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The Influence of Perceptions of the Park Environment on the Health of the Elderly: The Mediating Role of Social Interaction

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Abstract: The aging population has brought increased attention to the urgent need to address social isolation and health risks among the elderly. While previous research has established the positive effects of parks in promoting social interaction and health among older adults, further investigation is required to understand the complex relationships between perceptions of the park environment, social interaction, and elderly health. In this study, structural equation modeling (SEM) was employed to examine these relationships, using nine parks in Wuhan as a case study. The findings indicate that social interaction serves as a complete mediator between perceptions of the park environment and elderly health (path coefficients: park environment on social interaction = 0.45, social interaction on health = 0.46, and indirect effect = 0.182). Furthermore, the results of the multi-group SEM analysis revealed that the mediating effect was moderated by the pattern of social interaction (the difference test: the friend companionship group vs. the family companionship group ($Z = 1.965 > 1.96$)). Notably, family companionship had a significantly stronger positive impact on the health of older adults compared to friend companionship. These findings contribute to our understanding of the mechanisms through which urban parks support the physical and mental well-being of the elderly and provide a scientific foundation for optimizing urban park environments.

Keywords: perceptions of the park environment; social interaction; health of the elderly; mediating effect

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1. Introduction

The rapid development of aging has led to an increasing number of studies highlighting social isolation as a significant threat to the health of the elderly [1–6]. Social isolation among the elderly stems from various factors, including retirement, relocation, children leaving for education or employment, the loss of spouses and friends, and the decline in physical and psychological capabilities [7–9]. Notably, social isolation contributes to mental health issues such as anxiety, loneliness, depression, and suicide. It is also closely linked to physical ailments like obesity, hypertension, and heart disease [2,10,11]. Recognizing the health risks associated with social isolation in older adults, the World Health Organization (WHO) emphasized these concerns in its report entitled "Social Isolation and Loneliness among Older People". The WHO urges all countries to take action in order to eliminate the health risks posed by social isolation among the elderly [5,6].

Urban parks are widely acknowledged for their positive impact on physical and mental well-being. Firstly, they offer a serene and refreshing natural environment that elicits positive emotions, thus promoting health [12–14]. Secondly, urban parks facilitate various activities such as physical exercise and social interaction, which have a positive influence on health [15]. For the elderly population, urban parks provide valuable social interaction resources that contribute to social support, thereby reducing mental health risks like anxiety and loneliness [16,17]. However, there is a need for further exploration of the

underlying mechanisms linking the park environment, social interaction, and the health of older adults, especially with regard to the mediating role of social interaction [18].

Furthermore, studies have demonstrated that the health effects of social interaction among older adults in parks are influenced by two modes: family companionship and friend companionship [19,20]. Interpersonal relationships serve as the foundation for social interactions [21]. Family companionship focuses on emotional communication and support within the family, while friend companionship centers around shared hobbies like square dancing, singing, and playing board games [22,23]. Different activity contents might have varying impacts on health outcomes. Therefore, it is crucial to examine the differences in the effects of these two modes of social interaction on health [24].

In addition, previous research primarily examined the influence of objective park environments on social interactions and health, while paying limited attention to the role of subjective perceptions of the park environment. Perceptions of the park environment refer to park users' experiences and evaluations of the park's quality and amenities. Some studies indicate that parks impact health outcomes, such as relaxation and the promotion of social interaction, through perceptual dimensions like safety, comfort, and aesthetics [25,26]. Perceived safety is crucial for facilitating socialization and leisure activities, enabling individuals to better assimilate into the environment and enjoy recreational pursuits [27]. When people perceive the environment as comfortable, they are more inclined to engage in longer and more frequent social interactions [28–30]. Additionally, perceptions of aesthetics play a significant role in shaping social interactions, as visually appealing and inviting environments are more likely to foster participation in social activities [31]. Given that older adults are more vulnerable and sensitive to environmental perceptions [32,33], it is essential to focus on the mechanisms underlying the impact of subjective park environment perceptions.

