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THE INFLUENCE OF CAMPUS BUILT ENVIRONMENT CHARACTERISTICS ON WALKING BEHAVIOR AMONG COLLEGE STUDENTS

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Abstract

College students' sedentary and inactive lifestyles often lead to health issues like obesity and depression. The campus-built environment is crucial for encouraging college students' walking behavior, directly impacting their physical and mental health. However, it is unclear to what extent the campus-built environment characteristics contribute to college students' walking behavior. Therefore, this study aims to investigate the influence of campus-built environment characteristics on college students' walking behaviour. Utilizing the Neighborhood Environment Walkability Scale (NEWS) and the International Physical Activity Questionnaire (IPAQ), this study collected data from 687 students at two universities in China through a questionnaire survey and analysed the data using multiple regression techniques. The results show that land use diversity, accessibility, and infrastructure significantly influence walking behavior, totally explaining 26.3% of the variance. These findings highlight the importance of a walkable campus environment in promoting college students' walking behaviour, which is beneficial to their physical and mental health. Consequently, this study provides empirical evidence on specific built environment characteristics that encourage walking, serving as a valuable resource for future campus planning and health-promotion policy development.

Keywords: Campus Built Environment; Walking Behavior; College Student; Health

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INTRODUCTION

In the current context of rapid urbanisation, walking as an effective mode of physical activity has become a central concern in a number of areas, including public health, sustainable transport and urban planning (Bornioli et al., 2019; M. Liu et al., 2022; Van Holle et al., 2015). The United Nations and the World Health Organization, in their Sustainable Development Goals (SDGs) and Universal Health Coverage (UHC) programmes, have highlighted the building of pedestrian-friendly environments and the promotion of green mobility, such as walking, as the key measures to promote community cohesion, enhance the health benefits for residents and achieve sustainable development (Sacks et al., 2020; Siqueira et al., 2021).

Under the high-intensity and fast-paced lifestyle, the general public, particularly college students, face significant health challenges including obesity and depression (Wang Mohan, 2019; Mihailova & Kaminska, 2016; Sabra et al., 2007). The rapid expansion of transportation and logistics sectors, coupled with the pervasive use of the Internet, has fostered a sedentary lifestyle among college students (Wang, 2019). This sedentary behavior leads to inadequate physical activity, increasing various health risks (Hargens et al., 2021; W. Liu et al., 2021). Research suggests that walking serves as a vital daily transportation mode for college students and an effective means to boost physical and mental health (ZHOU, 2019; Pfisterer et al., 2022). It effectively alleviates stress, enhances mood, and bolsters psychological resilience (Harun & Nashar, 2017; Mu & Lao, 2022). Additionally, walking plays a key role in promoting green and sustainable development on campus (Liao et al., 2022; Ramakreshnan et al., 2020).

Over the past two decades, China's higher education institutions have seen remarkable growth, with the number of college and university rising from 1,041 in 2000 to 2,738 in 2020, and student enrollment increasing from 5.56 million to 32.85 million (Zhang et al., 2024). Despite this expansion, the development often overlooked the importance of campus built environment, leading to inadequate walking paths, poor accessibility, and unappealing landscaping (Zhang et al., 2023). These deficiencies have significantly degraded the walking experience, diminishing students' inclination to walk frequently (Liao et al., 2022; M. Liu et al., 2022). Additionally, Chinese university campuses are usually characterised by their closed boundary (Liao et al., 2022), and on-campus housing is typically required for students (Sun et al., 2018). Students' daily lives are largely confined within these campuses, where they frequently walk between various functional areas. In this environment, in addition to fulfilling commuting needs, walking has become a habit of life for students.

Although research has confirmed that the campus built environment significantly influences walking behavior, most related studies are still focused on Western countries (Hajrasouliha, 2017; Soares et al., 2022), with relatively few studies on Asia, particularly China (Mu & Lao, 2022; Zhang et al., 2024).

These studies primarily explore the characteristics of the built environment, such as land use, accessibility, walking infrastructure, and safety, and their impact on walking behavior (Liao et al. 2022; Horacek et al. 2018). Given the rapid expansion of higher education in China, many campuses are facing challenges such as improving space utilization efficiency and enhancing landscape aesthetics. These issues highlight the importance of studying the characteristics of the built environment in the context of high-density educational environments in China. Therefore, to address these issues, this study aims to investigate the influence of the campus built environment on college students' walking behaviour. The goal is to inform campus planning and design, ultimately fostering healthier and more active campus lifestyles.

