Personal, social and environmental determinants of educational inequalities in walking: a multilevel study

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EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

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Objective: To investigate the contribution of personal, social and environmental factors to mediating socioeconomic (educational) inequalities in women's leisure-time walking and walking for transport.
Methods: A community sample of 1282 women provided survey data on walking for leisure and transport; educational level; enjoyment of, and self-efficacy for, walking; physical activity barriers and intentions; social support for physical activity; sporting/recreational club membership; dog ownership; and perceived environmental aesthetics and safety. These data were linked with objective environmental data on the density of public open space and walking tracks in the women's local neighbourhood, coastal proximity and street connectivity.
Results: Multilevel modelling showed that different personal, social and environmental factors were associated with walking for leisure and walking for transport. Variables from all three domains explained (mediated) educational inequalities in leisure-time walking, including neighbourhood walking tracks; coastal proximity; friends' social support; dog ownership; self-efficacy, enjoyment and intentions. On the other hand, few of the variables examined explained educational variations in walking for transport, exceptions being neighbourhood, coastal proximity, street connectivity and social support from family.
Conclusions: Public health initiatives aimed at promoting, and reducing educational inequalities in, leisure-time walking should incorporate a focus on environmental strategies, such as advocating for neighbourhood walking tracks, as well as personal and social factors. Further investigation is required to better understand the pathways by which education might influence walking for transport.

Despite the well-known benefits of physical activity for health,[1 2] large proportions of the population in many developed countries are physically inactive.[1 3] Women engage in less leisure-time physical activity than men,[4 5] and those of low socioeconomic position (SEP) engage in less leisure-time and overall physical activity, including walking, than those of high SEP, regardless of the indicator of SEP used.[6–10] Socioeconomic differentials in physical inactivity are consistent with socioeconomic gradients in many health outcomes and represent a key pathway through which SEP affects health.

Despite substantial evidence of a socioeconomic gradient in physical activity, the underlying mechanisms remain largely unknown. Social–ecological models[11 12] posit that physical activity participation is influenced by multiple personal, social and physical environmental factors. Intrapersonal influences shown to positively affect physical activity include enjoyment of activity, self-efficacy, behavioural intentions and low perceived barriers to being active; social influences include social support from family and friends and being a member of a sporting or exercise club; and environmental influences include a safe neighbourhood, urban design features such as street connectivity, sprawl and land use mix, and access to pleasant and convenient places for recreation.[5 13–16] However, little is known about the extent to which these determinants vary across socioeconomic groups or whether such variation accounts for the socioeconomic inequalities in physical activity participation.

Of the few studies that have attempted to explain socioeconomic disparities in physical activity, factors from all three domains (personal, social, and environmental) have been identified as potential mediators of SEP–inactivity relationships. Personal mediators include physical activity history, lack of money or transport, illness/disability and personality factors[8 14 17–19]; social mediators include social participation[20]; and environmental mediators include poor neighbourhood aesthetics, design or access to facilities, and safety issues.[21–24] However, few studies have assessed multiple influences from more than one domain.[14 17] Studies using objective measures of the environment, and appropriate multilevel study designs to capture shared area-level influences, are particularly scarce.

We aimed to investigate educational variations in walking among women, and to examine, using a multilevel framework, the contributions of intrapersonal, social, and perceived and objectively assessed physical environmental factors to explaining socioeconomic variations in women's walking. Walking was examined for several reasons. It is a low-cost and easily accessible activity that can be performed by most individuals, regardless of fitness level, in a variety of locations,[25 26] and is the most common form of physical activity among women in Australia,[27] with one national survey[28] showing that 76% of Australian women had walked in the past week. As the educational distributions and determinants of walking may differ depending on the purpose of the activity,[13 23] we considered two aspects of walking—leisure-time walking and walking for transport.

METHODS

Sample

Data were collected from 1282 participants recruited using a stratified random sampling procedure from 45 Melbourne neighbourhoods of different levels of socioeconomic disadvantage. On the basis of qualitative data in which women were asked about their local neighbourhoods,[14] suburbs (commonly used units of geographical aggregation, usually comprising anywhere between about 4000 and 30 000 residents) were used as approximations of neighbourhoods.

