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Preventive Medicine 40 (2005) 363–372

Preventive Medicine

www.elsevier.com/locate/ypmed

Psychosocial and environmental factors associated with physical activity among city dwellers in regional Queensland

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Available online 7 August 2004

Abstract

Background. Research has recently adopted the use of social–ecological models in the study of physical activity. Few studies, however, have addressed the influence of the environment on activity using Geographic Information System (GIS)-derived measures of environmental attributes and self-report ratings of other environmental attributes. Even fewer have examined walking behaviors.

Methods. Self-report measures of physical activity, social support, self-efficacy, and perceived neighborhood environment were obtained by means of a Computer-Assisted-Telephone-Interview (CATI) survey of 1,281 residents of Rockhampton, Queensland. Over 94% (1,215) of respondents' residential locations were successfully geocoded into the existing city council GIS database. The self-report data, along with GIS-derived measures, were used to determine the relationships among selected variables of the neighborhood environment for each geocoded location.

Results. GIS-derived measures of street connectivity and proximity to parkland, the number of active people in a 1-km radius, and self-reported perceptions of neighborhood cleanliness showed associations with the likelihood of achieving sufficient levels of physical activity when adjusting for selected psychosocial variables. GIS-derived Euclidian distance to footpath networks, number of dogs in 0.8-km radius, network distance to newsagents, and perceptions of footpath condition were significantly associated with the likelihood of participating in any recreational walking.

Conclusion. Environmental characteristics were found to have differential influences on the two selected measures of physical activity. Aesthetics and safety appear to be important influences of physical activity, whereas proximal footpaths showed increased likelihood of participation in recreational walking. It is proposed that the strength of association between the environmental and physical activity may be improved if future research utilizes a Geographic Information System approach to the study of restricted geographical areas.

Keywords: Physical activity; Walking; Environment; Perceptions; GIS

Introduction

Physical inactivity is a major modifiable risk factor for many preventable diseases [1] and is widespread throughout many industrialized nations [1–3]. Attempts to address low physical activity levels have often been guided by research focused on the individual, largely neglecting the environment as an influence of behavior [4]. This focus on small group or individual-level interventions has raised concern regarding the ability to initiate positive changes in physical activity at the level of the population [5]. The physical environment has been identified as having the potential to influence the activity levels of large segments of the population [6] and has become a focus of recent research [7]. Results of research examining the environment's influence on physical activity suggest that accessibility and aesthetics are important influences of activity [7,8]. Findings that the built environment can effect activity decisions by providing cues and opportunities for activity to occur [9,10] emphasize the need for more research regarding the associations between environment and individual levels of physical activity.

The use of a social–ecological framework can better address the study of health-related physical activity at the population level as this approach acknowledges the influence of environment on activity [11]. The framework also

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0091-7435/$ - see front matter
doi:10.1016/j.ypmed.2004.06.017

allows for the incorporation of the numerous identified determinants of physical activity [12]. Research examining environmental influences on activity needs to address both the inter- and intrapersonal influences of activity [13] as the environment does not exact its influence on behavior separate from individual determinants of behavior [11]. Although within ecological models the term environment has been referred to 'as any space outside the person' [13], recent research has focused on the physical characteristics of the neighborhood environment [8]. The neighborhood environment has been conceptualized as an area equal to several city blocks [14] and has recently been operationalized as an area within a radius less than 0.9 km from one's residence [15]. Previous research [16,17] supports the use of small geographic areas relative to the person's place of residence when examining the environment's influence on activity. When examining the environment, several studies [18,19] have found that infrastructure such as shops and walking paths within walking distance of the home is positively associated with increased levels of walking. This suggests that accessible infrastructure may influence lower intensity activities. To date, however, these associations have not been empirically tested using objective measures of distance.

One of the principal methods of obtaining objective measures of distance is through the application of Geographic Information Systems (GIS) data. GIS allows for several of the methodological inaccuracies of self-report environmental measures to be overcome and increases the quantity and quality of environmental measures available to researchers [20]. For example, although self-reported perceptions of dogs and active people within the neighborhood have been positively associated with activity [21], self-report measures do not accurately measure the number of dogs or active people within the neighborhood. GIS allows for the combination of local government and CATI survey databases to provide more accurate determination of the prevalence of such characteristics within a predefined geographic area. GIS can also be applied to physical activity research to determine Euclidian and street network distances between origins and destinations to create measures of connectivity [23] used to determine the accessibility of destinations [24]. Although current research regarding environmental influences on physical activity is beginning to give us a clearer picture of these associations, the presence of methodological issues limit confidence in the findings. There remains a need to integrate objectively determined measures with subjective self-report data to obtain a clearer understanding of the association between the environment and physical activity. GIS allows this type of information to be used to improve our knowledge in this area.

