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Pro-environment behavioural moderators of the association between perceived walkability and social activity

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A R T I C L E I N F O

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Pro-environment behaviour
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Ghana

A B S T R A C T

Background: – several studies have confirmed the potential influence of walkability on social activity, but whether this relationship can be modified by pro-environment behaviours has not been evaluated. This study aimed to assess the association between perceived (self-reported) walkability and social activity and to ascertain whether this potential relationship is moderated by pro-environment behaviour (PEB) and socially responsible consumption (SRC).
Methods: – This study adopted a cross-sectional design with a sensitivity analysis and techniques against common methods bias. The study population was residents in Ablekuma North Municipality, Ghana. Participants were 792 residents who met some inclusion criteria. The G*Power 3.1.9.4 software was employed to determine a minimum sample for the study. Hierarchical linear regression (HLR) analysis was used to present the findings.
Results: – The study found a positive association between neighbourhood walkability and social activity, which suggests that residents who lived in more walkable neigbourhoods reported higher social activity. SRC and PEB positively moderated the foregoing relationship between neighbourhood walkability and social activity.
Conclusions: – Residents who lived in more walkable neighbourhoods reported higher social activity, and the positive relationship between walkability and social activity is strengthened by SRC and PEB. It can be concluded that walkability better supports social activity among residents with higher pro-environment behaviours.

1. Introduction

Anecdotal and empirical evidence shows that the built environment plays a crucial role in the improvement of population health. For instance, person-environment (P-E) fit models such as Lawton's (1989) docility-proactivity hypothesis and Cantor's (1975)

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life-space concept posit that optimal health is an outcome of the individual's utilization of neighbourhood resources (e.g., services, sidewalk, parks, destinations) through social and physical activities. Corroborating this argument are empirical studies that have confirmed that the foregoing environment resources have a positive influence on social activity (Asiamah et al., 2021; Delclòs-Alió et al., 2019), physical activity (PA) (Chudyk et al., 2017; Delclòs-Alió et al., 2019; Keats et al., 2020), and mental health (Asiamah et al., 2021; McCormack et al., 2020). It is, thus, understandable why neighbourhood improvement is an apex public health agenda.

Neighbourhood walkability is the degree to which a residential community provides access to built environment attributes (e.g., services, sidewalk, parks, destinations) that support or encourage social activities through walking (Van Holle et al., 2016; Van Dyck et al., 2011; Asiamah et al., 2021; McCormack et al., 2020). According to Sallis et al. (2010), neighbourhood walkability is characterized by high residential density, street connectivity, and mixed land use (i.e., a combination of commercial and residential uses of public space). Andrews et al. (2012) have argued that walkability goes beyond the above built environment attributes and encompasses social and cultural factors (e.g., cohesion, norms) that facilitate mobility and health in individuals with chronic conditions. Psychometric tools such as the Neighbourhood Environment Walkability Scale (i.e., American and Australian versions), measure the foregoing dominant features of walkability as well as sanitation and aesthetics (Asiamah et al., 2021; Sallis et al., 2010). Research to date (Matsumoto et al., 2022; Asiamah et al., 2021; Asiamah et al., 2021, 2021) has shown that social activities (i.e., helping others, making new friends) increase as neighbourhood walkability increases.

One of the main drawbacks to environmental sustainability is the failure of important stakeholders to play their role in protecting the environment. Among these stakeholders are individuals or citizens who are the end-users of neighbourhood resources (Rydenstam et al., 2020; Zhang et al., 2017). Citizens do not see themselves as actors responsible for the sustainability and walkability of their neighbourhoods; they think governments and their agencies are exclusively responsible for the design and maintenance of sustainable neighbourhoods (Zhang et al., 2017). Particularly in developing countries, this perception encourages deviant practices (e.g., destruction of community green spaces, indiscriminate waste disposal) that threaten neighbourhood walkability.

Deductively, individuals must be responsible for the walkability and sustainability of their neighbourhoods. This being so, their pro-environment behaviour (PEB) must be encouraged and maximized through public education. PEB is a conscious action people take to minimize the negative impact of their activities on the environment (Liu et al., 2014). Pro-environment behaviours include environment-friendly actions (e.g., avoiding single-use plastics, adopting proper waste disposal methods) that preserve neighbourhood green spaces and parks. Another form of PEB is Socially Responsible Consumption (SRC), which considers the environmental consequences of private consumption and seeks to minimize the damage of environmental resources while maximizing long-term benefits to society (Webb et al., 2008). The extant literature suggests that PEB and SRC are complementary behaviours that contribute to neighbourhood walkability (Opuni et al., 2022; Liu et al., 2014; Kwon et al., 2017; Xue et al., 2020). Though individuals and their communities do not have budgetary or political power to directly change local development plans or urban design, these behaviours can help preserve walkable neighbourhood attributes. For example, pro-environment behaviours (e.g., cleaning, environmental sanitation practices) contribute to sanitation (a component of walkability) and can preserve parks and green space (Asiamah et al., 2021; Kwon et al., 2017).

Recent calls to action have revealed a need for health promotion to emphasize the role of the individual in neighbourhood walkability improvement (Opuni et al., 2022; Kwon et al., 2017; McCormack et al., 2020; Asiamah et al., 2021). We reason that PEB and SRC are potentially the ultimate ways individuals can play this role, especially in developing African countries with the lowest neighbourhood walkability and pro-environment interventions (Asiamah et al., 2021; Asiamah et al., 2021). We, therefore, respond to the above call by investigating whether PEB and SRC can moderate the association between perceived walkability and neighbourhood-level social activity. We hereby define social activity as the degree of participation in events or activities in the community with others (Asiamah et al., 2020). Some of the activities are participating in voluntary work as well as community events, and visiting places with social network members. According to Van Holle et al. (2016), these activities are encouraged by the neighbourhood social environment characterised by but not limited to community attractiveness (e.g., greenspace, safety), street connectivity, and availability of social networks. These neighbourhood social factors are a core part of walkability and would, therefore, encourage social activity. Participating in the above social activities, which are included in the scale used to measure social activity in this study, also contributes to optimal health and quality of life (Frank et al., 2010; Asiamah et al., 2020). As such, studies on the role of walkability and pro-environment behaviors in social activity could provide key implications for health behavior and public health improvement.