To address the gaps in existing research, this study advances the understanding of the interaction mechanisms among perceptions of park environments, social interactions, and health [12–14,19,20,25,26]. The following hypotheses are proposed:

H1: *Perceptions of the park environment have a significant positive impact on health.*

H2: *Perceptions of the park environment have a significant positive impact on social interaction.*

H3: *Social interaction has a significant positive impact on health.*

H1 suggests a direct impact of perceptions of the park environment on health, while H2 and H3 propose indirect effects, indicating that perceptions of the park environment influence health through their impact on social interaction.

This study employed structural equation modeling (SEM) to analyze the relationships among perceptions of the park environment, social interaction, and the health of the elderly. Additionally, a multi-group SEM analysis was conducted to examine the moderating effects of different social interaction patterns (family companionship and friend companionship) on the relationship between perceptions of the park environment and health. Through this research, we aimed to gain a comprehensive understanding of how urban parks contribute to the physical and mental well-being of the elderly. The findings will provide a scientific foundation for designing strategies to optimize urban park environments.

2. Study Area

Wuhan, located in the eastern part of Hubei Province in central China, sits at the confluence of the Yangtze and Han Rivers. The city has a subtropical humid monsoon climate, characterized by distinct seasons, cold winters, and hot summers. By the end of 2021, Wuhan had established 101 comprehensive parks, with the total green space in urban areas amounting to 33,291.61 hectares [34]. The per capita park green space reached 14.49 square meters, and the green coverage rate in built-up areas was 43.07% [34].

This study focuses on nine comprehensive parks within the main urban area of Wuhan City (the location and scale information of the selected parks can be found in Appendix A). When selecting samples, the study matched park locations with the characteristics of the elderly population distribution. The nine selected parks are located in areas with the highest concentrations of elderly residents in the main urban area, and seniors are their primary user group. Figure 1 illustrates the spatial distribution of these parks.

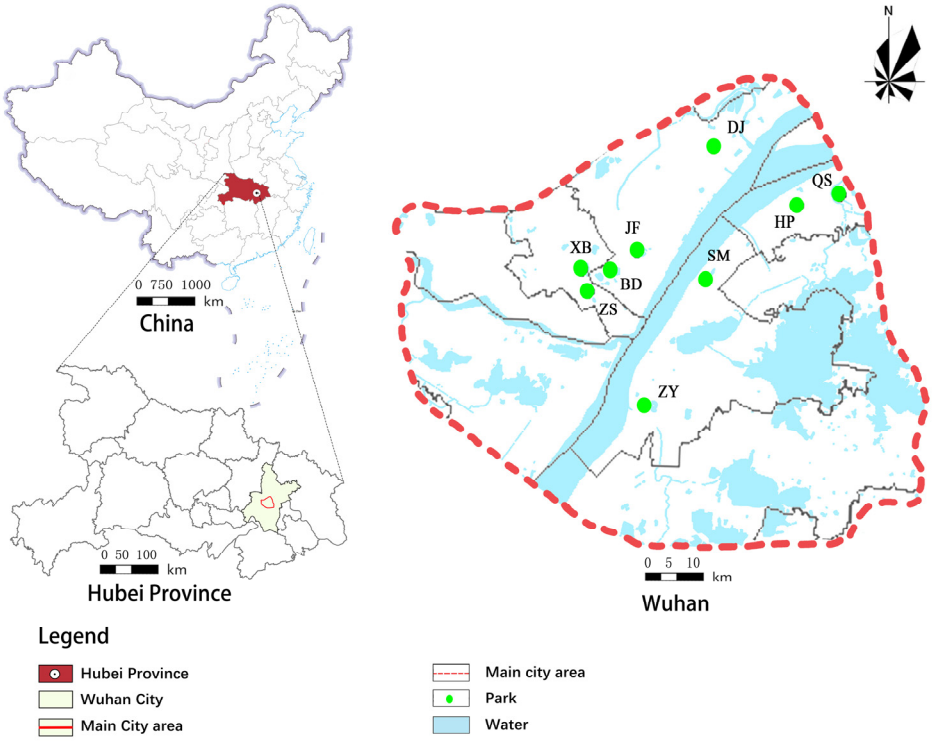

Figure 1. Spatial distribution of surveyed parks. Note: "ZY": Ziyang Park, "SM":Simeitang Park, "JF": Jiefang Park, "BD": Baodao Park, "ZS": Zhongshan Park, "XB": Xibeihu Park, "QS": Qingshan Park, "DJ": Dijiao Park, "HP": Heping Park.

