The association between neighbourhood walkability and after-school physical activity in Australian schoolchildren

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Short title: neighbourhood walkability & after-school PA

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Acknowledgements: CR wrote the manuscript, participated in data analysis and interpretation. JCB performed statistical analyses and helped with the results interpretation. RLO participated in the writing of the manuscript, data analysis and results interpretation. WX participated in the data analysis, its interpretation and writing of the manuscript. DG designed the study, participated in data analysis and interpretation, and manuscript writing. All authors critically reviewed the manuscript and approved the submitted version.

Financial disclosure

None to declare

Conflicts of interest

None to declare

Keywords: Exercise, Child, Walking, Residence Characteristics, schools, adolescent

Abstract

Introduction. Physical inactivity is a risk factor for many non-communicable diseases. As reported by the World Health Organisation, 81% of children worldwide are physically inactive. Environmental factors, such as neighbourhood walkability, can shape people's physical activity (PA) behaviour. This study explored the association between neighbourhood walkability and after-school PA among Australian schoolchildren.

Methods. The Department for Education and Child Development (DECD) distributed the survey to 189 schools across South Australia to assess the health and well-being of schoolchildren aged between 8 and 14 years. Neighbourhood was defined as an area corresponding to a four digit postcode, and its walkability was measured using Walk Score®. The association between neighbourhood walkability and after-school PA was analysed using multinomial logistic regression adjusted for age, gender, SEIFA score, number of days of TV watching, number of times of eating junk food, neighbourhood safety and children's weight status.

Results. Children residing in highly walkable areas (walker's paradise) compared to car-dependent areas had higher odds (OR(95%CI)) of engaging in after-school PA three (1.216 (1.029, 1.436), p = 0.021), four (1.287 (1.064, 1.557), p = 0.009) and five times a week (1.230 (1.030, 1.133), p = 0.022) compared to children never participating in PA.

Conclusion. Living in highly walkable areas (walker's paradise), compared to living in car-dependent areas was associated with higher levels of after-school PA.

So what Creating walkable neighbourhoods with greater access to amenities, services and public transportation may help increase after-school PA among schoolchildren.

Keywords: Exercise, Child, Walking, Residence Characteristics, schools, adolescent

Introduction

Physical activity (PA) is defined as any bodily movement that is produced by skeletal muscles and requires energy expenditure.[1] Regular PA is effective in the primary and secondary prevention of chronic non-communicable diseases such as cardiovascular disease, diabetes, depression, osteoporosis and some types of cancer.[2] It provides opportunities for people to interact with others, promoting psychological and social benefits.[3] Despite the established benefits of regular PA for health and well-being, levels of physical inactivity are increasing globally.[4]

Global PA recommendations indicate that adults should accumulate at least 150 minutes of moderate PA or 75 minutes of vigorous PA per week, whereas children should accumulate at least 60 minutes of moderate to vigorous PA daily.[1] However, based on WHO 2010 data, 81% of school children aged 11-17 years worldwide are not as active as recommended.[5] In Australia, according to the latest Australia's Health 2018 report, 74% of children aged 5-12 years and 92% of adolescents aged 13-17 years obtain less than 60 minutes of PA per day.[3] In addition to health implications, physical inactivity has major economic implications which resulted in an overall global 13.4 million Disability Adjusted Life Years (DALYs), costing the health care systems (INT$) 53.8 billion worldwide in 2013, and $13.7 billion in productivity losses due to deaths resulting from physical inactivity.[6]

The decision to engage in PA is influenced by the interplay between environmental settings, biological and psychosocial factors.[7-10] It has been recognised that the environment we live in may facilitate or discourage people's PA behaviour.[11, 12] In response to rising physical inactivity levels, WHO put forward a non-communicable disease action plan aiming at a 10% relative reduction in the prevalence of insufficient PA globally.[5] To achieve this target, WHO proposes multiple actions including those to develop urban planning and active transport policies to improve neighbourhood walking opportunities.[5] One of the ways to measure the current state of friendliness of a neighbourhood to walking is to assess its walkability, which considers aspects of urban design, street layouts and accessibility to amenities.[13] There are multiple approaches to measuring walkability such as via people's perceptions or environmental audits.[14] More recently, Walk Score® has become an increasingly recognised tool to measure neighbourhood walkability, as it is accessible, provides walkability data on an international scale and data are regularly being updated.[15]

The positive associations between walkability and PA in adults have been established.[16, 17] However, less is known about the association between neighbourhood walkability and children's after-school PA. Therefore, the aim of this study is to examine the association

between neighbourhood walkability and after-school physical activity in Australian schoolchildren.