By treating neighbourhood social activity as a response variable to neighbourhood walkability in this study, we do not only demonstrate the potential role of pro-environment behaviours in improving or sustaining neighbourhood walkability but also evidence how pro-environment behaviours can encourage social activity by preserving neighbourhood walkability. This is the first study investigating whether pro-environment behaviors can modify the association between perceived walkability and social activity. It could set the foundation for a potential intervention (i.e., a longitudinal study) and provides implications for health promotion with its nuanced sensitivity analysis. The three research questions expected to be addressed in this study are: (1) does perceived walkability have a significant relationship with social activity; (2) is the relationship between perceived walkability and social activity moderated by PEB, and (3) is the relationship between perceived walkability and social activity moderated by SRC?

1.1. Theoretical framework

Some P-E fit models serve as a lens for seeing and understanding the role of the environment in health-seeking behaviours and health. Two relevant examples are Lawton's (1989) docility-proactivity paradigm and the life-space theory of Cantor (1975). Lawton's framework argues that behaviours such as social activity in the neighbourhood are facilitated or encouraged by contextual attributes (e.g., services, sidewalks, destinations) inherent in walkability. Similarly, Cantor's model premises that the availability of the foregoing built-environment attributes in vantage locations of the neighbourhood encourages social activities through active modes of transportation such as walking, skating, and bicycling. Supporting these theories are empirical studies that have confirmed a positive association between walkability and social activity (Matsumoto et al., 2022; Asiamah et al., 2020, 2021). Studies (Koohsari et al., 2018; Kwon et al., 2017; Matsumoto et al., 2022) also recognise that the social inclusiveness of neighbourhoods can be enhanced by making communities more walkable. These frameworks, thus, imply that social activity would be higher in more walkable neighbourhoods. These pieces of empirical and anecdotal evidence form the basis of the primary relationship tested, which is a positive association between perceived walkability and social activity.

PEB and SRC are voluntary behaviours that can be informed by factors recognized by the theory of planned behaviour (TPB) as determinants of human actions. The TPB was proposed by Ajzen (1985) to explain the motivators of behaviour. It explains that *behavioural control* and *subjective norms* are two important factors that determine whether an individual can or will perform a behaviour such as PEB or SRC. Behavioural control is analogous to the individual's self-efficacy and the capability to perform a task whereas subjective norms constitute the approval of behaviour by others. Commentators (Xue et al., 2020; Opuni et al., 2022) have averred that people would perform PEB and SRC due to their behavioural control (i.e., willingness and ability) and the recognition of these behaviours as approved ways to protect the environment (e.g., subjective norms). For example, people may avoid single-use plastics in response to campaigns emphasizing the detrimental impacts of these materials (e.g., poor sanitation) on the neighbourhoods. We argue that people who perform this and similar behaviours (including those used as indicators of the scales used to measure SRC and PEB in this study) influence the walkability of their communities. Their influence on their neighbourhoods is characterised by their contribution to the provision, maintenance, or preservation of important domains of walkability, including those within the scale used to measure walkability in this study.

Further to the above, users of products with packs that are recyclable or biodegradable (a form of SRC) may contribute to a neat neighbourhood as these packs do not remain in the community as waste or debris. People who plant gardens or participate in community cleaning (forms of PEB) enhance neighbourhood greenspace. These pro-environment behaviours and similar behaviours that are part of the scale used to measure pro-environment behaviours in this study preserve or enhance walkability attributes. In most contexts, residents do not need the permission of governments and policymakers to perform these behaviours; these behaviours are rather encouraged because of their desired impact on the environment (Xue et al., 2020; Opuni et al., 2022). More so, people choose environment-friendly products, plant backyard gardens, and perform related behaviours at will, except in contexts where these behaviours flout national laws. On the other hand, anti-environment behaviours (e.g., irresponsible dumping of waste, consumption of products packed in single-use plastics) can make highly walkable neighbourhoods provided by governments less walkable as these plastics litter the community and, therefore, reduce the attractiveness of the neighbourhood, regardless of whether it is highly walkable. Services, which are a core part of walkability (Sallis et al., 2010), are unlikely to be patronised or provided in communities where sanitation is low and other walkability factors (e.g., lorry parks, streets) are inaccessible (Wey and Chiu, 2013; Opuni et al., 2022). Therefore, walkability would be higher in communities where more people perform environment-friendly behaviours that provide or maintain factors (e.g., sanitation, greenery) that are inherent of walkability or encourage the creation or provision of services (a component of walkability) (Opuni et al., 2022).

The moderating roles of SRC and PEB assessed in this study characterise the potential positive influence of the interaction between these behaviours and perceived walkability on social activity. This interaction connotes that perceived walkability and its potential influence on social activity would be higher as these behaviours increase among residents. Suffice it to say that social activity may be higher in communities where residents' pro-environment actions (i.e., SRC and PEB) contribute to high perceived walkability. The motivation to perform social activities in the community could come from higher walkability facilitated or maintained through SRC and PEB. Finally, we recognise differences in the psychometric structure of perceived walkability scales as well as the methodologies used to validate these scales. For instance, the version of perceived walkability used in this study is a shorter version comprising fewer

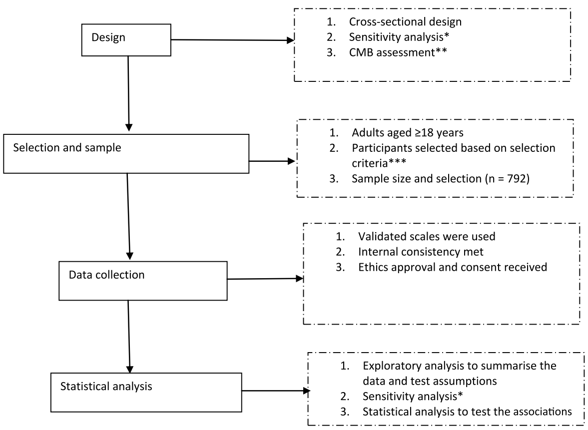

Fig. 1. A flowchart of the study design.

indicators of the key domains of walkability (e.g., street connectivity, mixed land use, parks, sanitation, aesthetics) and is easier to complete (Asiamah et al., 2021). Other extended scales measure similar domains of walkability but with more items (Cerin et al., 2019; Frank et al., 2010; Sallis et al., 2010). These differences imply that the strength of the foregoing associations may differ between walkability scales and contexts.