Studies examining environmental influences on activity have increased in recent times. However, the majority of these studies assess the environment using self-report measures of the environment, while few studies have utilized GIS-derived measures of the environment to objectively quantify the associations found using self-report measures. Research has demonstrated that influences on activity encompass variables from personal, social, psychological, and environmental domains [3,7], and it has been recommended that research should utilize models that incorporate these influences [4,13]. Consistent with these suggestions, the current study uses a social–ecological framework to examine the relationships between self-reported and GIS-derived measures of the environment and two selected measures of physical activity—a criterion level of activity participation for health and participation in any recreational walking.

Methods

Design

Cross-sectional self-report data regarding physical activity obtained by means of a Computer-Assisted-Telephone-Interview (CATI) survey were combined with GIS-generated data relating to the physical environment surrounding the respondent's residential address. Integrated data sets were used to determine the association between GIS-derived objective measures of environmental attributes and self-report ratings of other environmental measures and two measures of physical activity-attaining 'sufficient' physical activity and participation in recreational walking.

Sample

A two-stage stratified sampling design was used to randomly select the household and then the adult respondent within the household in Rockhampton, Queensland (population 62,845) [25]. The response rate for the survey was 46.6% with a total of 1,281 residents interviewed between August 2001 and September 2001. All participants were 18 years of age or older at the time of the survey and lived in a residence that was accessible by land-based telephone.

Demographic characteristics

The CATI survey included questions on sociodemographic factors including income, level of educational achievement, age, and gender.

Self-efficacy

Levels of self-efficacy for performing physical activity were assessed using a five-point Likert scale from 'not at all confident' to 'very confident.' Respondents were required to rate how confident they were that they could perform activity "even when it is very hot outside," "when you don't have anyone to exercise with," "when you don't have any money," "when you are tired," "when you feel you don't have time," and " when activity takes a lot of effort." Cronbach's alpha for these items was 0.76. All items were subsequently summed to form a single item for self-efficacy and dichotomized into high and low self-efficacy using a mean split.

Social support

Using a five-point Likert scale, respondents were asked to rate on a scale from "never" to "very often" how frequently over the previous 3 months that family, friends, and colleagues "had encouraged them to perform physical activity," "had done something to help you be physically active," "made it difficult for you to be physically active," and "offered to do physical activities with you." The four items assessing social support for physical activity had a Cronbach's alpha of 0.77 and were summed to form a single item for social support. The single social support variable was dichotomized into high and low categories of social support using a mean split.

Physical activity

The respondent's level of physical activity in the previous week was assessed using the Active Australia Physical Activity Questionnaire [26]. This instrument asks the respondent to recall the amount of time spent in activities such as walking for leisure or recreation, for transport purposes, and any moderate or vigorous activities for a period of at least 10 min in the previous 7-day period and has demonstrated moderate to very good test–retest reliabilities [27]. Respondents were asked to report the duration (in hours and minutes) and frequency of recreational and transport-related walking, vigorous sport and gardening, and moderate intensity exercise activities. Participation in 'sufficient' levels of physical activity was defined as attaining 150 min of activity throughout the previous week in all activities excluding vigorous gardening and is derived from national activity guidelines [26]. A measure of participation in recreational walking, defined as any self-reported recreational walking in the previous week, is also examined in this study. This measure was selected as a variable in the current study as it was deemed likely that the neighborhood environment could potentially display the most influence on an activity that frequently originates from one's home.

Perceived physical environment

Fifteen items were used to assess perceived environment. Items reflected a social–ecological approach to the study of physical activity and assessed the respondents' perceptions of their physical environment on a five-point Likert scale. The instrument included questions concerning safety, aesthetics, accessibility, and opportunities for physical activity. Items used are similar to those used in previous studies examining the environment [18,19,21,22,28] and assessed issues relating to accessibility, aesthetics, safety, and proximity of infrastructure. A copy of the questions is attached in Appendix A.