3. Research Methodology

3.1. Questionnaire Survey

This study employed paper questionnaires and conducted on-site surveys to evaluate the perceptions of the park environment, social interaction, and health status among elderly park users. The participants were randomly selected from visitors to the selected parks. The purpose and procedure of the survey were explained to the participants, and those who agreed to participate were given questionnaires to complete during their park visit. As participants, we had to ensure they met two criteria: first, they were over 60 years old, and second, they were accompanied by someone during their park activities. This approach aimed to ensure that their responses accurately reflected their firsthand experiences and that their park activities involved social interaction. The survey took place from December 2022 to November 2023, covering both weekdays and weekends. A total of 617 questionnaires were distributed, excluding invalid questionnaires with missing answers or incorrect responses, with 593 valid responses, resulting in a response rate of 96.11%. The reliability of the questionnaires was assessed using Cronbach's alpha, which indicated acceptable internal consistency ($\alpha = 0.74 > 0.70$). Table 1 presents the socio-demographic characteristics of the participants.

Table 1. Descriptive statistics of socio-demographic characteristics.

Characteristic	Group	Count	Percentage (%)
Gender	Male	331	55.82
	Female	262	44.18
Age	55~59	46	7.76
	60~69	231	38.95
	70~79	258	43.51
	80~89	53	8.94
	≥90	5	0.84
Education Level	Primary School	98	16.53
	Junior High School	172	29.01
	High School	180	30.35
	College and undergraduate	140	23.61
	Postgraduate and above	3	0.51
Family Structure	Living alone	60	10.12
	Living with spouse	324	54.64
	Two-generation living	36	6.07
	Three-generation living	166	27.99
	Others	7	1.18

3.2. Research Variables

3.2.1. Independent Variable: Perceptions of the Park Environment

Table 2 presents the three dimensions used to evaluate the perceptions of elderly individuals regarding urban park environments: Safety, Comfort, and Aesthetics [35]. These dimensions provide a comprehensive assessment of park quality and human perceptual experiences, and they are commonly utilized in research on park environment perceptions [28,35–38]. The Safety dimension assesses perceptions of both the social security situation and the completeness of safety facilities and signage within the park. The Comfort dimension is further divided into two sub-dimensions: comfort of facilities usage and comfort of the auditory and thermal environment. The Aesthetics dimension examines perceptions of both natural landscapes and cultural landscapes. Each sub-dimension is assessed using a five-point Likert scale ("Very Dissatisfied = 1", "Dissatisfied = 2", "Neutral = 3", "Satisfied = 4", or "Very Satisfied = 5") to collect participants' perceptions of park environments.

Table 2. Scale for perceptions of the park environment.

Perceptions of Park Environment Dimension		Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Safety	Social security situation	□	□	□	□	□
	Completeness of safety facilities and signage	□	□	□	□	□
Comfort	Comfort of facilities usage	□	□	□	□	□
	Comfort of auditory and thermal environment	□	□	□	□	□
Aesthetics	Aesthetics of natural landscapes	□	□	□	□	□
	Aesthetics of cultural landscapes	□	□	□	□	□

3.2.2. Mediating Variable: Social Interaction

The measurement of social interaction is primarily based on two dimensions: duration of social interaction and frequency of social interaction [39–41]. The duration of park social interaction is assessed by asking elderly individuals about the length of time they spend with family or friends in the park, using a four-point scale ("≤30 min", ">30 min to 1 h", ">1 to 2 h", or ">2 h"). The frequency of park social interaction is measured by inquiring about how often elderly individuals visit the park with family or friends, also using a four-point scale ("once every few months," "1–3 times per month," "several times per week," or "daily").

