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Article

Interaction of perceived Chinese campus walkability and psychosocial factors on college students' walking behavior

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Abstract: Walking, a physical activity beneficial for both physical and mental health, is influenced by various factors. Although previous studies have acknowledged that walking behavior is influenced by environmental and psychosocial factors, little is known about their interactions. Based on a socio-ecological model and focusing on Chinese college students, the purpose of this study was to examine the influence of campus walkability and psychosocial factors on college students' walking behavior, including the interactions between these factors. This study seeks to enhance understanding of how to promote walking behavior through campus environmental design and psychological interventions. Multiple regression analysis was conducted on the questionnaire data. Findings revealed that campus walkability significantly influenced both walking behaviors, alongside psychosocial factors such as attitude, self-efficacy, perceived benefits, perceived barriers, and subject norms. Additionally, significant differences in interaction effects between these factors were observed for purposeful versus recreational walking behaviors. These interactions suggest that campus walkability more substantially promotes walking behavior in students with negative psychosocial factors, whereas its impact is less pronounced in those with positive psychosocial factors. The results underscore the need to focus not only on developing walkable environments but also on understanding the synergies with the psychosocial factors of target populations, offering crucial insights for campus planning and health promotion practices.

Keywords: perceived campus walkability; psychosocial factors; walking behavior; socio-ecological model; interactions

1. Introduction

Amid rapid urbanization, walking as a form of physical activity has gained prominence in public health, sustainable transport, and urban planning (Bornioli et al., 2019; Liu et al., 2022; Van Holle et al., 2015). The United Nations and the World Health Organization, through their Sustainable Development Goals and Universal Health Coverage programs, emphasize that creating pedestrian-friendly environments and promoting green mobility like walking are crucial for community cohesion, residents' well-being, and sustainable development (Sacks et al., 2020; Siqueira et al., 2021; Wang Mohan, 2019). China, home to the world's largest university student population, has observed a yearly decline in students' physical fitness and an increase in sub-health conditions, as recent surveys indicate (Wang, 2019). These study identifies insufficient physical activity, notably inadequate walking and extended sedentary behavior, as major contributors to these public health issues, aside from dietary and genetic factors (Guo et al., 2022; Li et al., 2020). Walking serves not only

as a vital mode of transportation for college students but also as an effective physical activity. Its benefits extend well beyond transportation, significantly enhancing students' overall health. Furthermore, walking profoundly impacts students' mental health, effectively alleviating stress, improving mood, and bolstering mental resilience (Harun and Nashar, 2017; Horacek et al., 2018; Mu and Lao, 2022). Walking also plays a pivotal role in advancing sustainable development on campuses. Particularly with the Chinese government's promotion of Healthy China and Healthy Campus strategies, encouraging walking among university students aligns with current trends and social needs (Du et al., 2023). Consequently, to devise effective interventions for promoting walking among university students, a thorough investigation of the key factors influencing their walking behavior is urgently needed.

Recent studies have increasingly examined the impact of built environment and psychosocial factors on walking behavior. Walkability, a key aspect of the built environment, refers to the degree to which an area facilitates walking, encompassing aspects like road connectivity, land use diversity, infrastructure, aesthetics, and traffic safety (Annunziata and Garau, 2020; Fonseca et al., 2022; Knapskog et al., 2019). The Chinese campus environment, distinguished by its defined boundaries and excellent facilities, constitutes a unique area for walking, with its walkability being closely associated with student walking behaviors (Liao et al., 2022). Empirical studies from various countries indicate a positive correlation between walkability and both purposeful and recreational walking; higher walkability is associated with increased frequency and duration of walking activities. Studies in China demonstrate that campus walkability, particularly accessibility, significantly influences purposeful walking among college students, with a more pronounced effect on weekends compared to weekdays (Liu et al., 2022). A study from Iraq, investigating the influence of campus spatial organization on pedestrian speed at university campus, identified campus layout and walkway features as key determinants of pedestrian speed (Abdullah and Al Qemaqchi, 2021). A study at a U.S. public university observed that enhanced campus walkability improves daily commuting ease, enriches students' walking experience, and increases both purposeful and recreational walking frequency (Li et al., 2018). In tropical Malaysia, research indicated that campus connectivity, accessibility, and land use significantly affected students' propensity to walk (Ramakreshnan et al., 2020). Research at European public universities also confirmed the positive relationship between purposeful walking for commuting and campus walkability among college students (Attard et al., 2021). These studies enrich our understanding of campus walkability's impact and offer valuable recommendations for improving campus walking environments.