GIS procedures

Genamap version 8.1.1 was used to store and analyze the geographic information. Geocoding was performed by matching the residential location of survey respondents to those in the Rockhampton City Council (RCC) GIS database (n = 1,215). Each of the geocoded locations represented the position from which objective environment measures were taken. Euclidian and street network distances were calculated to the nearest parkland, shopping center, pathway network of 300 m, busy street (≥60 kph speed limit), and newsagent. The number of 'sufficiently active' people, and the number of registered dogs in radii of 0.5, 0.8, 1.0, and 1.5 km, were determined from each respondent's home. Activity classifications for sufficiently active people were based on current national guidelines [29]. The total amount of roadway within 20 m of a streetlight was also determined in these same radii. Lighting information used in the analysis was that provided to RCC in 2002 by the State's electrical supplier. For purposes of the study, dog count reflected the number of registered dogs only. Since registration is mandatory under law, this was considered an accurate reflection of the number of dogs present in the area. The location of newsagent outlets was determined by manual examination of the telephone directory and the Electronic White Pages, with locations being geocoded.

Analysis

A series of logistic regression analyses were performed using SPSS version 10.1, to examine the self-reported and GIS-derived measures of the environment associated with physical activity in the previous week. Two measures of physical activity were examined: 'sufficient' physical activity and 'any' recreational walking. In each model, sociodemographic variables of age, income, gender, BMI, social support for physical activity, and self-efficacy were adjusted for, as these are known to be associated with, physical activity [7]. Sufficient physical activity and participation in recreational walking were examined in separate models as the influences on these activity behaviors are expected to be different. In both models, demographic variables were entered on step one of the analysis (forced entry). Measures of self-efficacy and social support were forced into the model on the second step. The 15 measures of the perceived environment were conditionally entered on step three (forward conditional) and GIS measures were entered on step 4 (forward conditional). Significance was accepted at an alpha level of 0.05.

Results

Prevalence of physical activity

Of the 1,281 CATI survey respondents, 94.7% (1,215) of residential locations were able to be geocoded. Descriptive statistics are presented in Table 1. Within the total study population, 57.9% of respondents were categorized as sufficiently active to derive health benefits. Persons in the 18- to 29-year-old age group had the highest proportions of active people (66.1%) compared to any other age group. The lowest educational grouping (below grade 10 education) had the lowest prevalence of sufficiently active people (55.2%). Across all categories, males were active in higher in proportions compared to females except in the lowest income level.

Predictors of attaining sufficient physical activity

The first logistic regression model examined the association between identified environmental variables and sufficient physical activity while adjusting for selected psychosocial and demographic variables (Table 2). Only those respondents whose residential locations were successfully geocoded and provided complete survey information were used in the analysis of the activity levels (n = 760). On the first step of the model, analysis revealed that females were 41% less likely than males to attain sufficient levels of activity. In addition, obese persons were 43% less likely to attain sufficient levels of activity than their healthy weight counterparts. These demographic variables remained constant throughout the model. The addition of self-efficacy and social support on the second step of analysis reveals that when adjusting for the socio-demographic variables included on the first step, people reporting high levels of self-efficacy were 93% more likely to attain sufficient activity than those people reporting low levels of self-efficacy. People reporting high levels of social support were 2.57 times more likely to achieve sufficient levels of activity than those who reported low levels of social support.

Stepwise addition of perceived environment variables on the third step showed that when adjusting for the identified psychosocial variables, only perceptions of neighborhood tidiness made a reliable contribution to the prediction of attaining sufficient physical activity. People not agreeing that their neighborhood was clean and tidy were 2.67 times more likely to attain sufficient levels of activity than those people who agreed with the statement. On the final step, addition of GIS-derived objective measures revealed that proximity to parkland, route directness to parkland, and the number of active people within a 1.0-km radius made reliable contributions to the prediction of activity. Those people with the most proximal parkland beyond a network distance of 0.6 km were 41% more likely to achieve recommended level of activity than those with parkland within this distance. Similar odds ratios were present when examining route connectivity to the nearest parkland. Those people who had unacceptable route directness to the nearest parkland were 41% more likely to achieve sufficient levels of activity than those people who had acceptable route directness to parkland. The number of active people within a 1-km radius of respondent's homes was associated with activity, as those people who lived in areas where the number of active respondents people was in the middle tertile of people were 64% more likely to engage in sufficient levels of activity than those people who had the lowest levels. A positive but nonsignificant association between the prevalence of neighborhood activity levels and the measure of sufficient physical activity was also found for respondents living in highest tertile neighborhoods in terms of physically active respondents. People living in these areas were 14% more likely to reach this level of activity.

