The Relationship Between Urban Green Spaces and Residents' Mental Health: A Test of Physical Exercise's Mediating Role

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Abstract

This study examines the relationship between urban green spaces and residents' mental health, specifically focusing on the role of physical exercise as a mediator. These findings have important implications for urban planning, public health policy, and individual health promotion. This study utilised a cross-sectional design and included 2647 participants from the 2021 China General Social Survey (CGSS 2021), with an average age of (51.34±17.57) years. The study employed the instruments from CGSS 2021 to examine participants' perception of urban green spaces, physical exercise status, and mental health. Data analysis was conducted using SPSS version 21.0 and Stata 12.0. The analysis included Spearman's and Pearson's correlation methods, as well as multi-variable linear regression and mediation analysis. The study revealed a strong positive correlation between urban green spaces, physical exercise engagement, and the promotion of mental well-being. However, there was no statistically significant relationship found between the amount of urban green spaces and the frequency of exercise. Furthermore, after controlling for other variables, a significant positive correlation was found between the presence of urban green spaces and the mental well-being of the community. This relationship was partially mediated by physical exercise. The findings offer a scientific foundation for future urban planning, green space construction, and public health policy formulation. They also provide valuable references for enhancing residents' quality of life and promoting mental health.

Keywords: Green Spaces, Mental Health, Physical Exercise, Environment, Health Promotion.

Introduction

Mental health is a crucial aspect of personal growth (Herr, 1989). Studies by Guo, Hu and Min (2022), Jiang and Zeng (2024), and Li et al. (2022) have shown that mental health issues among Chinese residents have consistently increased from 1990 to 2019, with a notable surge in the burden of depression. While there has been a slight delay in the burden of anxiety disorders, it still remains severe. Hence, the mental health concerns of Chinese residents necessitate comprehensive attention, making the improvement of their mental well-being a prominent subject of discussion.

When developing mental health policies, it is important to consider a wide range of factors that can impact mental well-being. The social ecological model is a framework used to analyse factors related to mental health. It suggests that mental health promotion is influenced by elements at the micro, meso, and macro levels (Golden et al., 2015). Urban green spaces have gained attention as an important component of the urban ecosystem due to the acceleration of urbanisation. This attention is particularly focused on their impact on residents' mental health. Previous studies (Douglas, 2012; Jennings et al., 2017) have emphasised the importance of considering urban ecology at a broader scale. This has significant implications for the development of health promotion policies and urban planning and construction.

Urban green spaces play a crucial role in improving the living environment and promoting the health of residents (An et al., 2020; Lee & Maheswaran, 2011; Tyrväinen et al., 2014). Research has shown a positive association between urban green spaces and better mental health outcomes (Astell-Burt & Feng, 2019; Callaghan et al., 2021; Nutsford, Pearson, & Kingham, 2013). The influence of spaces on mental well-being is mediated by individuals' spatiotemporal choices, which are shaped by their spatial awareness, including preferences and time constraints (Tuo, Zhou, & Zhang, 2021). Participating in physical activities in green areas is an important behaviour that can help mitigate the effects of urban green spaces on mental health. Although the relationship between green spaces and mental health is acknowledged, there is a lack of research that thoroughly investigates the role of physical exercise as a mediator in this relationship.

This study aims to investigate the relationship between urban green spaces and mental health, focusing on the role of physical exercise as a mediator. The objective is to provide a basis for informed urban development, green space design, and the establishment of public health initiatives. The objective is to improve living standards and promote mental well-being in communities.