Details of recruitment and study design are described elsewhere.[29] All neighbourhoods within 30 km of the

Table 1 Distributions and bivariate associations of walking with demographic, educational, and personal, social and environmental variables

Variables	Percentage	% Reporting leisure-time walking	% Reporting walking for transport
Overall		65	79
Education			
Up to 10 years	20	61*	73†
12 years/certificate/trade, etc	41	64	81
University	39	70	79
Age (mean (SD) 41.8 (12.6)), years			
18–29	23	61	84
30–39	27	63	78
40–49	23	70	76
50–65	28	67	78
Environmental variables			
POS density			
Lowest quartile	26	65	79
Second quartile	26	66	76
Third quartile	24	64	81
Highest quartile	24	67	79
Walking track length			
Lowest quartile	28	58*	79
Second quartile	23	66	78
Third quartile	24	70	77
Highest quartile	25	69	80
Street connectivity			
Lowest quartile	25	62	74*
Second quartile	25	69	77
Third quartile	26	65	82
Highest quartile	24	66	82
Not coastal neighbourhood	86	63*	77*
Coastal neighbourhood	14	79	88
Neighbourhood aesthetics			
Low	27	57*	78
Mid	39	64	80
High	34	74	78
Neighbourhood safety			
Low	38	58*	79
Mid	29	66	76
High	33	73	81
Social variables			
Family social support			
Low	39	58*	75*
Mid	32	66	78
High	29	76	83
Friends' social support			
Low	27	57*	77†
Mid	39	66	77
High	25	78	83
Club membership	29	72*	77
No club membership	71	63	79
Not dog owner	60	61*	79
Dog owner	40	73	79
Personal variables			
Self-efficacy			
Low	32	46*	75*
Mid	32	67	81
High	36	81	80
Enjoyment			
Low	33	48*	76
Mid	34	68	80
High	33	81	80
Barriers			
Low	29	77*	79
Mid	37	68	77
High	34	53	80
Intentions			
Low	27	47*	78
Mid	35	66	80
High	38	78	77

POS, public open space.
*Within the same cell, proportions walking differ at $p<0.05$.
†$p=0.05$.

Melbourne business district were ranked according to the Socioeconomic Index for Areas, a census-derived score developed by the Australian Bureau of Statistics,[30] based on the suburb's relative disadvantage (ascertained from an aggregate indicator of multiple socioeconomic components, including residents' education levels, occupation and income). In all, 15 neighbourhoods were drawn at random from each of the lowest, middle and highest Socioeconomic Index for Areas septiles. A random sample of women aged between 18 and 65 years were then drawn from each of the 45 neighbourhoods, using the Australian electoral roll (registration on the electoral roll is compulsory for all Australian citizens aged ⩾ 18 years) with slight oversampling from the low and mid SEP neighbourhoods relative to the high SEP neighbourhood (by a ratio of 1.5:1.2:1) to counter the differential response rates by socioeconomic groups typically observed in health surveys.[31 32] The sample drawn to receive the physical activity survey consisted of 2400 women: 975 from low, 780 from mid and 645 from high SEP neighbourhoods. A second independent sample of 2400 women was drawn in the same manner for a separate nutrition survey and respondents to that survey were asked if they were willing to complete a second (physical activity) survey.

Procedures

The study was approved by the Deakin University Human Research Ethics Committee. Physical activity surveys were posted to 2400 women and nutrition surveys to a separate sample of 2400 women. A total of 1045 women responded to the initial physical activity survey. Of those women completing the nutrition survey, 509 also agreed to complete the physical activity survey, yielding a total sample of 1554 respondents. Excluding data from 14 women who had recently moved out of the study neighbourhoods and 258 women who had missing data on one or more study variables, the final sample size was 1282 (435 from high, 491 from mid and 356 from low SEP neighbourhoods).

Measures

Predictor variable: SEP

Women's self-reported highest educational level was used as an indicator of individual SEP, and was categorised as no formal qualifications/up to year 10; year 12/trade/apprenticeship/certificate/diploma; or university degree/higher degree.

Outcome variables

Walking for leisure-time and transport were assessed with the International Physical Activity Questionnaire-long questionnaire.[33] Separate questions asked about many days in the previous week the participant had walked for at least 10 min during leisure time and for transportation. Responses for each were dichotomised into ''Any walking'' and ''No walking''.