LITERATURE REVIEW

Walking, as a low-cost and easily adhered to physical activity, has been widely recognised as important in maintaining and enhancing individual health. Numerous interdisciplinary studies, including preventive medicine, public health and urban planning, have highlighted the positive role of daily physical activity in the prevention and control of chronic diseases (Clemente et al., 2016; McTiernan et al., 2019; Teuber & Sudeck, 2021). García-Hermoso et al. (2018) found that Colombian college students who walked to and from school had lower obesity rates and better metabolic health indicators than their less active peers. This underscores the importance of walking during young adulthood, a critical period for preventing obesity and metabolic syndrome (Haase et al., 2004). Additionally, walking significantly reduces mental stress. Bang et al. (2017) showed that college students participating in the Campus Forest Walking Programme experienced notable reductions in depressive symptoms and enhanced parasympathetic nerve activity, boosting mental health. Walking also promotes social interactions, increasing communication opportunities, fostering harmonious interactions (Bang et al., 2017; Kim & Yang, 2017), and enhancing a sense of belonging and social capital (Liao et al., 2022). In conclusion, walking positively impacts college students' physical and mental health and facilitates social interactions, enhancing the overall quality and sustainability of campus life. The realization of these benefits largely depends on the environment in which the pedestrians are situated, particularly the design and functionality of the built environment.

In exploring how the urban built environment influences walking behavior, researchers have identified various key factors, including accessibility, connectivity, and infrastructure. Cervero and Kockelman's '3D' principles—Density, Diversity, and Design—highlight core urban design elements that enhance walkability (Cervero & Kockelman, 1997). Alfonzo (2005), drawing on Maslow's Hierarchy of Needs, categorized the walking-related aspects of the built environment into five ascending levels: Feasibility, Accessibility, Safety,

Comfort, and Pleasurability. Additionally, the Neighborhood Environment Walkability Scale (NEWS) integrates eight critical dimensions such as residential density, land use diversity, street connectivity, access to services, pedestrian infrastructure, traffic safety, aesthetics, and crime safety to assess their impact on walking behavior (Cerin et al., 2009, 2010). Recent empirical studies, including those by Liu et al. (2023), confirmed significant correlations between elements like street greening and accessibility to public facilities with increased walking duration. Koo et al. (2022) further validated that the quality of pedestrian infrastructure and neighborhood greening significantly affect walking choices. Collectively, these insights have not only highlighted the importance of the urban built environment for walking but also provided crucial references for related research in campus environments. This, in turn, helps identify the campus environmental factors that influence student walking behavior.

In the context of university campuses, some studies have found that various built environment factors influence student walking behavior. Peachey & Baller (2015) discovered that land use diversity, aesthetics, and connectivity was closely linked to increased walking activities. Afsar et al. (2015) emphasized the role of accessibility and connectivity in enhancing walking behavior in a Malaysian university, noting a preference among students for specialized pedestrian shortcuts. Horacek et al. (2012) identified the safety of pathways as a critical element in assessing campus built environment. Similarly, Liao et al. (2022) found that factors such as connectivity, walking infrastructure, and safety positively influenced walking behavior by enhancing campus walkability. Molina-García et al. (2019) demonstrated that effective walking infrastructure significantly promoted active commuting in Spain. King et al. (2020) noted that aesthetic enhancements on campus could extend the duration students engaged in walking, benefiting their physical and mental health. Additionally, researchers analyzed 13 US campuses and concluded that safety and infrastructure were pivotal in fostering physical activity among students (Horacek et al., 2018).

As mentioned above, walking significantly enhances the physical and mental health of college students and fosters social interactions. Research has demonstrated that various characteristics of the built environment, including land use diversity, accessibility, connectivity, walking infrastructure, aesthetics, and safety, profoundly affect walking behavior. However, the specific influences of campus built environments on walking behavior differs across geographical and cultural contexts, indicating that research findings vary widely based on location and culture background. Consequently, this study seeks to investigate the relationship between the campus built environment and college students' walking behaviour in the Chinese context.