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Literature Review

The association between urban green spaces and mental health has been extensively studied in multiple research papers (Astell-Burt & Feng, 2019; Callaghan et al., 2021; Nutsford et al., 2013). Nutsford et al. (2013) found a significant negative correlation between the total green space and available green space within a 3-kilometer radius of residences and anxiety and emotional disorders. Astell-Burt and Feng (2019) identified a significant correlation between green space area exceeding 30% of the total and reduced psychological distress. A systematic review conducted by Callaghan et al. (2021) investigated the association between green spaces in urban settings and mental health. The review identified 23 out of 25 original studies that clearly demonstrated a significant positive correlation between these two factors. Mental health is often associated with subjective experiences, emotional responses, and cognitive evaluations. The presence of urban green spaces, including their size, number, and arrangement, is significant, but it may not have a direct impact on an individual's mental health. On the other hand, the way individuals perceive, experience, and use green spaces can more accurately indicate their influence on mental health. Previous research by Leslie and Cerin (2008) and Lin, Zhang and Guo (2023) has examined the relationship between perceptions of urban green spaces and mental health, revealing a positive correlation.

The presence of urban green spaces can facilitate mental well-being by promoting physical exercise, which in turn contributes to mental health. Physical exercise is a significant contributor to improving mental health (Hou, Weng, & Liu, 2020). Experimental studies have consistently demonstrated the positive impact of physical exercise on mental well-being (Atlantis et al., 2004; Ma, 2020; McGale, McArdle, & Gaffney, 2011). Furthermore, cross-sectional studies (Morgan & Goldston, 2013; Yao et al., 2022) have found a significant positive association between physical exercise and the mental well-being of individuals. Moreover, a collection of studies (He et al., 2019; Hillsdon et al., 2006; Schipperijn et al., 2013) provides evidence for the notion that urban green spaces promote increased participation and regularity in physical activity. Schipperijn et al. (2013) found a correlation between the size of green areas, tree canopy density, scenic pleasantness, and outdoor exercise frequency. Akpınar (2019) discovered a significant correlation between the presence of trees, lawns, sports facilities, and recreational equipment in urban green spaces and the exercise levels reported by adolescents.

Drawing from the existing body of research, this study posits the following hypotheses:

H1: Urban green spaces are significantly and positively associated with the mental health of residents.

H2: Physical exercise significantly mediates the relationship between urban green spaces and mental health.

Research Methods

Participants

This study utilises a cross-sectional methodology, utilising data from the 2021 Chinese General Social Survey (CGSS). The CGSS project in China collects comprehensive data at various levels, including societal, community, familial, and individual dimensions, in order to address important scientific and practical issues. The China General Social Survey (2021) serves as a comprehensive platform for interdisciplinary economic and social data, supporting research and policy-making. Due to its widespread use and accessibility in academia, education, and governance, ethical approval is not required for this study. CGSS ensures that its surveys are conducted with the participants' informed consent and implements anonymization measures during both the survey process and data entry. The investigators are unaware of the participants' identities, thereby ensuring maximum privacy protection.

The CGSS utilises a four-stage disproportionate probability sampling technique for participant selection. The primary sampling units initially include urban and suburban districts within prefecture-level cities, provincial capitals, and centrally-administered municipalities. Secondary units in this context refer to streets and townships. Tertiary units consist of residents' and villagers' committees. Ultimately, households are chosen and one individual per household is designated as the sampling unit. A total of 125 districts and counties (primary sampling units) were chosen, with a ratio of 295 streets to 205 townships in the secondary sampling units. Correspondingly, the ratio of residents' committees to villagers' committees in the tertiary sampling units is 590:410. The ratio of urban to rural samples in the final sampling units is 5900:4100, which satisfies the requirement for a total sample size of 10,000 in terms of urban-rural distribution. A total of 2647 valid records of data were obtained after excluding participants who provided invalid responses (e.g., "don't know," "refuse to answer") regarding urban green spaces, mental health, and physical exercise. This study utilises linear interpolation to fill in missing values of other control variables, taking advantage of its simplicity, wide applicability, continuous interpolation results, and strong interpretability.

The mean age of the 2647 participants was 51.34±17.57 years. The sample consisted of 46.2% males and 53.8% females, with 55.5% residing in urban areas and 44.5%

residing in rural areas. The distribution of education levels was as follows: 32.5% for primary school and below, 28.3% for junior high school, 18.2% for high school, technical secondary school, and vocational school, and 21.0% for college and above. The participants had an average BMI of (23.13±3.63) kg/m^2.