In addition to walkability, previous research has equally emphasized the role of psychosocial factors in walking behavior (Rhodes and Dickau, 2013). Psychosocial factors encompass the social and psychological dimensions influencing behavior, like attitude, self-efficacy and subject norms. Numerous studies applying the Theory of Planned Behavior and Social Cognitive Theory have investigated the impact of attitude, subject norms, and perceived behavioral control on walking intentions and behaviors (Darker et al., 2010; Koh and Mackert, 2016; G. Sun et al., 2015). Research has indicated a significant positive correlation between self-efficacy and recreational walking, while finding no substantial relationship with purposeful and recreational

walking (Deforche et al., 2010; Dyck et al., 2011). Furthermore, employing the health belief model, researchers have explored the specific impact of self-efficacy, perceived benefits, perceived barriers, and attitudes on walking behavior (Li et al., 2019; Oreskovic et al., 2015). These studies demonstrate a positive correlation between psychosocial factors and walking behavior; generally, more positive psychosocial factors coincide with more frequent and extended walking behaviors. These findings lay the groundwork for comprehending and investigating the psychosocial factors that affect college students' walking behavior.

While existing literature extensively explores the effects of psychosocial and environmental factors on walking behavior individually, most studies have not examined them as interconnected elements. Recently, researchers have supported the adoption of a socio-ecological model to gain a more holistic understanding of walking behavior (Hu et al., 2021; Mehtälä et al., 2014). This model underscores that individual behavior stems from an interplay of multidimensional factors, encompassing personal characteristics, social environment, and physical environment (Sulikova and Brand, 2021; Yu et al., 2023). In the context of walking research, this model has clarified that walking behavior is shaped not only by individual choices and behavioral intentions but also by the crucial roles of social and environmental factors, highlighting the multidimensional interplay between the factors rather than attributing behaviors to a single factor (Cerin et al., 2008; Ding et al., 2012; Haerens et al., 2009). Numerous studies have explored these interactions, yet the precise assumptions underlying them continue to be ambiguous (Beenackers et al., 2013; D'Haese et al., 2016; Dyck et al., 2011; Gay et al., 2011; Van Dyck et al., 2014; Van Holle et al., 2015). It also illustrates the complexity of interactions between the built environment and psychosocial factors. For instance, a study found that among older Americans with negative psychosocial traits, walkability had a stronger association with recreational walking, but its effect on transportation walking was insignificant (Carlson et al., 2012). Conversely, a study involving Belgian children found no interaction between psychosocial factors and walkability in walking behavior (D'Haese et al., 2016). Furthermore, despite the socio-ecological model offering invaluable insights into walking behavior, its application in China has been limited, with a predominant focus on the physical environment (Ma et al., 2019). There is a noticeable gap in research exploring the synergistic effects of individual, social, and environmental factors (Tang et al., 2023). Additionally, while studies employing the socio-ecological model for walking research have largely concentrated on community or street environment (Wu et al., 2023; Zhu et al., 2023), investigations specifically targeting campus environment are scarce. Consequently, the preceding literature review indicates the need for further exploration into how these factors collaboratively influence walking behavior among college students on Chinese campuses. A deeper insight into the interplay between campus walkability and various psychosocial factors in influencing college students' behavior will be crucial for identifying target groups for intervention and formulating effective walking promotion strategies.

Addressing the gaps in existing research, this study was conducted based on the socio-ecological theory, with the conceptual framework showed in **Figure 1**. According to this model, both campus walkability and psychosocial factors not only directly impact walking behaviors but also influence them through their interactions. The objective is to uncover the interaction between environmental and psychosocial factors and their collective effects on college students' walking behaviors (purposeful

and recreational) among college students. Consequently, the study seeks to resolve three research questions: (1) how do campus walkability and psychosocial factors independently influence college students' walking behaviors (purposeful and recreational walking)? (2) how do campus walkability and psychosocial factors interact to influence college students' walking behaviors (purposeful and recreational walking)? (3) do the interactions of campus walkability and psychosocial factors vary in its influence on different college students' walking behaviors?

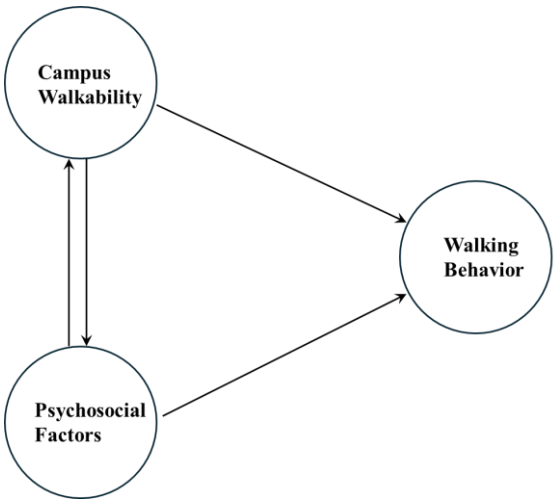

Figure 1. Conceptual framework of the relationships between campus walkability, psychosocial factors and walking behavior.