Predictors of participation in recreational walking

The second logistic regression model investigated the associations between demographic, psychosocial, and environmental variables with self-reported participation in recreational walking in the previous week (Table 3). Over 58% of the study population reported doing some recreational walking in the week prior to data collection. Analysis of

Table 1
Percentage of sufficiently active people within various sociodemographic categories

	Males (%)	Females (%)	Total sample (%)
Gender (n = 1,246)	64.4	52.4	57.9
Age (n = 1,246)			
18–29	74.0	58.8	66.1
30–44	60.8	48.7	54.3
45–59	65.0	46.6	55.3
60+	57.2	54.7	55.8
Education level (n = 1,233)			
≤Grade 10	66.2	48.6	55.2
Grades 11 and 12	62.7	56.0	59.2
Trade or associate dip.	64.2	54.5	60.3
Tertiary	64.4	55.6	59.2
Income (n = 898)			
<$300	54.4	60.6	57.8
$300–599	73.3	48.1	59.8
$600–1,000	64.9	50.5	57.8
>$1,000	68.0	51.2	59.4
BMI category (n = 1,165)			
Healthy weight	66.1	55.9	60.2
Underweight	77.8	42.9	50.0
Overweight	67.2	52.5	61.2
Obese	52.4	48.0	50.0
Social support (1,239)			
Low social support	57.7	46.8	51.9
High social support	83.6	66.8	74.1
Self-efficacy (n = 1,239)			
Low self-efficacy	47.6	43.6	45.1
High self-efficacy	72.4	60.8	66.9

Table 2
Modeling the association between sufficient physical activity and personal, social, and environmental variables[a]

Variable	n	Models 1[b,c]	Model 2[d]	Model 3[e]	Model 4[f]
Gender					
Male	373	1.00	1.00	1.00	1.00
Female	387	0.51 (0.37–0.69)	0.51 (0.38–0.71)	0.51 (0.37–0.71)	0.52 (0.37–0.72)
Age					
18–29	214	1.00	1.00	1.00	1.00
30–44	224	0.69 (0.45–1.04)	0.77 (0.50–1.19)	0.77 (0.50–1.19)	0.76 (0.49–1.18)
45–59	157	0.75 (0.47–1.20)	0.84 (0.51–1.37)	0.85 (0.51–1.39)	0.80 (0.48–1.32)
60+	165	1.00 (0.60–1.66)	1.21 (0.71–2.06)	1.27 (0.75–2.17)	1.22 (0.71–2.09)
Income					
<$300	142	1.00	1.00	1.00	1.00
$300–599	204	1.15 (0.73–1.82)	1.12 (0.70–1.78)	1.16 (0.72–1.85)	1.18 (0.73–1.90)
$600–1,000	199	1.10 (0.67–1.78)	1.08 (0.65–1.77)	1.13 (0.68–1.87)	1.13 (0.68–1.88)
>$1,000	215	1.14 (0.69–1.87)	1.04 (0.63–1.74)	1.09 (0.65–1.82)	1.07 (0.64–1.80)
Education level					
≤ Grade 10	232	1.00	1.00	1.00	1.00
Grades 11 and 12	133	1.16 (0.70–1.92)	1.08 (0.64–1.82)	1.12 (0.66–1.90)	1.07 (0.63–1.83)
Trade or associate dip.	236	1.14 (0.76–1.69)	1.05 (0.69–1.58)	1.08 (0.71–1.63)	1.04 (0.68–1.59)
Tertiary	159	1.33 (0.85–2.10)	1.19 (0.74–1.90)	1.18 (0.74–1.90)	1.07 (0.66–1.73)
BMI					
Healthy weight	354	1.00	1.00	1.00	1.00
Underweight	28	1.26 (0.56–2.86)	1.48 (0.64–3.43)	1.46 (0.61–3.30)	1.21 (0.51–2.86)
Overweight	256	0.97 (0.68–1.38)	0.97 (0.67–1.39)	0.96 (0.67–1.39)	0.98 (0.67–1.42)
Obese	122	0.57 (0.37–0.87)	0.57 (0.36–0.89)	0.55 (0.35–0.86)	0.57 (0.36–0.89)
Self-efficacy					
Low self-efficacy	285		1.00	1.00	1.00
High self-efficacy	475		1.93 (1.40–2.64)	1.93 (1.40–2.65)	1.97 (1.43–2.72)
Social support					
Low social support	544		1.00	1.00	1.00
High social support	216		2.57 (1.77–3.73)	2.61 (1.80–3.80)	2.61 (1.78–3.81)
The neighborhood is kept clean and tidy					
Agree	712			1.00	1.00
Not agree	48			2.67 (1.28–5.55)	3.13 (1.48–6.64)
Network distance to parkland					
Within 600 m	366				1.00
Beyond 600 m	394				1.41 (1.01–1.97)
Connectivity of parklands					
Acceptable	288				1.00
Unacceptable	472				1.41 (1.00–1.98)
No. of active people in 1 km radius					
Lowest tertile	258				1.00
Middle tertile	246				1.64 (1.11–2.43)
Highest tertile	256				1.14 (0.78–1.67)