2. Materials and methods

2.1. Study design

This study adopted a cross-sectional (correlational) design with sensitivity analysis and recommended procedures against common methods bias (CMB). Fig. 1 is a flowchart of the study design.

2.2. Study setting, sample and selection

The study participants were residents of Ablekuma North Municipality, Ghana. Ablekuma North Municipality is a cosmopolitan suburb of Accra, Ghana's capital city, covers an area of 11 km^2, and has a population density of 14,000/km^2 as well as a population of 159,208 (Anderson and Fridy, 2022; Codjoe and Afuduo, 2015). It, thus, constitutes about 6% of the area covered by Accra. Like most areas of Accra, this municipality is urban and characterizes urban design attributes such as tarred roads, streets, and residential facilities (e.g., markets, supermarkets, parks) for middle-income residents who constitute most of the population. The population of the area is generally young like the rest of Ghana (Mba, 2010) and has a median age of about 26 years (Anderson and Fridy, 2022). Like other municipalities in Accra, Ablekuma North Municipality receives a priority developmental budget aimed to improved its roads and amenities. This municipality was chosen because it provided access to participants from different tribes with low, moderate, and high socioeconomic statuses. Participants were selected at supermarkets, community centres, and parks where residents regularly commuted.

Two research assistants used a screening questionnaire to select eligible participants who met the following inclusion criteria: (1) having lived in the chosen community for at least a year; (2) not having any health condition that precluded independent walking; (3) having a minimum of a basic educational qualification (i.e., basic education certificate), which we used as an indicator of the ability to complete questionnaires in English, and (4) willingness to participate in the study voluntarily. We applied the first criterion to ensure that only residents who have had enough experience with the chosen neighbourhood participated in the study. A total of 902 individuals were selected. Before the participants were selected, we used the G*Power 3.1.9.4 software to calculate the minimum sample size required for the study. With relevant statistics (i.e., effect size = 0.18, power = 0.8, $\alpha = 0.05$) from Asiamah et al. (2021), this tool was used to reach a sample of 100. We gathered data on all selected participants to maximize generalizability.

2.3. Variables and measurement

The main variables of this study are social activity, neighbourhood walkability, and pro-environmental variables (i.e., PEB and SRC). Social activity was measured using the 8-item neighbourhood social activity scale associated with three descriptive anchors (i.e., *not at all (1), sometimes (3), and always (3)*). This tool measures the frequency of social activities (i.e., helping others, making new friends) performed by the individual in the neighbourhood and was preferred because it recently produced satisfactory validity and reliability indicators in some Ghanaian samples (Asiamah et al., 2020, 2021). Since all scales used were previously validated, we used only the Cronbach's α at a threshold of $p \leq 0.7$ to assess the internal consistency of the scales (Taber, 2018). Social activity produced a Cronbach's $\alpha = 0.75$, which confirmed its internal consistency. Items of this scale are shown in Appendix A. Neighbourhood walkability was measured with the Australian version of the Neighbourhood Environment Walkability Scale (NEWS-AU) with five descriptive anchors (i.e., *1 = strongly disagree; 2 = disagree; 3 = somewhat agree; 4 = agree, and 5 = strongly agree*). This 11-item tool was transferrable to Ghana because it comprises elementary walkability factors available in all urban settings, produced satisfactory psychometric properties in Ghanaian samples (Asiamah et al., 2021), and is easy to complete. Other NEWS versions are relatively long and previously produced low response rates (Asiamah et al., 2021). In the current study, it produced a satisfactory Cronbach's $\alpha = 0.76$. Appendix B shows items of NEWS-AU used in this study. SRC was measured using a 21-item tool with the same descriptive anchors as neighbourhood walkability. This measure was wholly adopted from Syed and Shanmugam (2020) for its satisfactory psychometric properties. In the current study, it produced a Cronbach's $\alpha = 0.93$. Appendix C shows items of the foregoing scale. PEB was measured with the 12-item scale with five descriptive anchors (i.e., *never – 1, rarely – 2, sometimes – 3, often – 4, and very often – 5*) adopted in whole from Lange and Dewitte (2021). Its Cronbach's alpha in the current study was 0.9. Appendix D shows the scale used to measure PEB.

2.4. Identification and measurement of confounding variables

A confounding variable is a variable that influences the independent variable or predictor (which is neighbourhood walkability in this study) and, therefore, increases or decreases the strength of the relationship between the independent variable and the dependent variable (Asiamah et al., 2019). Thus, possible correlates of neighbourhood walkability were the potential confounding variables in this study. Lewin's (1951) P-E fit theory posits that personal factors such as income, education, and sex are associated with the neighbourhood where the individual lives. Supporting this idea is research that has shown that personal factors such as individual income determine or can be associated with where people live; people with high income can decide to live in high socio-economic areas where walkability is higher (Koohsari et al., 2018; Wahl and Gerstorf, 2020; Asiamah, 2017). This fact recalls the concept of selective mobility or selective residential choice, which concerns the possibility of people with the requisite potential (e.g., having enough financial resources) choosing to live in some more privileged neighborhoods such as high socio-economic areas. Recent studies have also evidenced that gender, education, income, chronic disease status (CDS), physical factional ability, employment status, and age are significantly associated with neighbourhood walkability (Asiamah et al., 2020, 2021), which means that these personal factors can confound the primary relationships assessed in this study. These personal variables were, therefore, measured as potential confounders in this study.