2. Materials and methods

2.1. Study site and sample

This study was conducted in Anyang City, Henan Province, China, renowned as one of China's eight ancient capitals and a center for Chinese writing. In 2022, Henan Province is expected to rank first in the country in terms of the number of undergraduate students, with a total exceeding 2.8 million (Henan Provincial Development of Education, 2023). Anyang, a principal regional center city in Henan Province, hosts two public undergraduate universities—Anyang Institute of Technology (AIT) and Anyang Normal University (ANU)—with a combined student population of approximately 60,000 (Wang et al., 2023), as shown in **Figure 2**. Anyang also holds significant educational importance in Henan Province. The study chose AIT and ANU as study sites for following reasons: Firstly, their similarities in establishment period, size, and campus settings ensure the environmental consistency necessary for logical and reliable data analysis. Secondly, with walking as the predominant transportation mode for students at both institutions, examining the influence of campus walkability and psychosocial factors on walking behavior becomes particularly pertinent. Thirdly, as Anyang's sole public undergraduate institutions, AIT, specializing in engineering and technology, and ANU, focusing on humanities and social sciences, encompass a broad spectrum of academic disciplines. This selection strategy enhances the student sample's heterogeneity. Considering these aspects, selecting AIT and ANU as study sites is both representative and justified,

enriching the exploration of how environmental and psychosocial factors affect walking behavior.

Figure 2. Location of this study.

The study's participants were current college students at two universities in Anyang City. Using a random sampling method, we selected a representative percentage of students from various colleges and grades across different university. The study's sample size was determined using Krejcie and Morgan's (1970) standard method for calculating sample sizes in finite populations, and the calculation results suggested a minimum sample size of 381 participants to achieve representative results at a 95% confidence level with a 5% margin of error (Ramakreshnan et al., 2020). In total, 796 students completed the online questionnaire. To ensure data quality, questionnaires completed in under 180 seconds, those with overly consistent responses, or containing missing values were deemed invalid. After rigorous data cleaning, a total of 687 valid responses were obtained.

2.2. Research instrument

The research instrument for this study was a questionnaire, divided into three sections to gauge perceived campus walkability, psychosocial factors, and walking behaviors. Perceived campus walkability was measured using the Chinese version of the abbreviated Neighborhood Environment Walkability Scale NEWS-A) (Cerin et al., 2007). The selection of this scale was guided by two main factors: firstly, the scale's demonstrated reliability and validity enhance the trustworthiness and accuracy of this study's outcomes (Cerin et al., 2009); secondly, its extensive use in academic research supports cross-study comparisons (Liao, Xu, et al., 2022; Measures, 2009; Sun et al., 2019; Sun, 2020). For this study, six dimensions of the scale were employed: land use mix-diversity (e.g., distance from dormitory to facilities such as library, canteen, classroom buildings; 10 items), accessibility (e.g., public transportation, sidewalk obstacles; 8 items), connectivity (e.g., amount of cul-de-sacs, four-way intersections; 3 items), infrastructure (e.g., resting facilities, routine maintenance; 9 items), aesthetics (e.g., campus landscaping, campus air quality; 6 items) and safety (e.g., speed limits, pedestrian-vehicle conflicts; 4 items). Apart from the land use mix-diversity subscale, the remaining five subscales were evaluated on a scale ranging

from strongly disagree (1) to strongly agree (5). Land use mix diversity was assessed based on the walking distance from dormitory to various facilities, with response options ranging from 1 to 5 min (5) to over 30 min (1). Higher scores indicate a greater diversity of land uses and a more convenient lifestyle. Composite scores were calculated for each dimension, then summed and standardized to derive an overall measure of perceived campus walkability (Frank et al., 2010; Kaczynski et al., 2012).

The psychosocial factors chosen for this study represent some of the most consistently observed variables linked to walking behavior, with prior research providing a thorough explanation of their relationship (Rhodes et al., 2018; Trost et al., 2002). These variables were grounded in the Theory of Planned Behavior (Godin and Kok, 1996) and Social Cognitive Theory (Bandura and Walters, 1977). This study included five dimensions: self-efficacy (e.g., confidence to do the walking when feeling over-tasked or sad; 5 items), attitude (e.g., I like to walk, walking is my habit; 4 items), perceived benefits (e.g., staying in shape, facilitating socialization, facilitating self-discipline; 7 items), perceived barriers (e.g., lack of time, lack of self-discipline, lack of companionship; 7 items), and subject norm (e.g., my friends often accompany or encourage me to walk; 4 items). All items are derived from existing questionnaires used by adults (Beenackers et al., 2013, 2014; De Meester et al., 2013; Ding et al., 2012; Van Holle et al., 2015).

Walking behavior was assessed using the International Physical Activity Questionnaire (IPAQ), noted for its strong reliability and validity (Deforche et al., 2010). This study queried participants on the frequency (days in the past week) and duration (minutes per day) of physical activity specifically in the contexts of purposeful walking (e.g., walking to classroom, living places) and recreational walking (e.g., jogging) (Cao et al., 2021; Dyck et al., 2011; Joseph, 2006; P. Sun et al., 2019). Subsequently, the total weekly minutes spent on purposeful and recreational walking were calculated separately.