3.2.3. Dependent Variable: Health

In this study, the health of elderly individuals was assessed through two measurement dimensions: self-reported physical health and psychological health [18]. To assess physical health, data were collected by asking elderly individuals about their current physical health status, using a five-point rating scale ("Very Poor = 1", "Poor = 2", "Fair = 3", "Good = 4", or "Excellent = 5"). Similarly, data on psychological health were collected by asking elderly individuals about their current psychological health status, also using a five-point rating scale ("Very Poor = 1", "Poor = 2", "Fair = 3", "Good = 4", or "Excellent = 5").

3.2.4. Control Variable: Social Interaction Pattern

To explore the influence of social interaction pattern on the proposed model, this study takes it as a control variable. Social interaction patterns were divided into family companionship and friend companionship based on kinship and non-kinship relationships [42]. To assess the social interaction patterns in the park, participants were asked the question, "With whom do you mainly do activities in the park on a regular basis?" Among the participants, 416 elderly individuals reported engaging in activities with friends, while 177 elderly individuals reported engaging in activities with family members.

3.3. Statistical Analysis

This study employed structural equation modeling (SEM) to analyze the relationships among perceptions of the park environment, social interaction, and the health of the elderly. Additionally, multi-group SEM analysis was utilized to examine the moderating effect of social interaction patterns (family companionship and friend companionship) on these relationships.

The analysis follows the following steps:

(1) Model Fit Test: The adequacy of the model was assessed to ensure that it accurately represents the data.
(2) Mediation Analysis: Bootstrap methods were used to examine the mediation effect of social interaction on the relationships among perceptions of the park environment, social interaction, and health outcomes [43,44].
(3) Moderation Analysis: Multi-group analysis was conducted by inputting data from different groups, representing family companionship and friend companionship, into the model. A comparison between the unrestricted model and restricted model parameters was performed to identify the moderating effect of park social interaction patterns [45].

All analyses were conducted using IBM AMOS 26 software.

4. Results

4.1. Model Fit

Model fit is an essential measure that evaluates how well the model matrix aligns with the sample matrix. This study employed various indicators to assess the model fit, including x^2/df, GFI, RMSEA, CFI, and AGFI. These indicators have been commonly used in previous research studies [46–48]. As shown in Table 3, all of the indicators in this study

met the recommended threshold standards, indicating a good fit between the model and the data.

Table 3. Model fit test of the research model.

Indicator	x^2/df	RMSEA	GFI	CFI	AGFI
Standard Value	<4	<0.08	>0.90	>0.90	>0.90
Measured Value	3.852	0.069	0.980	0.950	0.950
Test Results	Passed	Passed	Passed	Passed	Passed

4.2. Structural Results

The structural results are presented in Figure 2 and Table 4. Based on the significance testing results of the path coefficients, the previously proposed hypotheses H2 and H3 were supported, while hypothesis H1 was rejected. The analysis demonstrated that perceptions of the park environment positively influence social interaction (standardized path coefficient $\beta = 0.45$, $p < 0.05$), thereby supporting hypothesis H2. This indicates that enhancing the safety, comfort, and aesthetics of the park environment significantly increases the level of social interaction among the elderly in the park. Social interaction exhibited a significant positive effect on health (standardized path coefficient $\beta = 0.30$, $p < 0.05$), providing support for hypothesis H3. This means that social interaction is an important factor influencing health, and by increasing the frequency and duration of social interactions, both mental and physical health can be improved. However, no significant correlation was observed between perceptions of the park environment and health (standardized path coefficient $\beta = 0.043$, $p > 0.05$). Consequently, the direct relationship between perceptions of the park environment and health, as proposed in hypothesis H1, was rejected.