RESEARCH METHODOLOGY

Study Area and Sample Size

This study was conducted in Anyang City, Henan Province, China, home to seven universities and technical colleges with a total enrolment of nearly 130,000 students. Two public universities, Anyang Institute of Technology and Anyang Normal University, were selected as the areas for this study, as shown in Figure 1. These two universities were selected due to their similarity in terms of level, size, campus environment, and operational history, enhancing the generalizability and reliability of the findings (Creswell, 2017). The two public universities enroll about 52,000 students (Yanyan Wang et al., 2023). Following Krejcie and Morgan's formula, a minimum sample size of 381 was determined necessary to achieve a 95% confidence level and a 5% margin of error (Krejcie & Morgan, 1970). Data was collected via a simple random sampling method from 796 students at two universities using an online questionnaire during June and July 2023. To maintain data quality, questionnaires completed in less than three minutes, with overly uniform or incomplete responses, were excluded as invalid. After data cleaning, 687 valid responses were retained, meeting the sample size requirements for the study.

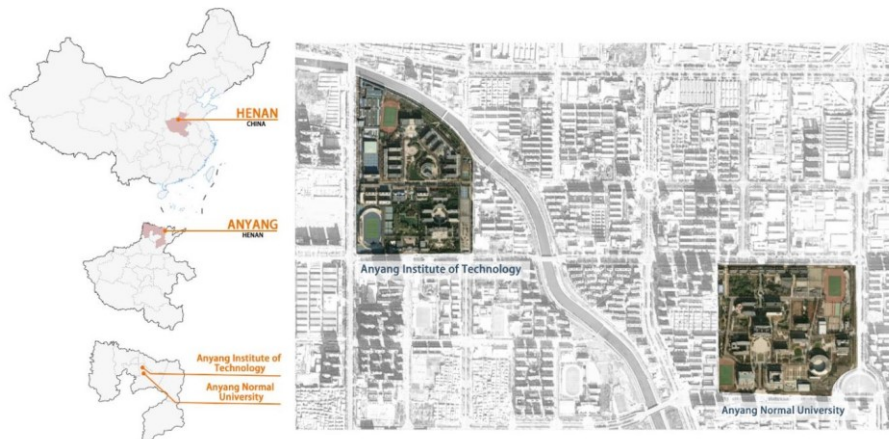


Figure 1: Location of this study.

Research Instrument

The research instrument for this study was a questionnaire divided into three sections: demographic characteristics (gender, grade, and major), campus built environment, and walking behavior. This study utilized the Neighbourhood Environment Walkability Scale (NEWS) adopted from Cerin et al. (2007), renowned for its reliability and validity (Cerin et al., 2009), to measure the campus built environment. Six dimensions of the scale were used in this study: land use diversity (e.g., distance from dormitory to facilities such as library, canteen,

classroom buildings; 10 items; Cronbach's $\alpha=0.93$), accessibility (e.g., availability of public transportation, sidewalk obstacles; 7 items; Cronbach's $\alpha=0.9$), connectivity (e.g., presence of shortcuts; 3 items; Cronbach's $\alpha=0.79$), infrastructure (e.g., availability of resting facilities, routine maintenance; 9 items; Cronbach's $\alpha=0.91$), aesthetics (e.g., campus landscape, campus air quality; 6 items; Cronbach's $\alpha=0.87$), and safety (e.g., speed limits, pedestrian-vehicle conflicts; 4 items; Cronbach's $\alpha=0.81$). Except for the land use mix diversity, the ratings for the other five subscales ranged from "strongly disagree" (1) to "strongly agree" (5). Land use mix diversity was assessed based on the walking distance from the dormitories to various facilities, with response options ranging from 1 to 5 minutes to over 30 minutes.

In addition, walking behaviour in this study was measured using the International Physical Activity Questionnaire (IPAQ), known for its high reliability and validity (Deforche et al., 2010). Participants reported their walking activities performed in the past 7 days, including frequency of activity (days in the past week) and duration (minutes per day). These data were used to compute the total minutes walked per week, providing a quantitative measure of walking behavior.

Data Analysis

Data analysis in this study was conducted using SPSS 26.0 software. Initially, descriptive statistics were calculated to understand the basic features of the data. Correlation analyses were then performed to explore relationships between dependent and independent variables. The presence of multicollinearity was examined using collinearity statistics. Subsequently, multiple regression analysis was carried out. Given the positively skewed distribution of the walking time data, a logarithmic transformation was applied to enhance data normality and linearity (Ding et al., 2012; D. K. Lee, 2020), thus improving the analysis's interpretability. Demographic variables were included as control factors in the regression model. Lastly, the model's explanatory power was evaluated by assessing the amount of explained variance and the significance of the standardized regression coefficients.