Income was measured as the gross monthly salary of the individual in Ghana cedis. Physical function was measured with a single item from Asiamah et al. (2021); this item asked the participants to rate their ability to perform physical tasks (e.g., lifting a bucket of water unaided) on a 4-point descriptive anchor (i.e., not at all – 1; low extent – 2; moderate extent – 3, high extent – 4). CDS was measured by asking participants to report their clinically diagnosed chronic conditions such as diabetes, and hypertension. This variable was dichotomized as follows: *none* (i.e., those with no chronic condition) and *one or more* (i.e., those with at least one chronic condition). Education was measured as the highest level of formal education acquired by the individual. CDS (i.e., none versus one or more), gender (i.e., male versus female), education, and employment (i.e., employed versus not employed) were measured as categorical variables, which were dummy coded in data analysis.

2.5. Survey instrument and steps against common methods bias

Two survey instruments were used. The first tool comprised six questions and was used by research assistants to recruit participants within the chosen community. The second instrument was a self-reported questionnaire used to collect the main data of this study. This tool had two main sections; the first section presented demographic and potential confounding variables while the second section presented scales measuring social activity, neighbourhood walkability, PEB, and SRC. An introductory section that presented the purpose of the study, ethics statement, selection criteria, and survey completion instructions was provided before these two sections. We followed two recommended and previously used steps to avoid or minimize CMB (Jordan and Troth, 2020; Asiamah et al., 2021). The first step concerned a non-statistical procedure in which we presented the main measures (i.e., social activity, neighbourhood walkability, PEB, SRC) in different blocks of information. Blocks containing the main variables were separated with preambles introducing the measurement scales. The second step is a statistical technique called Herman's one-factor method that evidences the absence of CMB if it produces two or more factors on each scale with exploratory factor analysis (Jordan and Troth, 2020). An exploratory factor analysis (with principal axis factoring) on the four measurement scales produced more than one factor for each scale as follows: social activity – 3 factors; PEB – 2 factors; SRC – 4 factors, and neighbourhood walkability – 3 factors. Items of factors associated with these four variables produced factor loadings $\geq$0.5. Thus, CMB was not an issue in this study.

2.6. Data collection procedure

This study was approved by an institutional review committee in Accra (001-ACE-2021) after all participants provided informed consent to participate in this study. We carried out two phases of data collection with the support of research assistants and private couriers. In the first phase, research assistants used the screening tool (survey) to select participants and collect their contact information. In the second phase, questionnaires in a sealed and stamped envelope were delivered to the participants through a private courier accompanied by a research assistant. The questionnaires were delivered at locations (i.e., home or office) provided by participants in the first phase of data gathering. Participants were guided by research assistants to complete the questionnaire instantly, but those who could not respond instantly were given two weeks to return completed questionnaires. Over four weeks (March 1 to April 2, 2021), participants completed and returned their questionnaires through the courier. Of the 902 questionnaires administered, 792 were analyzed; 110 questionnaires were not returned or had a major section not completed.

2.7. Statistical analysis procedure

Data were analyzed with the SPSS (Statistical Package for the Social Sciences) version 28 for Windows. Data were analyzed in three main phases, with the first phase concerned with exploratory analyses conducted to ensure that hierarchical linear regression (HLR) analysis could be used. Eleven (11) questionnaires that had missing data were not removed because their missing data were less than 10% and were randomly distributed (Madley-Dowd et al., 2019). Estimates of kurtosis and skewness produced satisfactory scores (i.e., kurtosis = −0.13; skewness = −0.28) recommended by Garson (2012). Stem and leaf plots also evidenced the absence of outliers in the data. The Kolmogorov-Smirnov test revealed non-normality of the data ($p < 0.001$; statistic = 0.13), but non-normality is not a problem at large samples such as ours (i.e., n = 792) and when no outliers are found in the data (Garson, 2012). Subsequently, we conducted a statistical analysis to find out if the primary relationships are linear or can be explained by a straight line. We plotted standardized residuals against standardized predicted values of the dependent variable in all the HLR models through which the primary relationships were tested. Our plots showed non-random patterns and, therefore, confirmed that the primary relationships could be explained with a straight line. These plots also showed a distribution of dots without a discernible (funnel-shaped) pattern and, thus, evidenced homoskedasticity, another requirement for multiple linear regression. Finally, the independence of errors and multicollinearity assumptions were respectively met with Durbin Watson statistics that are approximately 2 and tolerance $\geq$0.2 (Garson, 2012).

In the second phase, we performed a sensitivity analysis with HLR analysis to identify the ultimate confounding variables. This procedure, which has been documented in some previous studies (Rezai et al., 2009; Asiamah et al., 2021), aimed to screen for only background variables that could confound the primary relationships. In the first stage of this analysis, we fitted a univariate regression model to know the regression weight between neighbourhood walkability and social activity. We further estimated the effect sizes between potential confounding variables measured and neighbourhood walkability using a multiple linear regression model. Predictors from this model that had *p-values* >0.25 were removed from the analysis. At this stage, CDS, age, and two dummy variables (i.e., diploma, first degree) were removed. Subsequently, a multiple regression model was fitted to examine the effects of neighbourhood walkability and each of the covariates retained on social activity. Covariates that led to a 10% change in the effect of neighbourhood walkability on social activity (with reference to the model fit at stage 1) were selected as the ultimate confounding variables and were incorporated into the final analysis. The specific covariates selected are physical function and employment status.

At phase 3 where the main relationships were assessed, three baseline models that did not include the ultimate confounding variables were fitted. The first of these models examined the association between neighbourhood walkability and social activity, the second assessed the moderating role of SRC on the association between neighbourhood walkability and social activity, and the third evaluated the moderating role of PEB on the relationship between neighbourhood walkability and social activity. Further to this, we fitted the ultimate models by incorporating the ultimate confounding variables into each of the three baseline models. The ultimate models served as the source of findings on which conclusions in this study are based. To assess the moderating roles of interest, two interaction terms were computed in SPSS, namely the interaction between neighbourhood walkability and PEB (i.e., NW*PEB) and the interaction between neighbourhood walkability and SRC (i.e., NW*SRC). The relationship between these terms and social activity was then evaluated in the second and third models (i.e., baseline and ultimate models). Our analysis focused on *pure moderation* (Asiamah et al., 2021) as we were interested in only how the influence of neighbourhood walkability on social activity was affected by the pro-environment behaviours. Statistical significance of the results was detected at $p < 0.05$.

Table 1
Summary statistics on key variables (n = 792).