Variables and Tools

The study utilised tools derived from the CGSS 2021 survey questionnaire, with specific content outlined in Supplementary Material 1.

Dependent Variable

Mental health is the dependent variable in this study. During the CGSS 2021 survey, participants were asked to rate the frequency of feeling depressed or downhearted in the past four weeks using a five-point self-rating scale. The scale ranged from 1 to 5, with each number representing a different level of frequency: always, often, sometimes, rarely, and never. It can be observed that a higher score is indicative of a more favourable mental state.

Independent Variable

The focus of this study is on urban green space as the independent variable. The participants of CGSS 2021 were required to evaluate the seriousness of the "lack of green space" in their residential area. They were asked to rate it on a scale of 1 to 5, where 1 represented not serious, 2 represented not very serious, 3 represented general, 4 represented quite serious, and 5 represented very serious. A rating of 7 indicated that there was no such issue. In order to facilitate future statistical analysis in this study, we have adjusted the data to align with the potential positive relationship between the two variables. This study transformed the data into a scale of 1 to 6, indicating varying levels of severity ranging from very serious to no issue. The score directly correlates with the sufficiency of urban green space.

Mediator Variable

The mediator variable in this study is physical exercise. During the CGSS 2021 survey, participants were asked to rate the frequency of their physical exercise in the past year using a five-point scale. The scale ranged from daily exercise to never exercising, with each point representing a different level of frequency. In this study, the researchers assigned a value of 1 to 4 to represent engaging in physical exercise, and a value of 0 to represent not engaging in physical exercise. The purpose of this was to investigate the impact of exercise on the relationship between the two variables. Additionally, this study examined the correlation between exercise frequency and the variables by re-coding values 1 to 4 as different time intervals. This allowed for a more detailed analysis of the relationship between exercise frequency and the variables under investigation.

Control Variables

In this study, age, gender, education level, and body mass index (BMI) were chosen as control variables, as indicated by previous research (Feng & Shi, 2022; Wang, Yang, & Shi, 2023). (1) Age. The birth dates of participants were surveyed in the CGSS 2021 study. This study obtained the age of the participants by calculating (2021 - birth year). (2) Gender. This study assigned a value of 1 to "male" and 0 to "female". (3) Education level. Referring to the study by Feng and Shi (2022), this study assigned a value of 1 to "no education, private school, literacy class, primary school," meaning "primary school and below," assigned a value of 2 to "junior high school," assigned a value of 3 to "high school, technical secondary school, vocational school," and assigned a value of 4 to "college, undergraduate, graduate or above," meaning "college and above." (4) BMI. CGSS 2021 surveyed the height and weight of participants, and this study calculated the participants' BMI using the formula BMI = weight (kg) / height (m)^2.

Data Analysis

This study employed SPSS 21.0 and Stata 12.0 for data management and statistical analysis. The continuous data were summarised using the mean (M) and standard deviation (SD), while the categorical data were summarised using frequencies and percentages. Spearman's rank correlation initially examined the relationships between urban green spaces, mental health, and exercise habits. Pearson's correlation was used to analyse the relationships between green spaces, mental health, and exercise frequency. Multiple linear regressions were subsequently performed to examine the influence of urban green spaces on mental health, while controlling for confounding factors. Ultimately, the study investigated the relationship between urban green spaces, physical exercise, and mental health, specifically exploring physical exercise as a potential mediator. The regression coefficient of the independent variable on the dependent variable was denoted as α in this study. The regression coefficient of the independent variable on the mediator variable was denoted as β, and the regression coefficient of the independent variable on the dependent variable after the inclusion of the mediator variable was denoted as γ. Feng and Shi (2022) found that the presence of significant variables α, β, and γ indicates a mediating effect. A complete mediating effect is observed when γ is not significant. A partial mediating effect is indicated when γ is less than α. The significance level for all statistical methods in this study was set at α=0.05.