ANALYSIS AND DISCUSSION

Results

Table 1 shows the demographic characteristics of the participants in this study. Regarding gender, males comprised a larger proportion at 399 (58.1%), while females totaled 288 (41.9%). For grade distribution, Year 2 students formed the largest group at 29.3%, followed by Year 1 students at 26.8% (184 students), Year 3 students at 25.6% (176 students), and Year 4 students at 18.3% (126 students). Among academic majors, students in Science, Technology,

Engineering, and Mathematics (STEM) constituted the majority with 361 (52.6%), followed by humanities and social sciences with 198 (28.8%), and arts and other majors with 128 (18.7%).

Table 1. Descriptive statistics of demographic variables (N=687)

Variables	Categories	Frequency	Percentage (%)
Gender	Male	399	58.1
	Female	288	41.9
Grade	Year 1	184	26.8
	Year 2	201	29.3
	Year 3	176	25.6
	Year 4	126	18.3
	STEM	361	52.5
Major	Humanities and Social Sciences	198	28.8
	Arts and Other Fields	128	18.7

Table 2 outlines the descriptive statistics and correlation analysis results between walking behavior and various characteristics of the campus built environment. The analysis indicates that land use diversity, accessibility, connectivity, infrastructure, aesthetics, and safety each positively correlate with the length of walking time.

Table 2 Descriptive statistics and Pearson's correlations for dependent and independent variables

	M±SD	1	2	3	4	5	6	7
1.Walking(min/week)	415.89±229.56	1						
2.Land use-diversity	3.28±0.974	.265**	1					
3.Accessibility	3.36±0.990	.365**	.311**	1				
4.Connectivity	3.75±0.965	.208**	.402**	.267**	1			
5.Infrastructure	3.48±0.913	.356**	.421**	.308**	.419**	1		
6.Aesthetic	3.56±0.919	.195**	.298**	.263**	.444**	.397**	1	
7.Safety	3.67±0.915	.179**	.255**	.193**	.395**	.323**	.317**	1

**Correlation is significant at the 0.01 level (2-tailed).

Prior to conducting regression analyses, the study assessed multicollinearity among predictor variables using tolerance and Variance Inflation Factor (VIF) metrics(Oke et al., 2019). According to Table 3, all independent variables demonstrated tolerance values greater than 0.1 and VIF values less than 10, confirming the absence of multicollinearity and validating

the robustness of the regression model. The model showed a significance level of 0.000 ($F=14.014$, $p < 0.001$), indicating that it is suitable for predicting walking behavior. The coefficient determination value (R^2) shows that the percentage of dependent variables that can be predicted by the independent variables (Hair et al., 2014).

Table 3. Regression Coefficients

Model	Beta	t	Sig.	Tolerance	VIF
Gender	0.016	0.465	0.642	0.923	1.083
Grade	-0.068	-1.96	0.05	0.927	1.079
Major	-0.039	-1.152	0.25	0.959	1.043
Land use diversity	0.088	2.23	0.026	0.71	1.409
Accessibility	0.229	6.095	0.000	0.782	1.279
Connectivity	-0.008	-0.181	0.856	0.634	1.577
Infrastructure	0.187	4.547	0.000	0.654	1.53
Aesthetic	0.007	0.173	0.863	0.712	1.405
Safety	0.018	0.478	0.633	0.788	1.269
R			0.512		
R^2			0.263		
F			14.014***		

Note: Standardized coefficients are reported; *** $P < 0.001$

As shown in Table 3, the model results indicate that 26.3% ($R^2 = 0.263$) of college student walking behaviour can be explained by the independent variables. After adjusting for demographic factors, three key predictors emerged as significant: land use diversity ($\beta=0.088$, $p=0.026$), accessibility ($\beta=0.229$, $p<0.001$), and infrastructure ($\beta=0.187$, $p<0.001$). Conversely, connectivity ($\beta=-0.008$, $p=0.856$), aesthetics ($\beta=0.007$, $p=0.863$), and safety ($\beta=0.018$, $p=0.633$) did not significantly impact walking behavior.