[a] Attaining ≥ 150 min of physical activity per week (n = 458, 60.3%), insufficiently active (n = 302, 39.7%).
[b] Odds ratios and 95% confidence intervals.
[c] Step 1, forced entry.
[d] Step 2, forced entry.
[e] Step 3, forward conditional.
[f] Step 4, forward conditional.

variables entered into the model on the first step reveals that females were 40% more likely to engage in walking than males, and overweight people were 64% more likely to engage in walking than healthy weight individuals. The addition of self-efficacy and social support on the second step revealed that self-efficacy was not associated with activity. People reporting high levels of social support for activity were 65% more likely to participate in recreational walking than those people who reported low levels of social support when adjusting for the identified sociodemographic variables.

Stepwise addition of self-report measures of the environment revealed that those people who did not agree that the neighborhood footpaths were in good condition were 38% more likely to participate in recreational walking than those who thought the footpaths were in good condition. This was the only self-report measure of the environment to reliably contribute to the model predicting recreational walking in the previous week when adjusting for the previously identified psychosocial variables. The stepwise addition of GIS-derived measures of the environment on the fourth step of the analysis revealed that respondents with a footpath network beyond a

Table 3
Modeling the association between participation in recreational walking and personal, social, and environmental variables[a]

Variable	n	Models 1[b,c]	Model 2[d]	Model 3[e]	Model 4[f]
Gender					
Male	362	1.00	1.00	1.00	1.00
Female	379	1.40 (1.03–1.91)	1.41 (1.03–1.93)	1.38 (1.00–1.89)	1.41 (1.02–1.95)
Age					
18–29	209	1.00	1.00	1.00	1.00
30–44	216	1.31 (0.87–1.99)	1.41 (0.93–2.15)	1.37 (0.90–2.08)	1.38 (0.89–2.12)
45–59	153	1.27 (0.80–2.03)	1.36 (0.85–2.19)	1.32 (0.82–2.13)	1.50 (0.92–2.45)
60+	163	1.29 (0.79–2.31)	1.45 (0.87–2.41)	1.46 (0.88–2.43)	1.37 (0.81–2.31)
Income					
<$300	141	1.00	1.00	1.00	1.00
$300–599	199	0.74 (0.47–1.16)	0.72 (0.45–1.23)	0.70 (0.44–1.10)	0.69 (0.43–1.11)
$600–1,000	192	0.85 (0.52–1.37)	0.83 (0.51–1.39)	0.81 (0.50–1.32)	0.79 (0.48–1.30)
>$1,000	209	0.79 (0.49–1.30)	0.76 (0.46–1.27)	0.75 (0.45–1.23)	0.70 (0.42–1.17)
Education level					
≤Grade 10	229	1.00	1.00	1.00	1.00
Grades 11 and 12	132	1.47 (0.89–2.42)	1.44 (0.87–2.38)	1.41 (0.85–2.34)	1.35 (0.80–2.27)
Trade or associate dip.	226	1.19 (0.80–1.77)	1.15 (0.77–1.72)	1.18 (0.79–1.76)	1.20 (0.80–1.81)
Tertiary	154	1.45 (0.92–2.30)	1.40 (0.88–2.21)	1.35 (0.85–2.14)	1.32 (0.82–2.12)
BMI					
Healthy weight	342	1.00	1.00	1.00	1.00
Underweight	28	1.71 (0.74–3.94)	1.87 (0.81–4.33)	1.85 (0.80–4.29)	1.68 (0.71–3.96)
Overweight	250	1.64 (1.15–2.33)	1.62 (1.13–2.31)	1.62 (1.13–2.31)	1.73 (1.20–2.49)
Obese	121	1.12 (0.73–1.72)	1.12 (0.73–1.73)	1.08 (0.70–1.67)	1.11 (0.71–1.73)
Self-efficacy					
Low self-efficacy	279		1.00	1.00	1.00
High self-efficacy	462		1.18 (0.86–1.62)	1.19 (0.87–1.63)	1.18 (0.85–1.63)
Social support					
Low social support	531		1.00	1.00	1.00
High social support	210		1.65 (1.17–2.34)	1.63 (1.15–2.30)	1.68 (1.18–2.40)
The footpaths are in good condition					
Agree	483			1.00	1.00
Not agree	269			1.38 (1.00–1.91)	1.43 (1.02–1.99)
Euclidian distance to footpath					
Within 400 m	692				1.00
Beyond 400 m	60				0.31 (0.18–0.55)
No. of dogs within a 0.8-km radius					
Lowest tertile	254				1.00
Middle tertile	243				1.66 (1.13–2.43)
Highest tertile	245				0.82 (0.57–1.19)
Network distance to newsagent					
Within 600 m	99				1.00
Beyond 600 m	642				1.65 (1.05–2.58)