Research Results

The Relationship Between Urban Green Spaces, Physical Exercise, and Mental Health

Table 1 demonstrates a significant positive correlation between urban green spaces and exercise participation (r=0.044, P<0.05), as well as between urban green spaces and mental health (r=0.039, P<0.05). Additionally, exercise shows a significant positive correlation with mental health (r=0.104, P<0.01). The results from Table 2 indicate that there is no statistically significant correlation between urban green spaces and exercise frequency (r=0.022, P>0.05). However, a statistically significant positive correlation is observed between urban green spaces and mental health (r=0.055, P<0.001). Moreover, a noteworthy positive correlation exists between exercise frequency and mental health (r=0.139, P<0.01). Therefore, a notable correlation exists between urban green spaces, engagement in physical activity, and mental well-being. Subsequent research will only investigate the mediating role of exercise participation, rather than exercise frequency, due to the insignificant correlation between urban green spaces and exercise frequency.

Table 1

Correlation Analysis Results of Urban Green Spaces, Exercise Participation, And Mental Health

Variables	Urban Green Spaces	Exercise Participation	Mental Health
Urban green spaces	1.000		
Exercise participation	0.044*	1.000	
Mental health	0.039*	0.104**	1.000

Note: *P<0.05; **P<0.01.

Table 2

Correlation Analysis Results of Urban Green Spaces, Exercise Frequency, And Mental Health

Variables	Urban Green Spaces	Exercise Frequency	Mental Health
Urban green spaces	1.000		
Exercise frequency	0.022	1.000	
Mental health	0.055**	0.139**	1.000

Note: **P<0.01.

The Relationship Between Urban Green Spaces and Mental Health After Controlling for Variables

The results of the multiple regression analysis (Table 3) indicate a significant positive correlation (α=0.025, 95% CI=0.004~0.047, P=0.019) between urban green spaces and residents' mental health. This suggests that an increase in the availability of urban green spaces is associated with higher levels of mental health among residents. Furthermore, males exhibit higher levels of mental health compared to females (α=0.178, 95% CI=0.096~0.260, P<0.01). Additionally, the junior high school and above group demonstrates higher mental health compared to the primary school and below group (P<0.01). Moreover, there is a significant positive correlation between BMI and mental health (α=0.012, 95% CI=0.001~0.023, P=0.039). There is no statistically significant correlation between age and mental health (α=-0.001, 95% CI=-0.004~0.002, P=0.516).

Table 3

Multiple Regression Analysis Results of Urban Green Spaces and Mental Health

Variables	*a*	*SE*	*t*	*P*	95%*CI*
Urban green spaces	0.025	0.011	2.35	0.019	（0.004，0.047）
Age	-0.001	0.001	-0.65	0.516	（-0.004，0.002）
Gender					
Male	0.178	0.042	4.27	0.000	（0.096，0.260）
Education level					
Junior high school	0.295	0.054	5.43	0.000	（0.187，0.402）
High/ Technical/ Vocational school	0.429	0.064	6.71	0.000	（0.303，0.554）
College and above	0.439	0.069	6.35	0.000	（0.303，0.574）
BMI	0.012	0.006	2.07	0.039	（0.001，0.023）

The Mediating Role of Physical Exercise Between Urban Green Spaces and Mental Health

The results of the multiple regression analysis (Table 4) indicate a significant positive correlation (β=0.047, 95% CI=0.003~0.009) between urban green spaces and exercise participation. In addition, even after accounting for exercise participation, there remains a statistically significant

positive correlation between urban green spaces and mental health (γ=0.024, 95% CI=0.003~0.045). The results from Tables 3 and 4 indicate that the regression coefficient for urban green spaces on mental health is α=0.025, the regression coefficient for urban green spaces on exercise participation is β=0.047, and the regression coefficient for urban green spaces on mental health after including exercise participation is γ=0.024. All three coefficients (α, β, and γ) are statistically significant, suggesting the presence of a mediating effect. Furthermore, given that γ is less than α, a partial mediating effect exists. Figure 1 illustrates the pathway diagram of physical exercise in the association between urban green spaces and mental health.