Personal mediators

Of the 14 potential mediating variables assessed in this study, four were personal variables: self-efficacy, enjoyment, barriers and intentions. Self-efficacy was assessed using a modified measure[34] on which respondents reported, on a five-point Likert scale (not at all confident to extremely confident), confidence in walking in five difficult situations (when I am tired; in a bad mood; I feel I don't have time; on vacation; and when it is raining). Internal consistency for this scale was good (Cronbach's $\alpha = 0.86$).

Enjoyment of walking was assessed with a modified scale[35] comprising eight sets of opposing statements, each with a seven-point response, related to feelings about walking (eg ''I enjoy it'' *v* ''I hate it''; ''It's a lot of fun'' *v* ''It's no fun at all''). Internal reliability for this scale was very high (Cronbach's $\alpha = 0.96$). Perceived barriers to being physically active were assessed with items adapted from Brownson *et al*,[36] and added to in response to findings from a qualitative study on the barriers to physical activity among women.[14] Respondents indicated on a five-point scale how often 19 different barriers prevented them from being physically active (Cronbach's $\alpha = 0.87$). Intentions to be active were assessed with a seven-point response question (very unlikely to very likely) on the likelihood in the next 2 weeks of trying to engage in a regular exercise routine.[37] The self-efficacy, enjoyment and barriers responses were each summed, then tertiles were calculated based on the distributions, to classify respondents as scoring low, mid or high on each of these scales. Intentions were categorised as low (very unlikely to neither likely nor unlikely), mid (a little likely or quite likely), or high (very likely).

Social mediators

Four potential social mediators were assessed. Social support for physical activity from family was assessed with two items adapted from a well-validated, five-item response scale[38] which asked: During the past year, how often did members of your family (including partner/spouse): do physical activity with you? encourage you to be physically activity? The questions were repeated to assess social support from ''friends or work colleagues'' (Cronbach's $\alpha = 0.75$ for family and 0.83 for friends/colleagues). Tertiles of each social support scale were calculated. Respondents were also asked if they were members of a sporting, exercise or outdoor recreational group or club, and if they owned a dog.

Environmental mediators

Two perceived and four objectively assessed environmental mediators were included. Perceived environmental aesthetics were assessed with three items[39] assessing agreement (from 1, strongly agree, to 5, strongly disagree) with the statements ''My neighbourhood is attractive; there are pleasant walks to do; my neighbourhood is well-maintained'' (Cronbach's $\alpha = 0.89$). Perceived safety was assessed with three additional items: ''My neighbourhood is safe for walking; it is safe out walking day or night; the streets are well lit at night''[39] (Cronbach's $\alpha = 0.73$). Tertiles of summed scores were calculated to classify respondents reporting low, mid or high neighbourhood aesthetics and safety.

The Geographic Information System software package ArcView V.3.3 was used for geospatial analyses. Spatial data on suburb boundaries and roads and walking tracks were supplied by the State of Victoria, and the Open Space 2002 spatial dataset was supplied by the Australian Research Centre for Urban Ecology.[40] Four objective environmental mediators were calculated for each neighbourhood: coastal (bayside) suburb; the total area of free access public open space (eg parks, foreshores) as a proportion of the total area of the suburb; the total length of walking tracks as a proportion of the total area of the suburb; and the number of intersections with four or more roads, also adjusted for suburb area (street connectivity).

Covariates

χ^2 tests were conducted to test for potential confounding of the following covariates: age, marital status, presence of children in the home and pregnancy. None of these variables were associated with either outcome variable, and hence these were not adjusted for in multivariable analyses.

Statistical analyses

This study collected data at both the individual and the neighbourhood levels, and therefore multilevel statistical modelling was used to analyse the data.[41] Two-level models,

Table 2 Effects of adjusting for environmental, social and personal variables on associations between women's education level and likelihood of leisure-time walking in multilevel logistic regression models*