Name	Group[a]/Maximum[b]	Frequency[a]/Mean[b]	Percent (%)[a]/SD[b]
Categorical variables			
Gender	Male	378	47.70
	Female	414	52.30
	Total	792	100.00
Education	Basic/secondary	132	16.70
	Diploma	330	41.70
	First degree	234	29.50
	Master's degree	54	6.80
	PhD or equivalent	30	3.80
	Missing	12	1.50
	Total	792	100.00
Income (GhC)	<500	168	21.20
	501-1000	312	39.40
	1001–1500	120	15.20
	1501–2000	84	10.60
	2001–2500	42	5.30
	2501–3000	30	3.80
	3001–3500	30	3.80
	Missing	6	0.80
	Total	792	100.00
Employment status	Not employed	228	28.80
	Employed	546	68.90
	Missing	18	2.30
	Total	792	100.00
Chronic disease status	None	684	86.40
	1+	108	13.60
	Total	792	100.00
Continuous variables			
Physical function	4	2.87	1.08
Age (yrs)	68	31.20	11.39
SRC	105	70.81	13.53
Pro-environmental Behavior	55	36.07	10.66
Neighbourhood Walkability	50	34.89	6.27
Social Activity	24	17.63	2.96

—Not applicable; SRC – socially responsible consumption.
SD – standard deviation.
[a] for categorical variables.
[b] for continuous variables.

2.8. Findings

2.8.1. Summary statistics and sensitivity analyses

Table 1 shows the summary statistics on relevant variables. About 48% (n = 378) of the participants were men, whereas about 52% (n = 414) were women. The average age of the participants was about 31 years while the average social activity was about 18 (Mean = 17.63; SD = 2.96). Summary statistics on other variables are shown in Table 1. In Table 2, the crude regression weight between neighbourhood walkability and social activity is about 0.19 (β = 0.188; t = 5.37; p = 0.000). CDS, age, and two dummy variables on education (i.e., diploma, and first degree) were removed in the first stage of the analysis based on criteria established earlier in this paper. Gender, the remaining dummy variables on education (i.e., master's degree, PhD or equivalent), and all dummy variables on income (e.g., 501_1000; 1001_1500) were removed in the second stage. So, only physical function, and employment status were incorporated into the ultimate models as the ultimate confounding variables.

2.9. The main findings of the study

Table 3 shows Pearson's correlation matrix of the relevant variables. There is a positive correlation between neighbourhood walkability and social activity (r = 0.188; p = 0.000; two-tailed). This result means that higher neighbourhood walkability is associated with larger scores of social activity. A positive correlation between neighbourhood walkability and each of pro-environment behavior (r = 0.16; p = 0.000; two-tailed) and SRC (r = 0.332; p = 0.000; two-tailed) was also found. Table 3 shows other relevant correlations that form the basis of the HRL regression results. In Table 4 (first ultimate model), neighbourhood walkability has a positive association with social activity after controlling for physical function and employment status (β = 0.2; t = 5.45; p = 0.000). In the second ultimate model, the interaction between neighbourhood walkability and SRC has a positive association with social activity (β = 0.21; t = 5.88; p = 0.000), while the interaction term between neighbourhood walkability and pro-environment behaviour in the second ultimate model has a positive association with social activity (β = 0.41; t = 11.89; p = 0.000). In the second and third ultimate models, the regression weights are larger compared to the first ultimate model, suggesting that the two pro-environment variables enhanced the strength of the association between neighbourhood walkability and social activity.

Worth noting is the difference between the baseline and ultimate models; the regression weights differ between these models, suggesting that the ultimate weights (i.e., β coefficients in the ultimate models) would have been over or under-estimated without controlling for the confounding variables. Table 4 also shows Durbin Watson values that are approximately 2 as recommended in the literature (Garson, 2012), which implies that the independence of errors assumption is met. The tolerance values of the predictors also meet the criterion *tolerance* ≥ 0.2 as recommended (Garson, 2012), implying that the multi-collinearity assumption is also met. The significance of the F-test of each model at $p < 0.001$ indicates that all models were good. Figs. 1 and 2 show the strengths of the relationship between social activity and the interaction terms, which have been dummy-coded into two groups (i.e., low, and high). In Fig. 2, the group "low" produced a smaller variance compared to "high", which reflects the relatively weak state of the moderating influence of SRC. The contrast of this is seen in Fig. 3, suggesting that PEB more strongly moderates the primary relationship.

3. Discussion

This study assessed the association between neighbourhood walkability and social activity as well as the moderating influences of

Table 2
Key statistics from the sensitivity analyses (n = 792).

Independent variable	Stage 1			Stage 2		
	β	*T*	p	Adjusted β	Change in β	% Change in β
Neighbourhood walkability	0.188	5.368	0.000	–	–	–
Male (reference – female)[b]	−0.098	−2.452	0.015	0.185	−0.003	−2%
Physical function	−0.150	−3.495	0.001	0.170	−0.018	−10%
Employed (reference – not employed)	0.167	2.968	0.003	0.211	0.023	12%
CDS (reference – none)[a]	0.025	0.473	0.637	–	–	–
Age (yrs)[a]	−0.063	−1.110	0.268	–	–	–
Diploma (reference – basic/secondary)[a]	0.069	0.432	0.666	–	–	–
First degree (reference – basic/secondary)[a]	0.024	0.158	0.875	–	–	–
Master's degree (reference – basic/secondary)[b]	0.125	1.250	0.212	0.193	0.005	3%
Phd or equivalent (reference – basic/secondary)[b]	0.350	3.947	0.000	0.191	0.003	2%
501_1000 (reference – <500)[b]	0.574	4.353	0.000	0.181	−0.007	−4%
1001_1500 (reference – <500)[b]	0.497	4.800	0.000	0.191	0.003	2%
1501_2000(reference – <500)[b]	0.482	5.122	0.000	0.172	−0.019	−8%
2001_2500(reference – <500)[b]	0.188	2.814	0.005	0.190	0.002	1%
3001_3500 (reference – <500)[b]	0.098	1.751	0.081	0.188	0.000	0%

— Not applicable; Dependent variable for neighbourhood walkability in stage 1 is social activity; Dependent variable for potential confounding variables at stage 2 is neighbourhood walkability; CDS – chronic disease status.