As the questionnaire content regarding perceived campus walkability and psychosocial factors was derived from established scales and existing literature, confirmatory factor analysis (CFA) was utilized to ascertain its validity and reliability. We analyzed the composite reliability (CR) and average variance extracted (AVE) for the dimensions. Generally, a CR value of 0.70 or above and an AVE value of 0.50 or above are deemed acceptable (Liao, Xu, et al., 2022; Liu et al., 2022). The results indicated that the CR for all measured dimensions exceeded 0.7 and the AVE surpassed 0.5 (refer to **Tables 1** and **2**). Furthermore, the square root of the AVE for each dimension exceeded the absolute value of the correlation coefficient between that dimension and others (refer to **Tables 1** and **2**), affirming the questionnaire's strong structural validity. These results demonstrate that the questionnaire possesses strong reliability and validity.

Table 1. Reliability and validity of perceived campus walkability.

Dimension	1	2	3	4	5	6	CR	AVE
1. Land use mix diversity	0.756						0.93	0.571
2. Accessibility	0.343***	0.756					0.903	0.572
3. Connectivity	0.467***	0.315***	0.756				0.799	0.571

Table 1. (*Continued*).

Dimension	1	2	3	4	5	6	CR	AVE
4. Infrastructure	0.458***	0.342***	0.484***	0.735			0.913	0.54
5. Aesthetics	0.332***	0.297***	0.535***	0.444***	0.729		0.872	0.531
6. Safety	0.295***	0.228***	0.5***	0.373***	0.38***	0.725	0.815	0.525

Note: The bolded numbers represent the square root values of the AVE for each dimension and the italicized numbers indicate the correlation coefficients between dimensions， ***$P < 0.001$.

Table 2. Reliability and validity of psychosocial factors.

Dimension	1	2	3	4	5	CR	AVE
1. Self-Efficacy	0.78					0.887	0.609
2. Attitude	0.537***	0.777				0.858	0.603
3. Perceived Benefits	0.467***	0.542***	0.72			0.883	0.518
4. Perceived Barriers	0.486***	0.465***	0.341***	0.773		0.912	0.598
5. Subject Norm	0.276***	0.313***	0.265***	0.386***	0.729	0.82	0.532

Note: The bolded numbers represent the square root values of the AVE for each dimension and the italicized numbers indicate the correlation coefficients between dimensions， ***$P < 0.001$.

2.3. Data analysis

Data analysis in this study was conducted using AMOS and SPSS 26.0 software, along with the PROCESS plug-in. Initially, the questionnaire's reliability and validity were tested, followed by descriptive statistical analysis. For the regression analysis, due to the positively skewed distribution of walking hours data, a logarithmic transformation of outcome variables was applied to improve data normality and linearity (Ding et al., 2012; Lee, 2020). Concurrently, all independent variables were standardized to enhance the interpretability of the analysis.

Building on this, the study conducted regression analyses with purposeful walking and recreational walking as separate outcome variables. In each model, a psychosocial variable, campus walkability, and their interaction terms were included independently. Additionally, gender, grade level, major, transportation ownership, and monthly expenditure were incorporated as covariates in the model. This approach enabled the calculation of the main and interaction effects of the independent variables in each model, with statistical significance determined at an alpha level of 0.05. To visualize significant interactions, simple slope plots were used, depicting the predicted walking hours (in antilog minutes) relative to campus walkability. Two separate regression lines represented individuals with psychosocial characteristics one standard deviation above and below the mean, respectively, to clearly illustrate these interaction effects.

3. Results

3.1. Descriptive and correlation analysis

Table 3 presents detailed demographic variables of the student participants in this study. Regarding gender distribution, male students constituted the majority with 399 (58.1%), compared to 288 (41.9%) female students. Grade distribution showed

sophomores as the largest group, comprising 29.3%, followed by 184 freshmen (26.8%), 176 juniors (25.6%), and 126 seniors (18.3%). In terms of academic majors, students in Science, Technology, Engineering, and Mathematics (STEM) were predominant, totaling 361 or 52.6% of the sample. Humanities and sciences had 198 students (28.8%), while arts and others were represented by 128 students (18.7%). Regarding transportation, 50.3% of students had no means of transport and primarily walked, 36.7% owned e-bikes, and 13% had bicycles. Most students' monthly expenditure ranged between RMB 1000 and RMB 2000, representing 69.3% of participants. Conversely, 19.1% spent less than RMB 1000 per month, while 11.6% spent more than RMB 2000.

Table 3. Descriptive statistics of demographic variables.