Variables	Model 1 (education only)		Model 2 (education and environmental mediators)		Model 3 (education, environmental and social mediators)		Model 4 (education, environmental, social and personal mediators)	
Education								
Up to 10 years	1.00		1.00		1.00		1.00	
12 years/certificate/trade	1.12	0.81 to 1.43	1.09	0.78 to 1.41	1.01	0.68 to 1.34	1.05	0.70 to 1.41
University	1.45	1.13 to 1.77	1.30	0.97 to 1.62	1.23	0.89 to 1.58	1.19	0.82 to 1.56
Environmental variables								
Walking track length								
Lowest quartile			1.00		1.00		1.00	
Second quartile			1.30	0.97 to 1.63	1.32	0.95 to 1.68	1.28	0.92 to 1.63
Third quartile			1.54	1.21 to 1.86	1.51	1.17 to 1.84	1.46	1.10 to 1.81
Highest quartile			1.17	0.82 to 1.51	1.23	0.87 to 1.58	1.32	0.94 to 1.69
Not coastal neighbourhood			1.00		1.00		1.00	
Coastal neighbourhood			1.78	1.38 to 2.19	1.60	1.19 to 2.02	1.46	1.02 to 1.90
Neighbourhood aesthetics								
Low			1.00		1.00		1.00	
Mid			1.14	0.84 to 1.44	1.05	0.74 to 1.37	0.90	0.57 to 1.24
High			1.53	1.18 to 1.88	1.36	0.99 to 1.72	1.00	0.61 to 1.39
Neighbourhood safety								
Low			1.00		1.00		1.00	
Mid			1.28	0.99 to 1.58	1.20	0.89 to 1.51	1.09	0.76 to 1.42
High			1.55	1.24 to 1.87	1.43	1.11 to 1.76	1.26	0.91 to 1.60
Social variables								
Family social support								
Low					1.00		1.00	
Mid					1.12	0.84 to 1.41	1.01	0.70 to 1.31
High					1.69	1.37 to 2.00	1.29	0.94 to 1.63
Friends' social support								
Low					1.00		1.00	
Mid					1.38	1.10 to 1.66	1.39	1.09 to 1.69
High					2.13	1.79 to 2.48	1.77	1.39 to 2.14
Club membership					1.00		1.00	
No club membership					0.85	0.57 to 1.13	0.96	0.65 to 1.27
Not dog owner					1.00		1.00	
Dog owner					1.72	1.46 to 1.98	1.68	1.40 to 1.95
Personal variables								
Self-efficacy								
Low							1.00	
Mid							1.63	1.31 to 1.94
High							2.27	1.90 to 2.64
Enjoyment								
Low							1.00	
Mid							1.81	1.51 to 2.11
High							2.71	2.36 to 3.05
Barriers								
Low							1.00	
Mid							0.77	0.43 to 1.12
High							0.75	0.38 to 1.12
Intentions							1.00	
Low							1.79	1.48 to 2.11
Mid							1.73	1.35 to 2.11
High								
Random effects								
Area-level								
Median OR	1.17		1.00		1.00		1.00	

Values are OR (95% CI).
*Multilevel logistic regression models show the ORs for the likelihood of leisure-time walking according to education and environmental, social and personal variables. The median OR reflects the level-2 variation (ie the variation in the likelihood of leisure-time walking that is between neighbourhoods rather than between individuals).

with women (n = 1282) at level 1 and neighbourhoods (n = 45) at level 2, were fitted to estimate the contribution of personal, social and environmental mediators to explaining educational variations in women's walking during leisure-time and for transport.

The distributions of, and bivariate associations between, walking and demographic, educational and mediator variables were initially examined using descriptive and unilevel analyses. A series of two-level random intercept multilevel models were then fitted to examine the associations between women's education and walking, and to estimate the contributions of proposed mediating variables to explaining variation by education in the two walking outcomes. An initial model including only the predictor variable, education, was specified to establish the association between education and leisure-time walking and walking for transport (separately), before investigating any mediators (model 1). The contributions of proposed mediating variables were then investigated by extending model 1 to include the fixed effects for proposed mediators, with environmental (model 2), social (model 3) and personal (model 4) variables added sequentially in three separate blocks, representing mediators from the most distal

(neighbourhood, with public open space density, walking track length, street connectivity and coastal neighbourhood entered at level 2, and perceived neighbourhood aesthetics and safety at level 1) to the most proximal (personal). Only proposed mediators that were significantly associated bivariately with each walking outcome were included in these models. The reduction in the odds ratios (ORs) for education across models was interpreted as an indicator of the mediating role of each set of additional variables included in the model.[42] Analyses were performed using SPSS V.11.5 and MLwiN V.2.0.[43]

RESULTS

Table 1 presents the distributions of, and bivariate associations between, walking and demographic, education and mediator variables. Both leisure-time and transport-related walking were less common among women in the lowest educational group than among more educated women. Of the environmental factors assessed, coastal proximity was positively associated with both walking for leisure and transport. Walking track length and perceived neighbourhood aesthetics and safety were positively associated with leisure-time walking only, and street connectivity with walking for transport only. The support of family and friends for physical activity were positively associated with both types of walking, but club membership and dog ownership with leisure-time walking only. All four personal variables were associated with leisure-time walking in the expected directions, but only self-efficacy was associated with walking for transport.