[a] Participating in recreational walking (n = 431, 58.2%), not participating in recreational walking (n = 310, 41.8%).
[b] Odds ratios and 95% confidence intervals.
[c] Step 1, forced entry.
[d] Step 2, forced entry.
[e] Step 3, forward conditional.
[f] Step 4, forward conditional.

Euclidian distance of 0.4 km from their home were 69% less likely to walk in the previous week than those who had a footpath within that distance from their place of residence. People whose home was classed as being in the middle tertile of registered dog numbers within 0.8 km were 66% more likely to have reported some recreational walking than those people living in a residence with the lowest tertile of registered dog numbers. In addition, those people with a newsagent beyond a network distance of 0.6 km were 65% more likely to walk in the previous week compared to those people with a newsagent within this distance.

Discussion

There is now a focus on understanding the modifiable determinants of activity [4] through the use of ecological models of health behavior [13], which are capable of integrating the many identified correlates of activity [12]. The current research incorporated demographic, psychological, social, and environmental domains in the study of the correlates of participating in sufficient activity and participating in recreational walking in the previous week. A unique aspect of this research is the ability to integrate both self-report CATI survey data and GIS-derived measures of the environment to examine the neighborhood environment's influence on physical activity behaviors. This research utilized GIS measures of the neighborhood environment that have not yet been adopted in previous research. In doing so, the current study attempts to identify new correlates of the built environment to increase understanding of how the neighborhood environment influences activity levels. To date, no study has used GIS beyond determining proximity to recreational infrastructure [10,17] and its influence on physical activity. Therefore, the current study adds to the growing body of evidence that both the built and self-reported environment has an influence on community physical activity levels.

Examination of the odds ratios in the prediction of sufficient levels of physical activity showed that females were less likely than males to attain this level of activity, as were obese people relative to healthy weight people. People reporting high levels of self-efficacy and social support were more likely to attain sufficient levels of activity in the previous week compared to people reporting low levels of these correlates and is consistent with previous research [3,7,30]. In addition to these variables, strong negative associations were found between self-report measures of neighborhood cleanliness and the likelihood of attaining sufficient physical activity. People who did not agree that the neighborhood was clean and tidy were over three times more likely to attain recommended levels of activity than those who agreed. Initially, this may appear counterintuitive, as those people viewing the neighborhood as untidy and unclean are more likely to be active. However, those people who are active within the neighborhood may be more aware of the uncleanliness and untidiness in the neighborhood and report their perceptions of the environment accordingly. Similar reporting behaviors may be present when examining recreational walking behavior and self-report measures of footpath condition. As those people who regularly use the footpaths may be more aware of their condition and report the footpath condition accordingly, this finding is similar to previous suggestions of other self-report environmental measures associated with physical activity [21]. Other plausible explanations for these associations are that people with unclean or poorly maintained footpaths find locations outside of the neighborhood to perform their activity in. Previous research has reported a positive association between aesthetically pleasing environments and physical activity levels [18,31–34]; however, many of these studies were assessing different qualities of the aesthetic environment compared to this study and potentially account for the apparent conflicting findings. Counterintuitive findings such as these underscore the need for future research to find ways to more objectively measure items of environmental quality.