Methods

Study population

The study population consists of 17,880 students aged between 8 to 14 years (years 6 to 9) recruited in 2014 from 189 government and non-government schools (20%) across South Australia. All schools were invited by the South Australian Department for Education and Child Development (DECD) to administer the survey on health and well-being.[18] The survey was a modified version of the Middle Years Development Instrument (MDI), validated to meet the needs of Australian school students.[19] The MDI, originally developed at the University of British Columbia in Canada, consists of 76 items across five areas of development: physical health and well-being, connectedness, social and emotional development, school experiences and use of after-school time.

The survey was administered by teachers during school hours between October 13 and November 21, 2014. Teachers were provided with a pre-prepared information sheet to provide the details of the survey to their students, and they were asked to administer the survey when students were attentive and alert (e.g. not before lunch or Friday afternoons). The survey was estimated to take approximately 70 minutes for students to complete. The majority of the students undertook the survey online. However, a paper-based questionnaire was administered in a few schools; and these were sent to DECD for data entry. Distribution of the surveys by schools and children's participation in the study were voluntary.[18] Child caregivers were provided with additional information regarding the survey and were given the option to withdraw their child from the participant list (n=133). Schoolchildren also received the opportunity to opt-out (n = 136) after the teacher explained the project from a pre-prepared assent script. Therefore, a total of 17,611 students completed the survey.

Neighbourhood walkability

Neighbourhood was defined as an area corresponding to a four digit postcode.[20] Neighbourhood walkability was assessed using the Walk Score®, a publically available method (www.walkscore.com) for calculating walkability that awards points based on the distance to amenities (educational, recreational, food, entertainment and retail). Data regarding the distance and location of amenities are obtained from publicly available sources

including Google, Education.com, Open Street Map and Localeze.[15] Closely located amenities are allocated more points compared to those further away. To rank neighbourhoods, Walk Score is calculated for every neighbourhood block, whereby each point is weighted by population density. This enables that neighbourhood rankings reflect residential areas and that lower scores are not assigned due to parks or bodies of water. Walk Scores values range between zero and a 100.[15] The scores are grouped into five categories with 0-24 being very car dependent (almost all errands require a car), 25-49 being car dependent (most errands require a car), 50-69 being somewhat walkable (some errands can be accomplished on foot), 70-89 being very walkable (most errands can be accomplished on foot) and 90-100 being 'walker's paradise' (daily errands do not require a car).

After-school physical activity

After-school PA was assessed via the following survey question "During last week after-school (3 pm to 6 pm) how many days did you do sports and/or exercise for fun (for example, basketball, swimming, cricket, football, netball, dancing, or something else)?" Students could choose the answer from the following options: "Never, once a week, twice a week, 3 times a week, 4 times a week and 5 times a week (every day)."

Confounders

Confounding variables were self-reported by students and included age, gender, weight status (very underweight, slightly underweight, about the right weight, slightly overweight, very overweight), frequency of food and drink of high energy and low nutrient intake (never, once a week, 2 times a week, 3 times a week, 4 times a week, 5 times a week, 6 times a week, every day), TV watching after-school hours (never, once a week, twice a week, 3 times a week, 4 times a week, 5 times a week (every day)), and presence of safe places in the neighbourhood where children feel comfortable to hang out with friends (yes/no/don't know). We also included the socio-economic index for area (SEIFA) score that ranks areas in Australia according to relative socio-economic advantage and disadvantage.[21]