Table 2 presents results of the series of multilevel logistic regression analyses predicting the likelihood of leisure-time walking. Model 1 shows that women with university-level education were 45% more likely to walk during leisure-time than women with <10 years of education. However, these odds were reduced by one third (to OR 1.30) and fell just short of statistical significance once the four environmental mediators that were bivariately associated with leisure-time walking were added to the model (model 2). All four environmental variables were associated with the odds of walking in model 2; for instance, women living in a coastal neighbourhood were 78% more likely than other women to walk during leisure-time.

The slightly but not significantly increased ORs for the association between university education and leisure-time walking were further reduced (by 23%, to OR 1.23) when the four social mediators were included (model 3). All four social variables were significantly predictive of odds of leisure-time walking, and their inclusion in model 3 slightly reduced the strength of associations between environmental variables and odds of leisure-time walking. Finally, inclusion of all four personal variables reduced the magnitude of the increased odds of leisure-time walking among those with university education by a further 17%, to OR 1.19. In this final model, two environmental variables (walking track length and coastal proximity), two social variables (friends' support and dog ownership) and three personal variables (self-efficacy, enjoyment and intentions) remained significant. In general, the personal variables showed the strongest associations in this full model.

Table 3 presents corresponding results for transport-related walking. As shown in model 1, education level was significantly associated with walking for transport, but in this case the

Table 3 Effects of adjusting for environmental, social and personal variables on associations between women's education level and likelihood of walking for transport in multilevel logistic regression models*

Variables	Model 1 (education only)	Model 2 (education and environmental mediators)	Model 3 (education, environmental and social mediators)	Model 4 (education, environmental, social and personal mediators)
Education				
Up to 10 years	1.00	1.00	1.00	1.00
12 years/certificate/trade etc	1.59 (1.23 to 1.95)	1.54 (1.18 to 1.89)	1.51 (1.14 to 1.87)	1.49 (1.12 to 1.85)
University	1.30 (0.94 to 1.65)	1.15 (0.79 to 1.51)	1.12 (0.75 to 1.48)	1.10 (0.73 to 1.47)
Environmental variables				
Street connectivity				
Lowest quartile		1.00	1.00	1.00
Second quartile		0.82 (0.43 to 1.22)	0.84 (0.45 to 1.24)	0.83 (0.44 to 1.23)
Third quartile		1.57 (1.19 to 1.94)	1.60 (1.22 to 1.98)	1.59 (1.21 to 1.97)
Highest quartile		1.35 (0.96 to 1.74)	1.33 (0.94 to 1.72)	1.34 (0.95 to 1.73)
Not coastal neighbourhood		1.00	1.00	1.00
Coastal neighbourhood		2.93 (2.40 to 3.46)	2.76 (2.23 to 3.30)	2.74 (2.20 to 3.28)
Social variables				
Family social support				
Low			1.00	1.00
Mid			1.10 (0.78 to 1.42)	1.08 (0.76 to 1.41)
High			1.45 (1.09 to 1.80)	1.41 (1.05 to 1.77)
Friends' social support				
Low			1.00	1.00
Mid			0.93 (0.62 to 1.24)	0.93 (0.62 to 1.24)
High			1.25 (0.86 to 1.64)	1.22 (0.83 to 1.61)
Personal variables				
Self-efficacy				
Low				1.00
Mid				1.32 (0.98 to 1.66)
High				1.17 (0.83 to 1.50)
Random effects				
Area-level				
Median OR	1.34	1.00	1.00	1.00

Values are OR (95% CI).
*Multilevel logistic regression models show the ORs for the likelihood of walking for transport according to education and environmental, social and personal variables. The median OR reflects the level-2 variation (ie, the variation in the likelihood of walking for transport that is between neighbourhoods rather than between individuals).

increased odds of walking among both the middle (OR 1.59) and highest (OR 1.30) educated groups were only significant for women in the middle education group. These odds were only slightly reduced (to OR 1.54), but remained significant after including (in model 2) the two environmental mediators that were bivariately associated with walking for transport. Both street connectivity and coastal proximity were associated with odds of walking in model 2; for instance, women living in a coastal neighbourhood were almost three times more likely than other women to walk for transport.