Proximity and the directness of the route (connectivity) to parkland were examined and provided findings contrary to those that would be expected. Those people that had parkland further than 0.6 km and those people who had unacceptable connectivity were more likely to attain sufficient levels of activity than those who lived closer and had more direct routes. These unforeseen associations may be due to several reasons, one of which may be due to the ability of active persons to overcome barriers of distance through urban environments to engage in recreational activities. This is a plausible explanation, as sufficient activity included measures of moderate and vigorous intensity activities. Participation in these activities may require more skills and abilities than simple geographic proximity, and these participants may be more likely to overcome barriers such as distance to maintain their involvement in activity. This hypothesis is supported in the current research, as similar measures were not associated with the lower intensity activity of recreational walking. The associations between self-efficacy and activity vary greatly between modes, with sufficient activity having stronger associations with self-efficacy than participation in walking. The stronger association with sufficient activity may represent the increased skills and abilities that may be required to overcome barriers to participation relative to engagement in lower intensity activity. In addition, transportation literature suggests that land use mix and the attractiveness of the destination may influence people's activity behaviors [36]. These factors may be influential when facilities are less proximal, as land use mix may reduce the psychological barrier of distance by providing alternate activities in close proximity to the park that can be engaged in. It is recommended that future research includes factors specific to each activity and destination (park, gym, and recreation center) to clarify the influence that distance to a facility has on participation in activity.

It has been demonstrated previously that pathways that are located within walking distance of the home are positively associated with activity [18], and the current study adds to this evidence base. Strong associations were found between the proximity of pathway networks and participation in recreational walking. When controlling for the identified psychosocial variables, having a footpath network beyond 400 m from the home was associated with a 69% reduction in the odds of participating in walking in the previous week. This suggests that pathway networks in close proximity to the home are important cues and opportunities for people to engage in walking activities. As walking is known to be the most popular activity undertaken by Australians [35] and recommended in public health messages [29], these findings emphasize the need to develop neighborhood footpath networks. In addition, policy changes may be needed to ensure that networks are provided in close proximity to resident's homes to provide environmental cues for people to initiate activity.

Self-report measures of the presence of dogs in the neighborhood have been positively associated with physical activity [21]; however, attempts to objectively quantify the association between the numbers of neighborhood dogs and physical activity were not successful in this study. It is possible that it is not the mere presence or absence of dogs, but the nature of the dog presence—such as roaming dogs or the prevalence or proximity of dog attacks in neighborhood—which influences activity. It is also possible that neighborhood dogs may act as both a facilitator and inhibitor of activity in different ways. At the individual level, dog ownership may positively affect physical activity whereas the presence of a high number of dogs in other neighborhood households many inhibit activity. These issues need to be addressed in future research using available GIS technologies within similar geographic areas.

Previous research has shown that observing other people being active in the neighborhood is positively associated with activity [21]. The current study examined the association between the number of sufficiently active people within the neighborhood and activity. Although positive associations were observed, the direction of association is ambiguous, as significant positive associations were observed only for those people residing in areas that had the number of active survey respondents equal to the middle tertile. No significant association was observed for those people living within geographic regions with the highest number of active survey respondents. It may be that extremely high levels of active people within a neighborhood do not strongly influence activity in the presence of the identified psychosocial variables or other unmeasured characteristics of the environment, but rather it is moderate levels of active neighbors that provide the cue for activity to be engaged in. Further research is needed that integrates objective assessments of the number of active people within the neighborhood but also measures of where the majority of the activity occurs. Doing so will allow for the assessment of neighborhoods using objective counts of those people who recall performing the majority of their activity in the neighborhood and may better explain the associations observed in the current study.

Although the focus of the present study was the examination of the environment influences on activity, interesting associations emerged between participation in walking and people classified as overweight. Overweight people were 73% more likely to participate in recreational walking than healthy weight people in the previous week. This may have arisen because walking requires little in the way of facilities and can be performed by almost all people [37], and therefore walking in the neighborhood offers an ideal activity for those wishing to initiate activity. This finding may be encouraging evidence that overweight people are initiating activity behaviors within their local neighborhood. More research needs to be conducted to investigate the physical activity behaviors and underlying motivations taken by overweight individuals in their neighborhood.

It is notable that there was no significant relationship between self-efficacy and recreational walking, as self-efficacy is documented as a consistent correlate of activity [3,7]. It is possible that self-efficacy does not influence lower intensity activities such as walking as strongly as it does for higher intensity activities and may explain its lack of association in the model examining walking. As self-efficacy did not achieve significance at any stage in the model examining walking, yet was consistently associated with the likelihood of attaining sufficient activity, it may be that the measure of self-efficacy used is not specific to lower intensity activities such as walking. However, social support remains an important influence on the likelihood of attaining sufficient activity, and participation in walking in the presence of environmental influences when adjusting for other psychosocial variables.