[a] Removed in stage 1.

[b] Variable removed at stage 2.

Table 3
Pearson's correlation between relevant variables (n = 792).

Variable	#	1	2	3	4	5	6
Neighbourhood Walkability	1	1	.188**	.160**	.332**	−.217**	−0.042
Social Activity	2		1	.388**	.139**	−.106**	−.072*
Pro-environmental Behavior	3			1	−0.004	−.168**	0.032
SRC	4				1	0.003	−0.037
Physical function	5					1	.182**
Employed (reference – not employed)	6						1

**p < 0.001; *p < 0.05; SRC – socially responsible consumption.

Table 4
The association between neighbourhood walkability, social activity, and pro-environment behaviours (n = 792).

Model	Predictor	Regression Weights			95% CI	Tolerance	Model fit			
		B	SE	β(t)			R^2	Adjusted R^2	Durbin Watson	F
Baseline 1	(Constant)	14.54	0.59	(24.85)**	±2.30	–	0.035	0.030	–	28.81**
	Neighbourhood Walkability	0.09	0.02	0.19(5.37)**	±0.07	–				
Ultimate 1	(Constant)	15.15	0.73	(20.89)**	±2.85	–	0.050	0.049	1.79	13.83**
	Neighbourhood Walkability	0.09	0.02	0.20(5.45)**	±0.07	0.96				
	Physical function	−0.18	0.10	−0.07 (-1.79)	±0.40	0.93				
	Employed (reference – not employed)	−0.29	0.23	−0.04 (-1.23)	±0.92	0.97				
Baseline 2	(Constant)	15.76	0.36	(44.16)**	±1.40	–	0.037	0.035	–	30.03**
	NW*SRC	0.00	0.00	0.19(5.48)**	±0.00	–				
Ultimate 2	(Constant)	16.47	0.50	(33.26)**	±1.94	–	0.058	0.054	1.96	15.47**
	NW*SRC	0.00	0.00	0.21(5.88)**	±0.00	0.99				
	Physical function	−0.23	0.10	−0.08 (-2.34)*	±0.39	0.96				
	Employed (reference – not employed)	−0.26	0.23	−0.04 (-1.13)	±0.92	0.97				
Baseline 3	(Constant)	14.41	0.27	(53.03)**	±1.07	–	0.169	0.168	–	160.66**
	NW*PEB	0.00	0.00	0.41(12.68)**	±0.00	–				
Ultimate 3	(Constant)	14.81	0.44	(33.46)**	±1.74	–	0.170	0.166	1.69	51.64**
	NW*PEB	0.00	0.00	0.41(11.89)**	±0.00	0.94				
	Physical function	−0.02	0.10	−0.01 (-0.21)	±0.37	0.91				
	Employed (reference – not employed)	−0.47	0.22	−0.07 (-2.13)	±0.86	0.96				

**p < 0.001; *p < 0.05.
¯Not applicable; SE – standard error (of B); CI – confidence interval (of B); SRC – socially responsible consumption; NW – neighbourhood walkability; PEB – pro-environment behaviour.

pro-environment behaviours (i.e., PEB and SRC) on this relationship. The results of data analysis produced a positive association between neighbourhood walkability and social activity, suggesting that higher social activity was associated with higher neighbourhood walkability characterized by street connectivity, high residential density, and mixed land use (i.e., commercial and residential uses). On the one hand, this result is consistent with landmark P-E fit theories, specifically Lawton's (1989) docility-proactivity paradigm and the life-space theory of Cantor (1975). In harmony with our result, Lawton's model contends that behaviours such as social activity in the neighbourhood are facilitated by contextual resources that form the core of neighbourhood walkability (e.g., services, sidewalks, destinations). Cantor's concept better aligns with the foregoing result as it posits that walking and other social activities in the community are encouraged by walkable factors such as services, destinations, parks, and green spaces. On the other hand, our result is supported by several studies conducted around the world.

In Ghana, Asiamah et al. (2021) found that neighbourhood walkability in a sample of seniors is positively associated with social activity. Some studies (Sundquist et al., 2011; Chudyk et al., 2017) conducted in Sweden and Canada have also a positive association between walkability and physical activities (i.e., walking) facilitating community-level social interactions. Since physical activities performed in these studies are the means by which people maintain social activity (Asiamah et al., 2020), their association with walkability could signify a relationship between walkability and social activity. As mentioned earlier, social activity over the life

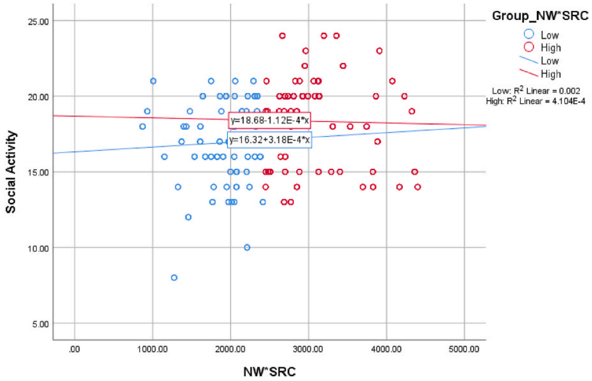

Fig. 2. The association between social activity and the interaction between neighbourhood walkability and SRC (n = 792; low = 396; high = 396).

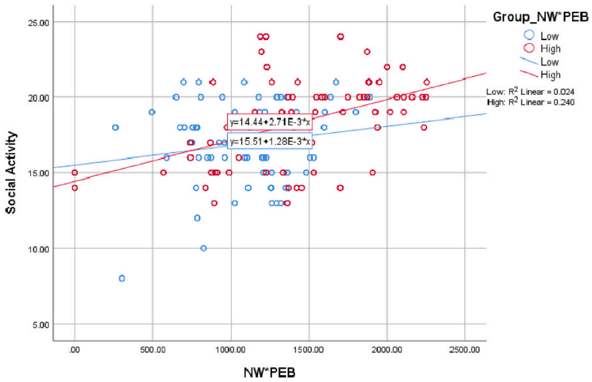

Fig. 3. The association between social activity and the interaction between neighbourhood walkability and pro-environment behaviour (n = 792; low = 396; high = 396).

course protects health (including mental health) and benefits quality of life (Frank et al., 2010; Van Holle et al., 2016); hence, the positive relationship between walkability and social activity in this study implies that improving walkability can benefit individual mental and physical health. Similarly, walkable communities better enable individuals to maintain social resources (e.g., social connections) that contribute to social activity as well as mental and physical health (Matsumoto et al., 2022; Asiamah et al., 2020).