Table 4

The Mediating Role of Physical Exercise Between Urban Green Spaces and Mental Health

Variables	Exercise Participation		Mental Health	
	β	95%*CI*	*γ*	95%*CI*
Urban green spaces	0.047*	（0.003，0.009）	0.024*	（0.003，0.045）
Exercise participation				
Yes			0.143**	（0.051，0.235）
Age	-0.013**	（-0.020，-0.007）	-0.001	（-0.003，0.002）
Gender				
Male	0.078	（-0.102，0.258）	0.176**	（0.095，0.258）
Education level				
Junior high school	0.498**	（0.290，0.706）	0.277**	（0.170，0.384）
High/ Technical/ Vocational school	1.438**	（1.160，1.716）	0.384**	（0.255，0.512）
College and above	2.324**	（1.948，2.670）	0.382**	（0.242，0.522）
BMI	0.012	（-0.013，0.036）	0.011*	（0.000，0.023）

Note: *P<0.05; **P<0.01.

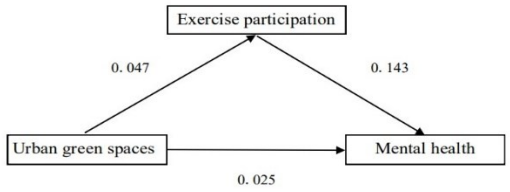

Figure 1: Pathway Diagram of Physical Exercise Between Urban Green Spaces and Mental Health.

Discussion

Urban Green Spaces Show a Significant Positive Correlation with Mental Health

The results demonstrate a significant positive correlation between urban green spaces and the mental well-being of residents, thereby supporting Hypothesis 1. The observed positive relationship is consistent with previous research findings (Astell-Burt & Feng, 2019; Callaghan et al., 2021; Leslie & Cerin, 2008; Lin et al., 2023; Nutsford et al., 2013). Research has shown that interacting with natural and green surroundings can reduce symptoms of anxiety, depression, and stress, while also improving overall well-being and life satisfaction.

The mechanisms through which urban green spaces enhance mental health can be explained at various levels: Exposure to urban green spaces has physiological benefits such as improving oxygen absorption, promoting respiratory health, reducing stress hormone levels, activating the parasympathetic nervous system, slowing heart rate, and lowering blood pressure. These effects help alleviate stress and promote mental health (Jia, Zhang, & Ding, 2023; Mygind et al., 2021; Thompson et al., 2012; Twohig-Bennett & Jones, 2018). Urban green spaces have been found to be restorative environments that can alleviate fatigue, relax mood, and reduce stress at the psychological level (Collado et al., 2017). Urban green spaces facilitate community interaction and socialisation, promoting social adaptation and mental health (Lu, Shu, & Wang, 2023).

Exercise Participation Plays a Mediating Role Between Urban Green Spaces and Mental Health

The study findings indicate that exercise participation plays a role in mediating the association between urban green spaces and mental health. However, the direct relationship between exercise frequency and the presence of green spaces does not reach statistical significance, thus not fully confirming Hypothesis 2. The relationship between exercise, urban green spaces, and mental health has been supported by previous research (Lu et al., 2023). The research mentioned above indicates that exercise has a greater impact compared to other potential factors, suggesting that urban green spaces primarily improve the mental health of residents by encouraging physical activity. Urban green spaces offer exercise amenities like walking paths, bicycle lanes, and fitness equipment. The presence of fresh air and natural landscapes in these spaces can enhance the enjoyment of exercise, thereby increasing residents' likelihood of engaging in physical activity. Physical exercise has been shown to enhance mental health by releasing endorphins, which can reduce pain and

improve mood (Daley, 2002). Regular exercise also has positive effects on sleep quality, self-esteem, and self-efficacy, all of which are linked to better mental health (Tie et al., 2023; Yang et al., 2012). However, this study found no correlation between urban green spaces and exercise frequency. This suggests that the impact of urban green spaces on exercise frequency may be minimal, and that exercise frequency is more likely influenced by personal preferences, time availability, and socio-economic factors. However, this study solely examined the association among the three entities using cross-sectional research, thus unable to establish a causal relationship between them. Future longitudinal studies are expected to investigate the causal relationship between the three factors to provide more robust evidence. This study has not yet examined the specific effects of different types of urban green spaces (e.g., parks, gardens, forests) on mental health, or how to optimise the design and planning of green spaces to enhance their positive impact on mental health. These limitations are attributed to the original data. Hence, additional investigation is required to examine these matters.