Variable	Categories	Number	Percentage（%）
Gender	Male	399	58.1
	Female	288	41.9
Grade	Freshman	184	26.8
	Sophomore	201	29.3
	Junior	176	25.6
	Senior	126	18.3
Major	STEM	361	52.5
	Humanities and Social Sciences	198	28.8
	Arts and Other Fields	128	18.7
Transportation ownership	None	346	50.3
	Bike	89	13.0
	E-Bike	252	36.7
Monthly expenditure (RMB)	<1000	131	19.1
	1000–2000	476	69.3
	2000–3000	56	8.2
	More than 3000	24	3.4
	More than 3000	24	3.4

Table 4 presents the descriptive statistical results and correlation analyses among walking behavior, perceived campus walkability, and psychosocial factors. The results indicated significant positive correlations between perceived campus walkability and both purposeful walking ($r = 0.413$, $p < 0.01$) and recreational walking ($r = 0.322$, $p < 0.01$). Regarding psychosocial factors, variables like self-efficacy, attitude, perceived benefits, and subject norms demonstrated significant positive correlations of varying magnitudes with both purposeful and recreational walking. Conversely, perceived barriers had significant negative correlations with both purposeful and recreational walking, suggesting that higher perceived barriers are associated with shorter walking time.

Table 4. Descriptive statistics and Pearson's bivariate correlations for dependent independent variables.

	Mean (SD)	Purposeful walking	Recreational walking
Independent variables			
Perceived Campus Walkability	3.46(0.644)	0.413**	0.322**
Self-Efficacy	3.18(1.049)	0.241**	0.375**
Attitude	3.64(0.996)	0.369**	0.438**
Perceived Benefits	3.85(0.843)	0.207**	0.433**
Perceived Barriers	2.95(1.017)	−0.180**	−0.210**
Subject Norm	3.48(0.935)	0.217**	0.103**
Dependent variables			
Purposeful walking	415.89(229.56)	-	-
Recreational walking	155.11(123.65)	-	-

SD = standard deviations, ** $p < 0.01$.

3.2. Associations with purposeful walking

The results of the regression analysis of perceived campus walkability and psychosocial factors with purposeful walking are shown in **Table 5**. Five models revealed that perceived campus walkability significantly and positively affected purposeful walking. The regression coefficients ranged from 0.1545 to 0.1933, each achieving statistical significance ($p < 0.001$). Regarding psychosocial factors, self-efficacy ($\beta = 0.0688$, $p < 0.001$), attitude ($\beta = 0.1356$, $p < 0.001$), perceived benefits ($\beta = 0.0437$, $p < 0.001$), and subject norm ($\beta = 0.0753$, $p = 0.0002$) were found to significantly positively affect walking duration. Conversely, perceived barriers ($\beta = -0.073$, $p < 0.001$) had a significant negative impact on purposeful walking.

About interaction effects, significant interactions were observed in three out of five models. A significant negative interaction effect was noted between perceived benefits ($\beta = -0.0464$, $p = 0.0106$) and subjective norms ($\beta = -0.084$, $p < 0.001$) in relation to campus walkability. Conversely, perceived barriers ($\beta = 0.0445$, $p = 0.0253$) demonstrated a positive interaction with walkability. Simple slope plots (**Figures 3a–c**) were generated, illustrating that a stronger relationship between campus walkability and purposeful walking existed in student groups with low perceived benefits and low subjective norms. Conversely, for students with high perceived barriers, campus walkability had a more pronounced effect on purposeful walking.

Table 5. Associations of perceived campus walkability, psychosocial variables, and perceived campus walkability × psychosocial interactions with purposeful walking.

	Purposeful walking			
	Standardized *β*	***SE***	***t***	***p***
Model 1				
Perceived Campus Walkability (PCW)	0.1852	0.022	8.4022	<0.001
Self-Efficacy (SE)	0.0688	0.0206	3.3422	<0.001
PCW*SE	−0.007	0.0198	−0.3516	0.7252

Table 5. (*Continued*).

	Purposeful walking			
	Standardized *β*	***SE***	***t***	***p***
Model 2				
Perceived Campus Walkability	0.1545	0.0212	7.2788	<0.001
Attitude (AT)	0.1356	0.0213	6.3782	<0.001
PCW*AT	−0.027	0.019	−1.418	0.1567
Model 3				
Perceived Campus Walkability	0.1818	0.0212	8.5611	<0.001
Perceived Benefits (PBe)	0.0437	0.0217	2.0073	0.0451
PCW*PBe	−0.0464	0.0181	−2.5642	0.0106
Model 4				
Perceived Campus Walkability	0.1933	0.0206	9.3868	<0.001
Perceived Barriers (PBr)	−0.073	0.0199	−3.676	<0.001
PCW*PBr	0.0445	0.0198	2.2419	0.0253
Model 5				
Perceived Campus Walkability	0.1779	0.0205	8.6608	<0.001
Subject Norm (SN)	0.0753	0.0202	3.737	<0.001
PCW*SN	−0.084	0.0192	−4.3666	<0.001