Statistical analysis

Descriptive statistics for categorical variables are presented as counts and percentages. Those for quantitative variables are presented as means and standard deviations if normally distributed, or medians and interquartile range if skewed. Some levels of categorical variables (weight status, junk food consumption, after-school TV watching) were collapsed to reduce issues of small cell counts. For the same reason 'very car dependent' and 'car

dependent' walkability categories were combined into a 'car dependent' category. The difference in study characteristics across levels of PA was analysed with chi-square tests for categorical variables and one-way between subjects' analysis of variance (ANOVA) for quantitative variables. Kruskal–Wallis test was used if ANOVA test assumptions were violated. The relationship between walkability and PA was analysed with multinomial logistic regression after adjusting for age, gender, SEIFA score, consumption of junk food, weight status, neighbourhood safety, and days of watching television after-school. We also tested for interaction effects of age, gender, and SEIFA with walkability on physical activity. The alpha threshold was set to 0.05 for all statistical tests. All analyses were conducted using R software (version 3.5) (R Core Team 2018).

Results

In total, 17,611 students completed the survey. Students with missing data for the variables of interest were excluded from the analysis (n=1239). Compared to students without missing data, those with missing data were more likely to be boys, more likely to report eating junk food 5 or more days a week, less likely to report presence of safe places in the neighbourhood where they feel comfortable to hang out with friends and less likely to watch TV 4 times or more per week, and more likely to live in socio-economically disadvantaged and car-dependent areas (Supplement Table 1).

Participant study characteristics are presented in Table 1. Compared to girls, boys were more likely to report undertaking after-school PA every day. Children reporting 'none' or 'once a week' engagement in after-school PA were more likely to live in greater disadvantaged areas compared to their counterparts who reported being more active after-school hours. The proportion of children of right weight, compared to those who reported being overweight or underweight, increased across different levels of after-school PA. Children who reported lower intake of junk food and living in areas of high walkability (Walker's paradise) also reported greater levels of after-school PA ($p<0.05$ for all).

The results of the multinomial logistic regression on the association between the neighbourhood walkability and children's levels of after-school PA are presented in Table 2. After adjusting for age, gender, SEIFA score, TV watching time, junk food consumption, neighbourhood safety and children's weight status, odds (OR (95%CI)) of engaging in after-school PA five times a week (1.230 (1.030, 1.133), p=0.022), four times a week (1.287 (1.064, 1.557), p=0.009) and three times a week (1.216 (1.029, 1.436), p=0.021), as opposed to never performing PA, were higher for those living in areas considered as

walker's paradise compared to those living in car dependent areas. There was an interaction effect between walkability and SEIFA score (p=0.013), whereby odds of engaging in PA for those living in areas of walker's paradise, compared to those living in car-dependent areas, were higher for individuals living in areas with greater relative socio-economic advantage.

Discussion

This study explored the association between neighbourhood walkability and after-school PA in over 16,000 Australian schoolchildren. Living in walker's paradise, as opposed to living in car-dependent areas, was associated with 21.6%, 28.7%, and 23% higher odds of engaging in after-school PA three, four or five times a week, respectively, compared to children who reported not being active during after-school hours. This association was independent of age, gender, SEIFA score, TV watching time, junk food consumption, neighbourhood safety and children's weight status.

The current study extends the evidence on the relationship between walkability and PA in children by reporting a positive association between neighbourhood walkability and after-school PA. This study concurs with previous studies which reported a relationship between walkability and active commuting and PA. In a cross-sectional study from Spain of 310 children (aged 10-12 years) utilizing a walk index based on net residential density, land-use mix and street connectivity, Molina-Garcia and Queralt[22] reported that children residing in more walkable neighbourhoods attain more PA (in terms of active transport). In another study based in Spain of 325 children (aged 14-18 years), using the same walkability index, Molina-Garcia et al[23] reported that moderate to vigorous PA (measured by accelerometers) was highest amongst children living in high SES/high walkability neighbourhoods. Kurka et al.[24] examined walkability (using the Neighborhood Environment Walkability scale [NEWS]) in two US regions among children (n=678, aged 6-12 years). They observed that in San Diego County, children in less walkable neighbourhoods report performing less out of school PA. Kligerman et al.[25] observed that adolescents (n=98, mean age 16.7 years) from San Diego county, who lived in high walkable neighborhoods (based on land-use mix, retail density, intersection density and residential density) were more likely to be physically active (measured using an accelerometer) than those in less walkable neighborhoods.