Furthermore, the relationship between neighbourhood walkability and social activity found in this study was positively moderated by SRC, which implies that the relationship between neighbourhood walkability and social activity is stronger at higher SRC. To explain, SRC discourages the consumption of products and services (e.g., single-use plastics) that pollute parks, gardens, and spaces meant for social inclusion; people reporting high SRC would prefer services or products that are recycled, eco-friendly, and easily removed from public spaces (Seyfang, 2006). From another perspective, SRC represents consumption among residents that would encourage the provision of new services (Seyfang, 2006; Syed and Shanmugam, 2020). The high financial performance of service providers due to SRC would attract other businesses into the neighbourhood, which would, in turn, increase the mix of services available to residents. An increase in neighbourhood services would encourage stakeholders (i.e., governments, civil society) to develop community infrastructure (e.g., parks, sidewalks, roads, streets) that form the core of neighbourhood walkability (Wu et al., 2020; Xue et al., 2020). Commentators (Grant et al., 2010; Asiamah et al., 2021) have argued that neighbourhood infrastructure or walkability is enhanced as more services are introduced in the community because service providers contribute to the creation of a sustainable built environment or encourage the government to implement pro-environment interventions.

This study further affirmed the moderating influence of PEB on the association between neighbourhood walkability and social activity, which connotes that neighbourhood walkability has a stronger association with social activity among those who reported higher PEB. This finding is consistent with the reasoning that environment-friendly behaviours that preserve or revive built environment attributes would strengthen the influence of the neighbourhood on health behaviours, including social activity. As expected, PEB has a stronger moderating influence on the relationship between neighbourhood walkability and social activity. One of the reasons for this difference is that PEB is an embodiment of environment-friendly actions from residents that span consumption, volunteering, and advocacy (Liu et al., 2014; Moghimehfar et al., 2017; Xue et al., 2020). While SRC indirectly contributes to neighbourhood walkability through only consumption, PEB constitutes conscious efforts made to impact the community. These efforts include conserving gasoline by walking or bicycling, the use of acceptable waste disposal methods, planting of orchards and gardens that improve neighbourhood greenery, and taking part in routine community cleaning programs. Walking and bicycling preserves neighbourhood air quality, planning of orchards and gardens adds to neighbourhood greenery, and cleaning of the community results in sanitation. Since neighbourhood air quality, greenery, and sanitation are a key component of walkability that encourage walking (Koohsari et al., 2018; Sallis et al., 2010), the foregoing efforts are expected to increase walkability, serving as the basis of the above confirmed moderating role.

Our results have key theoretical and practical implications. Our confirmation of the moderating roles of SRC and PEB lends support to the TPB. This theory argues that actions taken by people are motivated by the perceived benefits of the actions. From this perspective, the moderating roles imply that residents who are aware of the importance and benefits of environmental sustainability would inculcate environment-friendly behaviours. Thus, the TPB explains why pro-environment behaviours are probable in any context and why campaigns encouraging these behaviours can be fruitful, at least by preserving walkable attributes in the community. This idea brings to mind the practical implications of this study, which include a need for stakeholders including researchers to initiate and progress a program of health promotion focused on conscientizing residents to pursue pro-environment behaviours. Drawing on the TPB, it is understandable that these campaigns can lead to a desired behavioural change tied to people's willingness to act to protect and preserve built environment resources. Particularly in a time of climate change when many communities and people are experiencing extreme events, these campaigns can encourage people to play a role in environmental sustainability programs and to see neighbourhood improvement as a responsibility of all stakeholders, including residents. This being so, researchers in the field of environmental health and architecture ought to build a discourse regarding how pro-environment behaviours among individuals can be encouraged as a strategic way to make the creation of walkable neighbourhoods more effective, especially in developing countries where politicians are less interested in neighbourhood walkability improvement programs (Singh, 2016; Asiamah, 2017; Asiamah et al., 2021). This study provides an important objective for future research and sets the foundation for the aforementioned discourse.

We would want to admit that this study has some limitations. The most noteworthy ones are our utilization of a sample from Ablekuma North, Accra, Ghana, and our use of a non-probability sampling approach. Consequently, our results may have limited generalizability and application in other contexts. The association between perceived walkability and social activity could be influenced by residential self-selection since people, especially those with high income, would choose to live in highly walkable neighborhoods if they knew walkable communities are more suitable for social activity (Van Dyck et al., 2011). These people are more likely to perform pro-environment behaviors owing to their awareness of the role of walkability in social activities. Our inability to consider residential self-selection as a potential moderator is, therefore, a limitation.

We utilized subjective measures of walkability instead of objective measures [e.g., measuring walkability with GIS (Geographic Information Systems)], which means our data on walkability could have been biased. Moreover, this study adopted a cross-sectional approach and, therefore, does not establish cause and effect between the variables. For the above reasons, the replication of this study in other settings and the application of more robust designs (e.g., experimental designs) is imperative. Social distancing measures taking in response to the Coronavirus disease 2019 (COVID-19) may have affected this study's social activity ratings; participants possibly reported lower scores due to their compliance with COVID-19 social distancing measures. Macro-level built environment attributes such as net residential density, intersection density, and retail floor to land area ration could confound the relationships tested, but this variables could not be measured in this studies and were, therefore, not considered. Future researchers are encouraged to consider these variables as potential confounders. Finally, social activity was measured and analyzed as a unidimensional construct, so this study could not show the specific items of social activity that correlated with walkability and the interaction terms (i.e., NW*SRC, NW*PEB).