The ORs for the association between middle-level education and transport-related walking were again only slightly reduced (to OR 1.51) when the two bivariately significant social mediators were included (model 3). Social support from family, but not from friends, remained significant in this model. Finally, the single personal variable bivariately associated with transport-related walking, self-efficacy, did not remain significant in the full model (model 4). Inclusion of self-efficacy in model 4 only marginally reduced the increased odds of walking of those with middle education compared with the low-education group, and it had minimal effect on the strength of associations of environmental and social variables and transport-related walking. Coastal proximity remained the strongest predictor of walking for transport in this final model, with family social support and street connectivity also being significant. Although the association between educational level and transport-related walking was slightly attenuated, it remained statistically significant even in this final model with all mediators included.

DISCUSSION

This is one of the first studies to examine the importance of personal, social and environmental factors in explaining educational differences in physical activity using multilevel modelling techniques. Consistent with previous reports,[6–9] we found educational variations in the outcomes examined, with those in the lowest educational group less likely to participate in leisure-time and transport-related walking. Variables from each of the three domains contributed to mediating educational variations in odds of leisure-time walking. Although the environmental variables alone reduced the association between education and leisure-time walking, their strength was reduced considerably once social and particularly personal variables were considered. Once all three sets of variables were considered, the association between education and leisure-time walking was weak and non-significant, suggesting that educational inequalities in leisure-time walking were almost wholly explained by the personal, social and environmental variables tested. In this final model predicting leisure-time walking, cognitive variables (self-efficacy, enjoyment and behavioural intentions) remained the strongest predictors, although environmental variables made a substantial mediating contribution. Together, these findings indicate that, although selected physical environmental variables (walking track length and coastal proximity) are key correlates of leisure-time walking and represent an explanatory pathway by which education may influence leisure-time walking, personal and social factors are also important.

Fewer variables were bivariately associated with walking for transport, and these did not show evidence of substantial mediating effects on associations of education with transport-related walking. However, we examined a relatively limited range of objectively assessed environmental variables. Other variables that may influence walking for transport include: access to sidewalks[44] or to a variety of destinations to walk to[45]; urbanisation or land use mix[16]; or perceiving neighbours as being active.[46] Such structural variables might also mitigate the effects of personal and social factors, which in this study did not show strong associations or mediating effects of inequalities in transport-related walking. The finding that associations of particular environmental variables with leisure-time and transport-related walking differed in terms of strength and significance is consistent with previous research,[45] and confirms arguments[23] that understanding determinants and mediators of physical activity will be facilitated by focusing on outcome-specific hypotheses.

Our findings are based on cross-sectional data; thus, it is premature to conclude definitive causal effects. It is possible that individuals choose the environments in which they live to suit their behavioural preferences (eg their desire to walk), rather than choosing to be active as a consequence of environmental influences.[47] Other limitations include the use of self-report measures, although valid and reliable instruments were used where possible. In addition, this study was limited to one city. The strengths of the study include the relatively large sample and multilevel design to test for environmental effects appropriately, and a combination of objective and perceived measures of environment.

In conclusion, our results suggest that focusing on personal, social and environmental variables may be important in reducing educational inequalities in women's leisure-time walking. Further research is required to identify the mediators of educational variations in transport-related walking. In addition, further research is necessary to better understand the origins of educational variations in the mediators identified here (eg why low-education groups have lower levels of self-efficacy for walking or poorer access to neighbourhood walking tracks). Promoting walking may provide a key avenue for reducing socioeconomic inequalities in physical activity. To do so, public health strategies might focus on enhancing self-efficacy for and promoting enjoyment of walking, fostering walking intentions and encouraging the engagement of family and friends to support walking among those who are socioeconomically disadvantaged. Further, urban planning strategies aimed at promoting more walkable neighbourhoods might focus on improving access to walking tracks and coastal

What is already known

- Lower levels of participation in physical activity among people of low socioeconomic position (eg, those with low education) are well documented.
- However, the mechanisms underlying these differentials are not known.