Other studies conducted within this field have revealed a different association between walkability and PA to that observed in this study. Graziose et al.[26] reported that walkability (based on land-use mix, retail density, intersection density and residential density) alone was not associated with PA in their study of New York City grade five school children (n=952). It is likely that this finding may be explained in part due the recruitment of children who lived in highly walkable areas when compared to the city wide average.[26] Janssen et al. noted that

Canadian students (n=3012, grade 6-8) who lived in low walkability neighborhoods (based on population density, mixed land use, intersection density, and sidewalk coverage) engaged in more outside school PA and were more likely to achieve recommendations for moderate to vigorous PA levels. This result may be partly explained by researchers' focus on playability and walkability rather than PA. Van Dyck[27] investigated the differences in PA between adolescents (n=120, aged 12-18 years) living in one highly walkable suburb and one low walkable suburb (measured using the NEWS) in Belgium. They observed that lower walkability and larger distance to school was associated with more PA (more cycling for transport and a trend towards more steps per day). This outcome may be explained by the larger distance to school among those that lived in less walkable suburbs, and a positive attitude to cycling for transport amongst Belgian adolescents.

There are four domains of physical activity including recreational, occupational, active transport and household activities.[9] Active transport to and from school and recreational PA could be major modes of PA obtained by children outside of school. Neighbourhoods categorised as highly walkable are more likely to be pedestrian friendly with increased walking routes, provide greater opportunities for active transport and closer proximity to amenities including schools.[22, 28] This could shorten average trip distances and encourage frequent trips via active transport for children to nearby amenities thereby increasing their levels of PA achieved. Frank et al.[29] observed in their study that participants preference for walkable neighbourhoods and residing in this type of neighbourhood was associated with a greater likelihood of walking. This may be similar in families, in that families with a preference for walking may prefer to reside in more walkable areas, therefore, children living in more walkable areas can attain more PA after school.[29]

Children residing in more walkable neighbourhoods have reported obtaining higher levels of after-school PA. Increasing after school physical activity is important, as it helps children maximise the overall amount of daily physical activity in which they engage.[30] Therefore, encouraging the development of environments that are walkable, supportive of active commuting and with space for recreational activity may help increase after-school PA among children.[1] Children who perceived their neighbourhoods as safer reported higher levels of PA. Therefore, it is important that local councils and state governments provide safer walking routes to schools to encourage active transport.[31] Additionally, increasing awareness about active transport to and from school and the importance of PA for both children and their parents via the provision of information brochures and school or council programs could ensure that those living in walkable neighbourhoods are aware of active transport to and from school. This may be supported by existing health promotion programs which support

active travel to school (such as the Walk to School program, an initiative of VicHealth)[32] or information such as the Make Your Move – sit less be active brochure.[33]

Participants residing in car dependent areas or less walkable areas indicated lower levels of after-school PA. Therefore, implementation of recreational facilities such as public parks and walking routes could encourage a recreational form of PA. For children residing in lower walkable areas and who cannot utilise active transport, encouraging participation in physical activities at school or family PA outside of school hours (e.g. community programs) may assist with improving children's PA.[33]

Limitations and strengths

This is a cross-sectional study, so causal relationships between neighbourhood walkability and PA cannot be inferred. Students self-reported their after-school PA, which may be accompanied by recall and social desirability bias, which may underestimate or overestimate the true association between neighbourhood walkability and after-school PA. Also, the questionnaire provided only information on the number of days children engaged in physical activity, while information on time and intensity children engaged in the activity each day was not available. Walk Scores were calculated based on four digit postcodes, however, calculating Walk Scores based on the full students' addresses would have provided more accurate neighbourhood walkability scores. Walk Score may not be a true representation of neighbourhood walkability, as it is calculated based on the distance to amenities, while it does not take into account other measures of walkability, such as street connectivity, sidewalk availability, land-use mix or street lighting. Other variables not accounted for, such as student's psychological and social factors, or urban design (not considered by Walk Score) could have also influenced the relationship between neighbourhood walkability and after-school PA behaviour. The results of the study should be interpreted with caution, as about 7% of students were missing data for the variables of interest, hence the analyses were performed on a sample of 16,372 students rather than on that of 17,611 students initially completing the survey. Additionally, the study focus was on schoolchildren in South Australia; therefore, the results may not be generalisable to other populations, or schoolchildren living in other Australian states and territories. Despite the limitations, this is one of the first studies to describe the association between neighbourhood walkability and after-school PA in Australian school children. Compared to studies published on the topic, this study has a large sample size and adjusted for confounders such as consumption of junk food, sedentary behaviour (TV watching), and neighbourhood safety that may have been missed in previous studies.

