 to −2.17)***	−3.51 (−6.04 to −0.98)**	−4.32 (−6.61 to −2.02)***	−3.41 (−5.94 to −0.89)**
Q5 (most disadvantaged)	−6.73 (−9.28 to −4.17)***	−5.36 (−8.38 to −2.34)***	−6.46 (−9.01 to −3.90)***	−5.10 (−8.12 to −2.08)**
Women (n = 2977)				
Q1 (least disadvantaged)	–	–	–	–
Q2	−1.60 (−3.50 to 0.28)	−0.78 (−2.81 to 1.25)	−1.31 (−3.16 to 0.53)	−0.68 (−2.68 to 1.31)
Q3	−1.93 (−4.00 to 0.13)	−0.87 (−3.21 to 1.47)	−1.57 (−3.60 to 0.44)	−0.80 (−3.09 to 1.49)
Q4	−3.27 (−5.38 to −1.16)**	−1.65 (−4.17 to 0.86)	−2.81 (−4.88 to −0.74)**	−1.66 (−4.13 to 0.79)
Q5 (most disadvantaged)	−7.59 (−9.91 to −5.28)***	−5.98 (−8.78 to −3.17)***	−6.82 (−9.09 to −4.55)***	−5.69 (−8.44 to −2.94)***

Abbreviation: CI, confidence interval.
[a]Physical function score ranged from 0 to 100, where 0 represents minimal functioning and 100 represents maximal functioning.
[b]Adjusted for age, education, occupation, and household income.
[c]Model 1 + adjustment for neighborhood-level perceptions of safety from crime.
[d]Model 1 + adjustment for walking for recreation.
[e]Model 1 + adjustment for neighborhood-level perceptions of safety from crime and walking for recreation.
*$P < .05$. ** $P < .01$. *** $P < .001$.

Limitations

This study has a number of limitations. First, the cross-sectional design means that claims about causality must be made with caveats, as it is plausible that poor physical function could negatively impact on WfR. Examining change over time in neighborhood disadvantage, NPSC, WfR, and physical function would add strength to the study findings. Furthermore, examining these relationships in the context of residential mobility over time (allowing for large changes in neighborhood exposures), and analysis of within-individual changes, would have provided stronger evidence for causal claims.[60] Second, the study data were obtained from the fourth wave of the HABITAT survey, and sample attrition at both baseline and the fourth wave may have implications for generalizability. The nonresponse rate in the HABITAT baseline study was 31.5%, and a comparison of the HABITAT baseline sample with census data indicates an underrepresentation of men, those not in the workforce, those with low-income household, and those living in disadvantaged areas.[61] Therefore, it is likely that our findings underestimate the true magnitude of the relationships examined. Third, data on WfR, NPSC, and physical function were self-reported and therefore subject to recall bias.[62,63] Fourth, the WfR survey item did not specify the setting in which walking activity was undertaken. It is possible that the reported walking duration was undertaken outside of participants' neighborhood. In addition, the walking item in the survey was unable to capture the intensity of walking, which has shown to be more important to health than the total walking time.[64]

This study highlights the potential importance that contextual characteristics, such as NPSC, can have in explaining the relationship between neighborhood disadvantage and physical function. Such findings are also promising in terms of public health interventions. Interventions aimed at improving safety within the neighborhood, integrated with supportive environments for physical activity, may have beneficial impacts on the population's physical function. The National Heart Foundation of Australia,[65] for example, has promulgated a blueprint for community and neighborhood designs that support active living. These include the enhancement of natural surveillance of street and open spaces, removing graffiti, and repairing vandalism damage to enhance perceptions of safety that supports physical activity; the implementation of such measures is likely to reduce neighborhood inequalities in physical function.

Conclusion

This study found a strong graded relationship between neighborhood-level socioeconomic disadvantage and physical function, and this was partly explained by differences in NPSC and WfR between disadvantaged and advantaged neighborhoods. This study adds to the limited understanding of neighborhood disadvantage and physical function, which could, in turn, inform more effective interventions for maintenance of physical function. These findings call for further investigations of the complex interplay between environmental- and individual-level mechanisms in relation to health. Policies and interventions that act on the mechanisms identified in this study may help to mitigate neighborhood inequalities in physical function.

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