Discussion of Control Variables

Firstly, previous research (Emslie et al., 2002) has found that male residents generally exhibit better mental health. When encountering obstacles, males tend to be more inclined towards actively seeking solutions and striving to overcome challenges. The adoption of a "action-oriented" approach may facilitate the manifestation of a more favourable psychological attitude when confronting specific challenges. Nevertheless, it should be noted that males do not necessarily outperform females in all areas of mental health. Both males and females possess unique strengths and face specific challenges in relation to mental health. Females may prioritise emotional communication and expression, leading to stronger relationships and increased emotional support (Brody, 2013).

Secondly, higher education levels are associated with increased participation in exercise and improved mental health, consistent with previous research (Kondirolli & Sunder, 2022; Linder et al., 2020). Individuals with higher levels of education are more likely to participate in physical exercise and experience improved mental health. This can be attributed to their increased knowledge about mental well-being, enhanced resilience and stress management abilities, improved job opportunities and income, expanded social networks, increased social support, and greater success in setting and achieving personal goals.

Ultimately, there is a significant positive correlation between BMI and mental health. This finding contradicts the primary findings of prior studies (Herhaus et al., 2020; Sawyer et al., 2011), which demonstrated a negative association between BMI and mental health. The relationship between BMI and mental health is influenced by various factors such as gender, age, ethnicity, cultural background, and socioeconomic status. Hence, variations in research subjects, methodologies, and samples can lead to divergent findings across different studies. Further investigation is required to better understand the correlation between BMI and mental health, with the aim of establishing a more evidence-based approach to the prevention and treatment of associated disorders.

The Innovativeness and Value of This Study

The study makes two significant contributions. Firstly, it utilises the CGSS 2021 dataset, a comprehensive and representative national academic survey, providing a strong empirical foundation. Secondly, it investigates the role of physical exercise as a potential mediator in the relationship between urban green spaces and mental health, enhancing our understanding of the underlying mechanisms.

This study's value lies primarily in its contribution to policy making and practical guidance. This study highlights the significance of urban ecology in developing health promotion policies and urban planning. It offers evidence-based recommendations for urban planners and policymakers to facilitate the rational planning and utilisation of urban green spaces. The research findings provide valuable practical guidance for urban planning, green space development, and the formulation of public health policies. These findings contribute to enhancing residents' quality of life and promoting mental health.

Limitations of this study

This research presents significant findings and thorough analysis, while also acknowledging certain limitations. The cross-sectional design used in this study prevents the determination of causal relationships between variables. This study primarily utilises the CGSS 2021 dataset, which may suffer from sample selection bias as it may not adequately capture the diversity of all Chinese residents. This study did not differentiate between various types of urban green spaces (e.g., parks, gardens, forests) and their correlation with mental health. Future research should investigate the impacts of different types of green spaces. Future research should address these limitations by employing more sophisticated research designs and analysis methods to gain a more thorough and profound understanding.

Conclusion

The study utilised data from the CGSS 2021 to identify a significant positive association between urban green spaces

and the mental health of residents. The study also found that exercise partially mediates this relationship. This finding has favourable implications for future policy development and practical guidance. The study offers a foundation for urban planners to take into account the distribution, accessibility, and quality of green spaces in a more comprehensive manner during the design and planning of urban areas. Furthermore, it offers empirical support for public health policymakers advocating for the establishment of green exercise spaces in communities. The research results can be utilised to educate the public about the health benefits of urban green spaces, increase their awareness, and promote greater participation in outdoor activities and physical exercise among residents. This study suggests that future research should use a longitudinal study design and employ multidimensional statistical techniques to investigate the positive impacts of various urban green spaces on mental health. This approach will help to enhance our understanding of the underlying mechanisms involved.

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