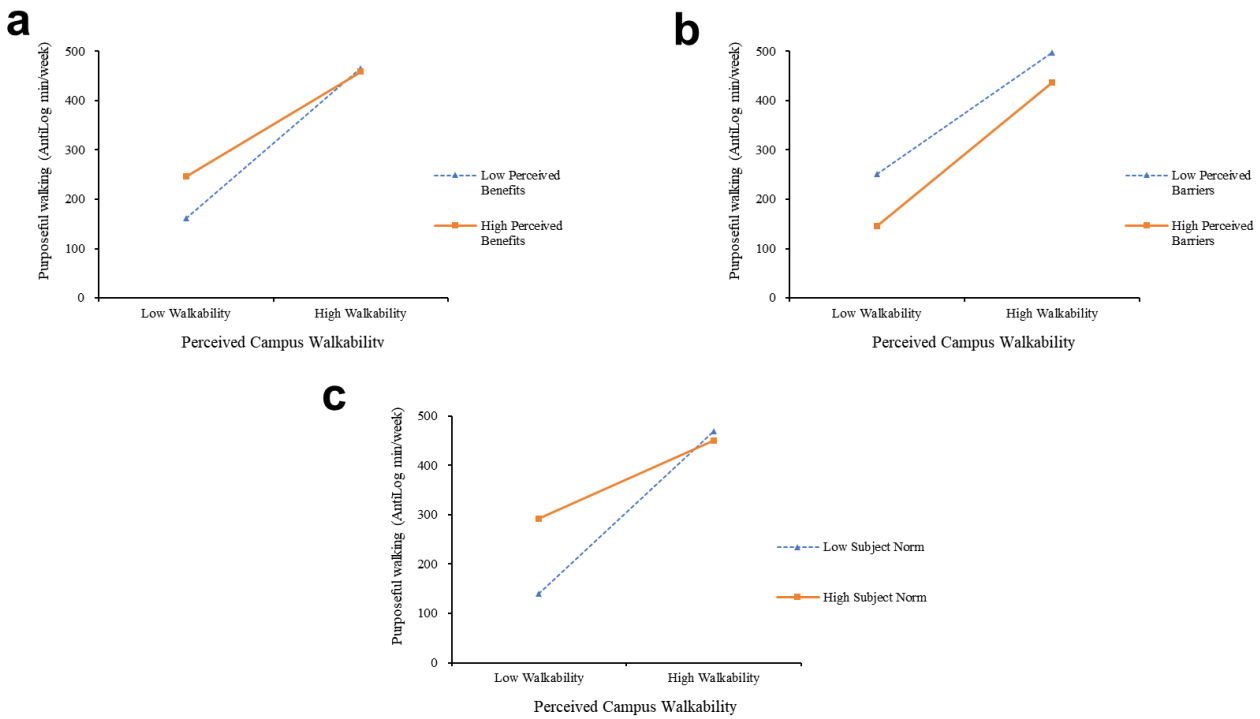

Figure 3. Simple slope plots.

Figure 3a–c Interaction effect of psychosocial factors and campus walkability (−1 and +1 standard deviation) on purposeful walking. Note: purposeful walking is in min/week with anti-logarithm transformation, and perceived benefits, subject norms and perceived barriers are standardized. Lines are −1 SD and +1 SD for psychosocial

factors.

3.3. Associations with recreational walking

The results of the regression analysis of perceived campus walkability and psychosocial factors with recreational walking are shown in **Table 6**. The influence of perceived campus walkability on recreational walking was significant across all models, with regression coefficients varying from 0.1906 to 0.2944, consistently achieving statistical significance ($p < 0.001$). Regarding psychosocial factors, self-efficacy ($\beta = 0.3055$, $p < 0.001$), attitudes ($\beta = 0.3751$, $p < 0.001$), and perceived benefits ($\beta = 0.3809$, $p < 0.001$) exhibited strong positive effects, while perceived barriers ($\beta = -0.1851$, $p < 0.001$) had a significant negative impact.

Regarding interaction effects, our examination revealed that four out of the five models did not demonstrate significant interactions. The sole exception was the interaction between campus walkability and subject norms, which achieved statistical significance ($\beta = -0.0758$, $p = 0.0323$). **Figure 4** illustrates that in student groups with lower levels of subjective norms, a stronger relationship was observed between campus walkability and recreational walking.

Table 6. Associations of perceived campus walkability, psychosocial variables, and perceived campus walkability × psychosocial interactions with recreational walking.