Conclusion

We explored the association between neighbourhood walkability and after-school PA in over 16,000 Australian schoolchildren. Living in highly walkable areas (walker's paradise), compared to living in car-dependent areas was associated with higher levels of after-school PA. Implementing policies that create walkable neighbourhoods may help increase after-school PA among schoolchildren.

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Table 1: Characteristics of study participants

	After-school physical activity							
	Total N = 16372	Never n = 3288	Once a week n = 3050	Twice a week n = 3191	Three times a week n = 2754	Four times a week n = 1662	Five times a week (every day) n = 2427	P value
Age Mean ± SD	13.53 ± 1.16	13.74 ± 1.15	13.46 ± 1.15	13.45 ± 1.16	13.54 ± 1.15	13.50 ± 1.14	13.42 ± 1.14	<0.001
Gender (n (%))								<0.001
Girls	8253 (50.4)	1618 (49.2)	1703 (55.8)	1651 (51.7)	1396 (50.7)	833 (50.1)	1052 (43.3)	
Boys	8119 (49.6)	1670 (50.8)	1347 (44.2)	1540 (48.3)	1358 (49.3)	829 (49.9)	1375 (56.7)	
SEIFA score Mean ± SD	993.15 ± 69.96	979.21 ± 72.11	989.85 ± 69.14	996.28 ± 68.45	1001.33 ± 67.32	1004.05 ± 67.48	995.34 ± 71.46	<0.001
Weight status (n (%))								<0.001
Underweight	2494 (15.2)	572 (17.4)	458 (15.0)	458 (14.4)	359 (13.0)	221 (13.3)	426 (17.6)	
Right weight	9895 (60.4)	1716 (52.2)	1820 (59.7)	1982 (62.1)	1749 (63.5)	1080 (65.0)	1548 (63.8)	
Overweight	3983 (24.4)	1000 (30.4)	772 (25.3)	751 (23.5)	646 (23.5)	361 (21.7)	453 (18.6)	
Safe places in the neighbourhood (n (%))								<0.001
No	1369 (8.4)	443 (13.5)	258 (8.5)	210 (6.5)	169 (6.1)	112 (6.7)	177 (7.3)	
Yes	12558 (76.7)	2142 (65.1)	2288 (75)	2555 (80.1)	2267 (82.4)	1367 (82.3)	1939 (79.9)	

Don't know	2445 (14.9)	703 (21.4)	504 (16.5)	426 (13.4)	318 (11.5)	183 (11)	311 (12.8)	
Days of TV (n (%))								<0.001
Never	1402 (8.6)	447 (13.6)	233 (7.6)	216 (6.8)	170 (6.2)	112 (6.7)	224 (9.2)	
1-3 times a week	6497 (39.7)	1076 (32.7)	1168 (38.3)	1335 (41.8)	1228 (44.6)	756 (45.5)	934 (38.5)	
4+ times a week	8473 (51.7)	1765 (53.7)	1649 (54.1)	1640 (51.4)	1356 (49.2)	794 (47.8)	1269 (52.3)	
Junk food (n (%))								<0.001
Never or once a week	4085 (25.0)	765 (23.3)	705 (23.1)	763 (23.9)	682 (24.8)	416 (25.0)	754 (31.1)	
2-4 times a week	7369 (45.0)	1241 (37.7)	1355 (44.4)	1526 (47.8)	1389 (50.4)	836 (50.3)	1022 (42.1)	
5+ times a week	4918 (30.0)	1282 (39.0)	990 (32.5)	902 (28.3)	683 (24.8)	410 (24.7)	651 (26.8)	
Walkability (n (%))								0.026
Walker's Paradise	663 (4.0)	97 (3.0)	118 (3.9)	123 (3.9)	130 (4.7)	86 (5.2)	109 (4.5)	
Very Walkable	3324 (20.4)	691 (21.0)	600 (19.6)	677 (21.2)	555 (20.2)	327 (19.6)	474 (19.5)	
Somewhat Walkable	2721 (16.6)	544 (16.5)	490 (16.1)	523 (16.4)	456 (16.5)	281 (16.9)	427 (17.6)	
Car-Dependent	9664 (59.0)	1956 (59.5)	1842 (60.4)	1868 (58.5)	1613 (58.6)	968 (58.3)	1417 (58.4)	

The association of study characteristics with physical activity was explored using Chi-square test and ANOVA for categorical and continuous variables, respectively.