The measure of footpath condition was the only self-report measure relating to safety that gained significance in either model examining physical activity. Other measures relating to safety, such as the presence of self-reported street lighting and perceptions of crime, did not gain significance in models examining the different modes of activity. The lack of association found between the self-reported presence of street lighting and activity is consistent with previous research using similar measures [21,22]. The use of GIS-derived measures of street lighting and illumination also failed to show any relationship to physical activity. It is also possible that the influence of lighting on physical activity as measured in this study is not strong enough above important psychosocial variables to significantly contribute to explaining the variance in activity behavior. Given the relative paucity of GIS-derived environmental attributes [20,31,38], it is important that further work be done to better reflect the built environment on measures such as these.

Findings regarding the associations between walking for recreation and the network distance to the nearest newsagent were contrary to what was expected. Previous research has shown that people tend to select modes of transport other than walking if community services and transport stops are more than 0.4 and 0.8 km from their home [39]. The current results suggest that having a newsagent beyond 600 m from the home increased the likelihood of participating in walking. Some caution needs to be taken in interpreting this information as there may be other environmental or geographic information that has not been factored into these findings. For example, no GIS-derived objective measures of terrain were utilized in the present study. It may be that the presence of steep hills plays a significant role in the association between distance between shops and services and activity levels.

The use of GIS in physical activity research is increasing and the selected size of geographic areas assessed using GIS has the potential to influence the associations between the environment and activity. It has recently been suggested that geographic areas within 1 km radius of people's homes be employed when using GIS-derived measures to examine the environment [15]. The current study used radii ranging from 0.5 to 1.5 km from the geocoded location of the respondent's place of residence. The 1.5-km radius was used in anticipation that a small regional community, such as the one studied, may have broader neighborhood influences than those residing in larger communities. There was no support for this approach, however, as no significant relationships were found between the selected measures of physical activity and any GIS-derived environmental attributes beyond 1.0 km.

There are several limitations to the current study that may have influenced the results. The first is that geocoding of the survey respondents residential locations was performed approximately 17 months after the initial survey was performed. This time, lag is not expected to affect the results as the characteristics of the physical environment assessed using GIS in this study did not change substantially during the time period. Although the dog registration and street lighting data used were from 2002—1 year after the CATI survey was performed—it is assumed that these environmental characteristics differed little over this time in the study area. Finally, those respondents that were surveyed whose usual place of residence that fell outside of the city area of Rockhampton were excluded from the geocoding process, as their homes were disproportional distanced from infrastructure assessed using GIS and therefore would have skewed the sample data accordingly.

Conclusion

Suggestions for research to examine the environment in the presence of inter- and intrapersonal influences have been made previously [13], and those environmental variables that achieved significance in the current study did so even when adjusting for these important psychosocial and demographic variables. This research demonstrates that new and important contributions can be made to the literature using this approach, which is required when assessing environmental influences on activity behaviors using social ecological approaches. The scarcity of research examining the environment's influence on walking [8] and the need to understand the influences of walking [36] make the findings examining walking important to the field. Results of current and previous research [16,17] support the use of radii less than 1 km from the home when examining the neighborhood environment. Measures of distances and connectivity to parklands did not demonstrate clear associations with activity behavior. It is recommended that alternate measures of parks and parkland be developed and utilized in future research. Possible avenues may arise from the study of children's activity [40] using not only the proximity of parks but their prevalence in relation to activity behaviors. This research can be performed easily using GIS technologies. Including measures of land use mix and density may provide important insights into how the built environment influences activity. The continued refinement of measures used to determine the environment's influence on activity needs to be sustained. In doing so, objective measures of the environment available from GIS must be employed as the measures are varied and relatively simple to obtain [20]. This research provides further evidence that different environmental characteristics influence different modes of activity.

Acknowledgments

Funding for this study was provided by Queensland Health as part of 10,000 Steps Rockhampton. GIS analysis was performed on behalf of the authors by Land Information Systems at Rockhampton City Council.

Appendix A. Perceived environment attributes measured in the study

The next few questions are about the neighborhood you live in. For each statement, please tell us if you strongly disagree, disagree, are unsure, agree, or strongly agree with what we have said

1. It is safe to walk in your neighborhood.
2. Dogs frighten people who walk in your neighborhood.
3. The neighborhood is friendly.
4. Crime is high in the neighborhood.
5. There are pleasant walks to do in your neighborhood.
6. Shops and services are in walking distance.
7. You often see people out on walks in your neighborhood.
8. Your neighborhood is kept clean and tidy.
9. There are busy streets to cross when out on walks.
10. The footpaths are in good condition.
11. There is heavy traffic.
12. It is safe to cycle in your neighborhood.
13. The streets are well lit.
14. There are steep hills.
15. There are open spaces (such as parks and ovals) for people to walk in or around my neighborhood (e.g., shops, parks, services).

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