What this paper adds

- The findings suggest that a combination of personal, social and environmental factors contribute to explaining lower levels of leisure-time walking among women with low education.
- Factors mediating educational variations in walking for transport differ from those related to leisure-time walking and require further investigation.
- Policy/programme implications: Public health strategies aimed at promoting leisure-time walking among low-education groups might focus on enhancing self-efficacy and enjoyment and engaging social support, as well as on urban planning strategies to build more walkable neighbourhoods in disadvantaged areas.

localities and considering greater connectivity among streets, particularly in areas of disadvantage.

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REFERENCES

1 **US Department of Health and Human Services (DHHS)**. *Physical activity and health: a report of the surgeon general*. Atlanta, GA: US DHHS, 1996.
2 **Bauman AE**. Updating the evidence that physical activity is good for health: an epidemiological review 2000–2003. *J Sci Med Sport* 2004;**7**:6–19.
3 **National Centre for Social Research, Department of Epidemiology and Public Health at the Royal Free and University College Medical School**. *Health survey for England 2003*. London: Department of Health, 2004.
4 **Bauman A**, Ford I, Armstrong T. *Trends in population levels of reported physical activity in Australia, 1997, 1999 and 2000*. Canberra: Australian Sports Commission, 2001.
5 **Trost SG**, Owen N, Bauman AE, *et al*. Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc* 2002;**34**:1996–2001.
6 **Crespo CJ**, Ainsworth BE, Keteyian SJ, *et al*. Prevalence of physical inactivity and its relation to social class in U.S. adults: results from the Third National Health and Nutrition Examination Survey, 1988–1994. *Med Sci Sports Exerc* 1999;**31**:1821–7.
7 **Dowler E**. Inequalities in diet and physical activity in Europe. *Public Health Nutr* 2001;**4**:701–9.
8 **Droomers M**, Schrijvers CT, van de Mheen H, *et al*. Educational differences in leisure-time physical inactivity: a descriptive and explanatory study. *Soc Sci Med* 1998;**47**:1665–76.
9 **Hallal PC**, Azevedo MR, Reichert FF, *et al*. Who, when and how much? Epidemiology of walking in a middle-income country. *Am J Prev Med* 2005;**28**:156–61.
10 **Salmon J**, Bauman A, Crawford D, *et al*. The association between television viewing and overweight among Australian adults participating in varying levels of leisure-time physical activity. *Int J Obes Relat Metab Disord* 2000;**24**:600–6.
11 **Sallis J**, Owen N. Ecological models. In: Glanz K, Lewis FM, Rimer BK, eds. *Health behaviour and health education:. theory, research and practice*. San Francisco: Jossey-Bass, 1997:403–24.
12 **Stokols D**. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot* 1996;**10**:282–98.
13 **Humpel N**, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity: a review. *Am J Prev Med* 2002;**22**:188–99.
14 **Ball K**, Salmon J, Giles-Corti B, *et al*. How can socioeconomic differences in physical activity among women be explained? A qualitative study. *Women Health* 2006;**43**:93–113.
15 **Estabrooks PA**, Lee RE, Gyurcsik NC. Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Ann Behav Med* 2003;**25**:100–4.
16 **Saelens BE**, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med* 2003;**25**:80–91.
17 **Burton NW**, Turrell G, Oldenburg B. Participation in recreational physical activity: why do socioeconomic groups differ? *Health Educ Behav* 2003;**30**:225–44.
18 **Chinn DJ**, White M, Harland J, *et al*. Barriers to physical activity and socioeconomic position: implications for health promotion. *J Epidemiol Community Health* 1999;**53**:191–2.
19 **Droomers M**, Schrijvers CT, Mackenbach JP. Educational level and decreases in leisure time physical activity: predictors from the longitudinal GLOBE study. *J Epidemiol Community Health* 2001;**55**:562–8.
20 **Lindstrom MB**, Hanson BS, Ostergren PO. Socioeconomic differences in leisure-time physical activity: the role of social participation and social capital in shaping health related behaviour. *Soc Sci Med* 2001;**52**:441–51.