DISCUSSION

Analysis results reveal that land use diversity positively affects walking duration, indicating that land use diversity can encourage more frequent walking among students. Supporting this, Ramakreshnan et al. (2020) identified land use diversity and proximity to services as key factors enhancing walking behavior, underscoring the benefits of a high-density mix of uses. Similarly, Keat et al. (2016) highlighted the impact of walking distances between critical facilities like student housing and academic buildings, suggesting that shorter distances might reduce walking deterrents. Based on these insights, future campus planning

should focus on enhancing mixed land use and minimizing distances between key facilities to promote walking.

Accessibility significantly and positively influences walking behaviour. It enhances the convenience and practicality of walking, which is integral to daily student activities, thereby strongly predicting the total walking hours of college students. This result aligns with previous studies emphasizing the significant impact of accessibility on walking. For instance, Lee & Shepley (2020) emphasized the importance of optimizing campus accessibility, specifically by reducing the walking obstacles, as essential for promoting student walking. Similarly, Simonson et al. (2013) noted that improving campus accessibility not only facilitates walking but also positively correlates with an enhanced educational experience for students.

Regarding walking infrastructure, it also showed a significant positive effect on walking behaviour, underscoring its critical role in promoting pedestrian activity. Improvements in infrastructure, including regular maintenance, resting areas, waste bins, well-maintained pavements, ample shade, and adequate nighttime lighting, not only make walking more comfortable but also more appealing. These enhancements encourage students to more frequently choose walking as their preferred mode of transportation. This is supported by Bang et al. (2017), whose research found that a campus forest walking program significantly boosted walking behavior by optimizing the walking environment.

Meanwhile, connectivity, safety, and aesthetics do not significantly influence walking, which appears inconsistent with other studies. For instance, Raswol (2020) assessed the quality of the walking environment on Iraqi campuses, with a particular emphasis on safety, which had a direct impact on students' walking. Similarly, Afsar et al. (2015) found that shortcuts and the connectivity of sidewalks on campuses were significant factors in influencing students' walking decisions. A potential explanation for this phenomenon is that connectivity and safety ranked highly in the assessment of the campus built environment in this study, suggesting that in campus environments where basic standards of connectivity and safety are already met, their improvement has a lesser direct impact on walking behaviour. As the teaching, living, and other services at this study site are more centralized and located at relatively short distances, students may not need to rely on multiple routes or shortcuts in their decision to walk.

Furthermore, the environmental characteristics of Chinese campuses, such as relative closeness and strict on-campus traffic management (for example, strict speed limits and restrictions on the entry of non-campus staff vehicles), already ensure a certain level of safety for walking. Consequently, safety may be perceived as a basic expectation rather than a variable factor, rendering the additional influence of safety factors on walking behaviour insignificant (Foster et al., 2010). This emphasizes the importance of considering environmental

characteristics in different contexts when studying walking behaviour, as the effectiveness of influencing factors can vary across contexts.

Moreover, while the campus aesthetics may increase the overall attractiveness of the environment, it may have a limited direct influence on walking behaviour. Similar findings were found in a study by Deforche et al. (2010), which noted that campus aesthetics have a limited direct influence and may be less significant compared to other factors such as accessibility and walking infrastructure.

The findings highlight that although connectivity, aesthetics, and safety are important, land use diversity, accessibility, and infrastructure play a more crucial role in enhancing walking behavior on campuses. Consequently, campus planning and design strategies should prioritize these elements to effectively encourage active walking among students.

CONCLUSION

This study elucidates the impact of land use diversity, accessibility, infrastructure, connectivity, aesthetics, and safety on college students' walking behavior, using regression analysis to assess these factors. Key findings demonstrate that land use diversity, accessibility, and infrastructure notably increase the duration of walking among students by enhancing service diversity, optimizing pathway access, and improving infrastructure. These insights provide a solid empirical foundation for designing campus environments that promote active lifestyles and lay the groundwork for further studies in Asian countries on the effects of such environments on student health. It is envisioned that campus planners and designers will use these results to develop spaces that encourage more walking and activity among students.

The study faces certain limitations that should be considered. Firstly, it was conducted in Anyang, China, at specific universities, which may not fully represent other university environments, thus potentially limiting the broader applicability of the findings. Secondly, the reliance on self-reported questionnaires to measure walking behavior might compromise data accuracy. To enhance data reliability in future research, the use of objective tracking tools such as accelerometers or pedometers is recommended to more accurately measure walking behavior (Chaudhry et al., 2020).

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