Table 2. Results from the multinomial logistic regression featuring the relationship between neighbourhood walkability and after-school physical activity

	After-school physical activity (days per week) ExpB (95%CI), p				
Walkability	**Never vs. Once**	**Never vs. Twice**	**Never vs. Three**	**Never vs. Four**	**Never vs. Five (every day)**
Car-Dependent	Reference	Reference	Reference	Reference	Reference
Somewhat Walkable	0.890 (0.775, 1.023), 0.100	0.931 (0.812, 1.069), 0.311	0.956 (0.828, 1.103), 0.535	0.975 (0.826, 1.150), 0.762	1.013 (0.876, 1.172), 0.860
Very Walkable	0.936 (0.824, 1.063), 0.309	1.060 (0.936, 1.202), 0.358	1.025 (0.899, 1.169), 0.713	1.010 (0.866, 1.178), 0.899	0.988 (0.862, 1.133), 0.867
Walker's Paradise	1.139 (0.959, 1.353), 0.138	1.059 (0.895, 1.254), 0.505	1.216 (1.029, 1.436), **0.021**	1.287 (1.064, 1.557), **0.009**	1.230 (1.030, 1.469), **0.022**

The model was adjusted for age, gender, SEIFA score, TV watching time, junk food consumption, neighbourhood safety and children's weight status

Supplementary table 1. Comparing students with missing values and students without missing values.

Variable	Without missing values N = 16372	With missing values N = 1239	P-value*
Age: Mean ± SD	13.5 ± 1.2	13.4 ± 1.2	0.449
Girls (N (%))	8253 (50.4)	534 (43.1)	**<0.001**
SEIFA score: Mean ± SD	993.2 ± 70.0	982.3 ± 72.2	**<0.001**
SEIFA score: Median (IQR)	998.4 (949.8, 1049.3)	984.5 (940.2, 1041.4)	**<0.001**
Weight status (N (%))			0.440
Underweight	2494 (15.2)	182 (16.5)	
Right weight	9895 (60.5)	662 (60.2)	
Overweight	3983 (24.3)	256 (23.3)	
Physical activity (N (%))			0.097
Never	3288 (20.1)	190 (22.6)	
Once a week	3050 (18.6)	154 (18.3)	
Twice a week	3191 (19.5)	165 (19.6)	
Three times a week	2754 (16.8)	113 (13.4)	
Four times a week	1662 (10.2)	82 (9.8)	
Five times a week	2427 (14.8)	137 (16.3)	
Junk food (N (%))			**0.002**
Never/Once a week	4085 (25.0)	276 (25.6)	
2-4 times a week	7369 (45.0)	432 (40.0)	
5+ times a week	4918 (30.0)	372 (34.4)	
Safety (N (%))			**0.016**
Don’t know	2445 (14.9)	276 (22.3)	
No	1369 (8.4)	101 (8.6)	
Yes	12558 (76.7)	862 (73.4)	
Days of TV (N (%))			**0.018**
Never	1402 (8.6)	64 (11.3)	
1-3 times a week	6497 (39.7)	237 (41.9)	
4+ times a week	8473 (51.8)	265 (46.8)	

Walkability (N (%))			**0.013**
Car-Dependent	9664 (59.0)	785 (63.3)	
Somewhat Walkable	2721 (16.6)	183 (14.8)	
Very Walkable	3324 (20.3)	235 (19.0)	
Walkers Paradise	663 (4.1)	36 (2.9)	

*P-value for difference between students with and without missing values. Quantitative variables were analysed with t-tests or Mann-U Whitney tests depending on whether the variable was normal or skewed, respectively. Chi-square test were used to analyse categorical variables.