21 **van Lenthe FJ**, Brug J, Mackenback JP. Neighbourhood inequalities in physical inactivity: the role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands. *Soc Sci Med* 2005;**60**:763–75.
22 **Wilson DK**, Kirtland KA, Ainsworth BE, *et al*. Socioeconomic status and perceptions of access and safety for physical activity. *Ann Behav Med* 2004;**28**:20–8.
23 **Giles-Corti B**, Timperio A, Bull F, *et al*. Understanding physical activity environmental correlates: increased specificity for ecological models. *Exerc Sport Sci Rev* 2005;**33**:175–81.
24 **Ross CE**. Walking, exercising, and smoking: does neighbourhood matter? *Soc Sci Med* 2000;**51**:265–74.
25 **Morris JN**, Hardman AE. Walking to health. *Sports Med* 1997;**23**:306–32.
26 **Hardman AE**, Stensel DJ. *Physical activity and health: the evidence explained*. London: Routledge, 2003.
27 **Australian Bureau of Statistics**. *Participation in sport and physical activities, Australia, 2002*, Catalogue number 4177. Canberra: Australian Government Publishing Service, 2003.
28 **Armstrong T**, Bauman A, Davies J. *Physical activity patterns of Australian adults. Results of the 1999 National Physical Activity Survey*, Catalogue number CVD 10. Canberra: Australian Institute of Health and Welfare, 2000.
29 **Ball K**, Crawford D, Mishra G. Socioeconomic inequalities in women's fruit and vegetable intakes: a multilevel study. *Public Health Nutr* 2006;**9**:623–30.
30 **Australian Bureau of Statistics**. *Census of population and housing: Socio-Economic Indexes for Areas (SEIFA), Australia*, Catalogue 2033.0.55.001. Canberra: Australian Bureau of Statistics, 2003.
31 **Sheikh K**, Mattingly S. Investigating non-response bias in mail surveys. *J Epidemiol Community Health* 1981;**35**:293–6.
32 **Madigan MP**, Troisi R, Potischman N, *et al*. Characteristics of respondents and non-respondents from a case–control study of breast cancer in younger women. *Int J Epidemiol* 2000;**29**:793–8.
33 **Craig CL**, Marshall AL, Sjöström M, *et al*. International Physical Activity Questionnaire (IPAQ): 12-country reliability and validity. *Med Sci Sports Exerc* 2003;**35**:1381–95.
34 **Marcus BH**, Selby VC, Niaura RS, *et al*. Self-efficacy and the stages of exercise behaviour change. *Res Q Exerc Sport* 1992;**63**:60–6.
35 **Kendzierski D**, DeCarlo KJ. Physical activity enjoyment scale: two validation studies. *J Sport Exerc Psychol* 1991;**13**:50–64.
36 **Brownson RC**, Baker EA, Housemann RA, *et al*. Environmental and policy determinants of physical activity in the United States. *Am J Public Health* 2001;**91**:1995–2003.
37 **Giles-Corti B**, Donovan RJ. Relative influences of individual, social environmental, and physical environmental correlates of walking. *Am J Public Health* 2003;**93**:1583–9.
38 **Sallis JF**, Grossman RM, Pinski RB, *et al*. The development of scales to measure social support for diet and exercise behaviours. *Prev Med* 1987;**16**:825–36.
39 **Giles-Corti B**, Donovan RJ. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Prev Med* 2002;**35**:601–11.
40 **Australian Research Centre for Urban Ecology**. *OSPACE metadata*. Melbourne: Australian Research Centre for Urban Ecology, 2003.
41 **Goldstein H**. *Multilevel statistical models*, 3rd edn. London: Edward Arnold, 2003.
42 **Baron RM**, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Perspect Soc Psychol* 1986;**51**:1173–82.
43 **Rasbash J**, Steele F, Browne W, *et al*. *A user's guide to MLwiN, Version 2.0*. London: Institute of Education, University of London, 2004.
44 **Pikora TJ**, Giles-Corti B, Knuiman MW, *et al*. Neighbourhood environmental factors correlated with walking near home: using SPACES. *Med Sci Sports Exer* 2006;**38**:708–14.
45 **Hoehner CM**, Brennan Ramirez LK, Elliott MB, *et al*. Perceived and objective environmental measures and physical activity among urban adults. *Am J Prev Med* 2005;**28**:105–16.
46 **Addy CL**, Wilson DK, Kirtland KA, *et al*. Associations of perceived social and physical environmental supports with physical activity and walking behaviour. *Am J Public Health* 2004;**94**:440–3.
47 **Krizek KJ**. Pretest-posttest strategy for researching neighbourhood-scale urban form and travel behaviour. *Transport Res Rec* 2000;**1722**:48–55.