	Recreational walking			
	Standardized *β*	***SE***	***t***	***p***
Model 6				
Perceived Campus Walkability (PCW)	0.2265	0.038	5.9663	<0.001
Self-Efficacy (SE)	0.3055	0.0354	8.6223	<0.001
PCW*SE	0.0068	0.0341	0.1984	0.8428
Model 7				
Perceived Campus Walkability	0.1906	0.0367	5.1913	<0.001
Attitude (AT)	0.3751	0.0368	10.2004	<0.001
PCW*AT	0.0058	0.0329	0.1767	0.8598
Model 8				
Perceived Campus Walkability	0.215	0.0357	6.0171	<0.001
Perceived Benefits (PBe)	0.3809	0.0366	10.4116	<0.001
PCW*PBe	0.0349	0.0305	1.147	0.2518
Model 9				
Perceived Campus Walkability	0.2944	0.0368	8.002	<0.001
Perceived Barriers (PBr)	−0.1851	0.0355	−5.2167	<0.001
PCW*PBr	−0.0204	0.0355	−0.5746	0.5658
Model 10				
Perceived Campus Walkability	0.2851	0.0378	7.5476	<0.001
Subject Norm (SN)	0.053	0.0371	1.4297	0.1533
PCW*SN	−0.0758	0.0353	−2.1451	0.0323

Figure 4 Interaction effect of psychosocial factors and campus walkability (−1 and +1 standard deviation) on Recreational walking. Note: Recreational walking is in min/week with anti-logarithm transformation, and subjective norms are standardized. Lines are −1 SD and +1 SD for subject norms.

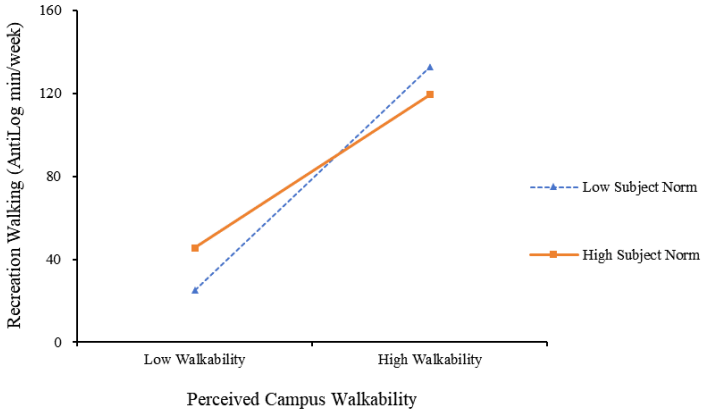

Figure 4. Simple slope plot.

4. Discussion

Previous studies on walking behavior have often overlooked the interaction between built environment and psychosocial factors. This study addresses this gap by examining the interaction between these factors in walking behavior, framed within a socio-ecological model. This study not only clarifies the combined impact of these factors on walking behavior but also provides new perspectives on the wider social and environmental determinants influencing walking behavior.

Addressing the study's first research question, the results demonstrated that both the perceived campus walkability and psychosocial factors exert a significant impact on walking behavior. In terms of campus walkability, perceived campus walkability significantly positively influenced both purposeful and recreational walking, aligning with findings from previous research (D'Haese et al., 2016; De Meester et al., 2013; Dyck et al., 2011). This indicates that high-quality walking environments on campus substantially contribute to college students' walking behavior. Consequently, college students are more likely to walk, whether for reaching specific destinations or for leisure, in the presence of the aforementioned high-quality campus walking environment. Furthermore, compared to purposeful walking, campus walkability more significantly impacts recreational walking, likely because the latter is influenced by subjective factors such as perceptions, attitudes, and interests, whereas the former is constrained by objective factors like time, distance, and cost. Therefore, an attractive and walkable campus environment is likely to encourage students' participation in recreational walking.

Concerning psychosocial factors, this study discovered that self-efficacy, attitudes, and perceived benefits significantly positively affected both purposeful and recreational walking, aligning with theoretical expectations and previous studies (Carlson et al., 2012; Gay et al., 2011; Van Dyck et al., 2014; Van Holle et al., 2015). These findings imply that college students with greater self-efficacy, more positive attitudes,

and higher perceived benefits of walking are likely to spend more time walking, whether for specific purposes such as going to the library or for leisure. Notably, subject norms did not significantly impact recreational walking, possibly due to college students' growing emphasis on independence and autonomy, leading to more freedom in choosing leisure activities like walking, regardless of others' perceptions (Giles-Corti and Donovan, 2002). Conversely, perceived barriers significantly negatively influenced the duration of both purposeful and leisure walking. This underscores the importance of addressing and mitigating these perceived barriers to effectively promote walking behavior (Carlson et al., 2012; Gay et al., 2011). The implications of these findings are substantial for developing strategies and interventions to encourage walking, as they shed light on the psychological and social dimensions impacting college students' walking behavior.