Despite the above limitations, this study is the first to discuss how pro-environment behaviours can affect the influence of walkable neighbourhoods on healthy behaviours such as social activity. It, thus, sets the foundation for a major debate that would eventually define and conceptualize the role of individuals in the improvement of walkable neighbourhoods. Moreover, it employed methods that reduced the risk of bias associated with the cross-sectional design. For instance, our sensitivity analysis, though hardly employed by cross-sectional researchers (Asiamah et al., 2019), is recognized by the STROBE (i.e., Strengthening the Reporting of Observational Studies in Epidemiology) checklist as a necessary part of observational studies (Da Costa et al., 2011). Our application of this technique and measures against CMB maximizes the statistical validity of our results. These techniques would serve as a model for future cross-sectional studies.

4. Conclusion

High social activity is associated with larger scores of neighbourhood walkability, which implies that social activity is higher in more walkable neighbourhoods in the study area. The two pro-environment behaviours (i.e., SRC and PEB) positively moderate the foregoing relationship between neighbourhood walkability and social activity. This is to say that neighbourhood walkability is more positively associated with social activity among residents who reported larger SRC and PEB scores. PEB, compared to SRC, produces a more compelling moderating influence on the relationship between neighbourhood walkability and social activity as it increased the strength of the relationship between neighbourhood walkability and social activity by about 51%. Given these findings, health, and public education campaigns conscientizing residents to inculcate pro-environment behaviours or make environment-friendly consumption choices would benefit neighbourhood walkability. This study also emphasizes a need for residents to perform pro-environment behaviors by regularly participating in community cleaning events, using products that produce less waste, maintaining gardens and green spaces owned by them, and patronizing businesses that fund sustainability projects in their communities. Being the first to examine whether the relationship between perceived walkability and social activity is moderated by pro-environment behaviors, this study may inform future research utilizing stronger designs and methods. The measurement of walkability using objective methods (e.g., GIS-based measurement) is a potential way future research can advance this study. Future studies may also replace social activity (the dependent variable) with objectively measured physical activity.

Author contributions

ED conceived the research idea, partly provided funds for the study, and coordinated data gathering. NA wrote the original manuscript whereas FFO, ECO, and CKR critically reviewed the manuscript. All authors proofread and approved the draft manuscript.

Ethical statement

This study was approved by an institutional review committee in Accra after all participants provided informed consent to participate in this study. The ethics review number is 001-ACE-2019.

Financial disclosure

The authors did not receive funding for this study.

Declaration of competing interest

The authors declared no conflicts of interest.

Data availability

Data will be made available on request.

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Appendix A. Items used to measure social activity

No.	Item	Not at all	Sometimes	Always
1	Interact with friends			
2	Play games e.g. Ludo, Oware, etc.			
3	Go to an organised event e.g. cinema, sports, drama, etc.			
4	Provide help to a family, friend, etc.			
5	Cater for the sick or a disabled person			
6	Make new friends			
7	Participate in community-related events e.g. cleaning			
8	Participate in charity or voluntary work			

Source: Asiamah et al. (2021).

Appendix B. Items used to measure neighbourhood walkability

#	Statement	1	2	3	4	5
1	Many places are easy to go within walking distance					
2	It is easy to walk to a public transport stop					
3	There are footpaths on most of the streets					
4	There are crosswalks and pedestrian signals					
5	The streets in my neighbourhood are not hilly					
6	Walkers in my neighbourhood can easily be seen					
7	There is lots of greenery around my neighbourhood					
8	There are many interesting things to look at					
9	There is not much traffic along nearby streets					
10	My neighbourhood has parks and walking trails					
11	Crime rate in my neighbourhood is not a problem					

Note: *1 = strongly disagree; 2 = disagree; 3 = somewhat agree; 4 = agree, and 5 = strongly agree.*
Source: Asiamah et al. (2021)

Appendix C. Items used to measure socially responsible consumption

#	Statement	1	2	3	4	5
1	I make an effort to support and buy from companies that promote the conservation of natural resources.					
2	I make an effort to support and buy from companies that have fair business practices.					
3	I make an effort to support and buy from companies that practice waste management and recycling.					
4	I make an effort to buy from companies that promote clean production and avoid contaminating the environment.					
5	I make an effort to support and buy from companies that hire employees who are refugees (displaced or reincorporated people) in society.					
6	I enjoy buying from companies that promote products that are beneficial to good health.					
7	I make a conscious effort to limit my use of products made from scarce resources.					
8	I enjoy buying handcrafted products as a way of supporting national labour.					
9	I make an effort to support and buy from companies that have good labour practices regarding their employees.					
10	I make an effort to buy from companies that pay fair and decent salaries.					
11	I avoid buying products from companies that exploit resources and workers from my country.					
12	I make an effort to buy from companies that hire disabled people.					
13	I avoid buying from companies that discriminate based on gender, religion or race.					
14	I make an effort to rationalize the consumption of products that seem to have contaminants (i.e., detergents, aerosols, batteries).					
15	I consume only those goods and services I need so that our resources will last longer.					
16	I make an effort to limit the consumption of gas and water in my home.					
17	I make an effort to buy energy-saving appliances.					
18	When I buy vegetables or preserved food, I worry that these may contain pesticide residue and preservatives.					
19	I avoid consuming products that are health hazards (i.e., cigarettes and alcohol).					
20	I avoid consuming in restaurants, bars or closed spaces where smoking is permitted.					
21	I avoid eating food products high in calories or saturated fats.					

Note: *1 = strongly disagree; 2 = disagree; 3 = somewhat agree; 4 = agree, and 5 = strongly agree.*
Source: Syed and Shanmugam (2020)

Appendix D. Items used to measure pro-environmental behaviour

#	Please describe how often you:	Never	Rarely	Sometimes	Often	Very often
1	looked for ways to reuse things					
2	recycled newspapers					
3	recycled cans or bottles					
4	encouraged friends or family to recycle					
5	purchased products in reusable containers					
6	picked up litter that was not your own					
7	composted food scraps					
8	conserved gasoline by walking or bicycling					
9	wrote a letter supporting an environmental issue					
10	voted for a candidate who supported environmental issues					
11	donated money to an environmental group					
12	volunteered time to help an environmental group					

Source: Lange and Dewitte (2021).

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