In response to the second research question of this study, the results revealed some interactions between perceived campus walkability and psychosocial factors affecting walking behavior. We observed that these interaction effects varied depending on the type of walking behavior. Specifically, in the analysis of purposeful walking, the interaction effects of perceived benefits, perceived barriers, and subjective norms with campus walkability were all significant. These interaction effects were contrary to the main positive effect of campus walkability, suggesting that these psychosocial factors somewhat mitigated the influence of walkability on walking. This finding aligns with prior research (Ding et al., 2012; Kaczynski et al., 2012; Van Dyck et al., 2014), although it contrasts with a European study on adolescents. That study observed that psychosocial factors significantly bolstered the link between neighborhood and school environments and the physical activity of adolescents (Haerens et al., 2009). **Figure 3a–c** illustrate that the correlation between campus walkability and purposeful walking was stronger among students with lower perceived benefits compared to those with higher perceived benefits. Students who value walking's benefits tend to walk even in less walkable campus environments; in contrast, those with lower perceived benefits are more inclined to walk when the campus environment is more walkable. An explanation for the impact of perceived barriers is that high walkability in campus environments can counterbalance the negative effects of these barriers, even when students perceive them. Moreover, students might reassess their perceived barriers, leading to increased interest and motivation to walk more in such environments. Concerning subjective norms, research indicates that when students strongly perceive norms or expectations favoring walking, enhancements in campus walkability may not further motivate them (Ding et al., 2012). Conversely, for students with less pronounced subjective norms, improved campus walkability can be a stronger motivator, as their inclination to walk may stem more from high-quality walking environments, including safe paths, good lighting, and appealing landscape.

When evaluating interaction effects on recreational walking, it was found that only one model demonstrated a significant interaction effect (refer to **Figure 4**). This finding suggests that in student groups with strong subject norms, walking behavior is predominantly influenced by social expectations and norms. Consequently, even with improved campus walkability, its positive impact may be diminished in these students who already opt to walk because of strong social expectations. Conversely, among

students less influenced by subject norms, walking behavior may arise more from personal preference or campus convenience. Meanwhile, the only significant interaction between subject norms and campus walkability indicates that college students are highly influenced by their peers. Consequently, promoting healthy walking behaviors among this group can be more effective when positive role models are established among students, leveraging their daily influence to reach a broader audience.

Regarding the third question in this study, we found differences in the interaction effects of campus walkability and psychosocial factors on purposeful versus recreational walking. Interestingly, this is in contrast to the general results of previous studies, which have typically found this interaction effect to affect recreational walking more than purposeful walking (Carlson et al., 2012; Ding et al., 2012; Haerens et al., 2009). In the present study, in the purposeful walking analyses, the interaction effects were significant across the three models, particularly with regard to perceived benefits, perceived barriers, and subjective norms. On the contrary, in the recreational walking analysis, the interaction effect was significant in only one model, showing a more pronounced interaction for purposeful walking and a relatively weak interaction for recreational walking, this finding aligns with the results of a study conducted in Belgium (Deforche et al., 2010). This may be related to the daily life and study schedule of college students. Purposeful walking, such as going to class, to the lab, or to the library, usually has a fixed route and schedule, so the interaction between campus walkability and psychosocial factors may be more significant. In contrast, recreational walking is more influenced by students' personal preferences and interests, making it likely that even under excellent environmental conditions they may choose other forms of leisure activities, such as bicycling, working out, or participating in clubs, and the irregularity and variety of leisure activities may make the interaction between environmental and psychosocial factors less significant or direct.

5. Conclusion

Based on a socio-ecological model, this study offers insights into the combined influence of perceived campus walkability and psychosocial factors on college students' walking behavior. Specifically, our findings indicate stronger interaction effects in purposeful walking compared to recreational walking, diverging from prior studies. This distinction may stem from the unique characteristics of the college student population, which exhibits greater regularity and consistency in purposeful walking, in contrast to the more diverse and spontaneous nature of leisure activities. Consequently, recognizing the distinctiveness of specific groups is essential in future research aimed at promoting walking behavior. Moreover, these insights can assist policy makers and urban planners in more effectively promoting walking. Mere enhancement of the physical environment or exclusive focus on psychological interventions may not suffice. Instead, integrated strategies combining environmental improvements and psychological interventions may prove more efficacious.

The limitations of this study include its sample being drawn solely from one Chinese city, potentially limiting the generalizability of the findings due to regional specificity, and the possibility of self-reporting bias inherent in questionnaire-based

data. Consequently, these findings should be interpreted with caution and are not universally applicable to all college student populations or other cultural and social contexts. In light of these results and limitations, future research could adopt more objective and precise methods for data collection and analysis, such as employing smartphones or wearable devices to track walking activities and utilizing geographic information systems (GIS) or virtual reality (VR) technology for assessing campus walkability (D'Orso and Migliore, 2020; Liao et al., 2022). Additionally, future studies should broaden their sample to include universities from diverse regions, types, and sizes, while considering the impact of various cultural and social backgrounds to enhance the study's representativeness and generalizability.

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