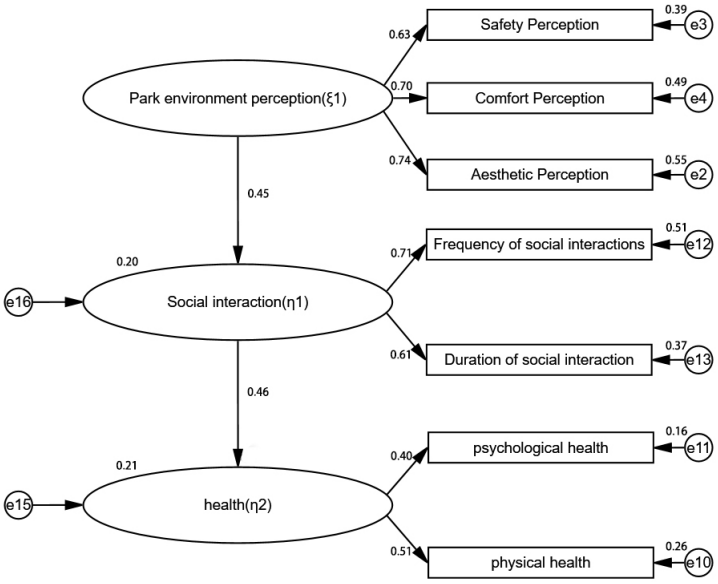

Figure 2. Path coefficients of the structural equation model.

Table 4. Results of the structural equation model.

Path	Standardized Path Coefficient	S.E.	C.R.	*p*	Hypothesis	Support
ξ1→η2	0.312	0.033	1.180	0.238	H1	Rejected
ξ1→η2	0.452	0.097	6.744	***	H2	Supported
η1→η2	0.455	0.083	3.363	***	H3	Supported

Note: *** significance at $p < 0.001$.

These results indicated that although no significant direct relationship between perceptions of the park environment and the health of the elderly was observed, it is possible that there could be an indirect effect mediated by social interaction. Therefore, in this study, further investigation of this potential mediating effect was undertaken.

4.3. Mediation Analysis

This study employed the Bootstrap method and the bias-corrected method to estimate the mediation effects, which can address non-normality and power limitations [49]. Mediation testing was conducted using Bootstrap with 2000 samples and a 95% confidence interval [50]. The significance of the indirect effects was examined by calculating the asymptotic critical ratio (Z) and confidence intervals for the lower and upper bounds (95% BC, 95th percentile) [49]. When Z > 0 and a 95% confidence interval does not contain zero, there is an indirect effect.

In the research model, this study analyzed the specific indirect effects between perceptions of the park environment and health. As shown in Table 4, the results revealed a specific indirect effect of 0.182 through social interaction. The Z-value of 22.680 exceeded the significance level of 1.96, and the 95% confidence interval did not include zero, indicating statistical significance.

Although the direct effect of perceptions of the park environment on health was not significant, it exerted a significant indirect impact on health through the mediating variable of social interaction. As shown in Table 5, the total effect was equal to the indirect effect from the independent variable (perceptions of the park environment) to the dependent variable (health). This suggests that social interaction fully mediates the relationship between perceptions of the park environment and health. Thus, social interaction played a crucial role in connecting perceptions of the park environment to health outcomes.

Table 5. Direct, indirect, and total effects in the structural equation model.

Source of Effect	Coefficient	Coefficient Product	BCEBC 95%	Percentile 95%
	SE	Z	Lower	Upper
Direct Effects	-	-	-	-
Indirect Effect	0.182	0.68	22.680	0.050
Total Effect	0.182	0.68	22.680	0.050

Note: 2000 bootstrap samples.

4.4. Multi-Group Analysis

This study employed multi-group SEM analysis to investigate potential variations in measurement parameters and structural relationships across different modes of social interaction. The suitability of the nested models in the multi-group analysis was assessed using various indices, as presented in Table 6. All of the indices surpassed the standard critical values, indicating that the model was well suited for the multi-group analysis. During the analysis, the study followed the invariance procedure recommended by Byrne et al. (1989). This procedure involves initially imposing equivalence constraints on measurement parameters across the sample groups [45].

Table 6. Fit indices of the nested model sequence in multi-group analysis.

Indicator	x^2/df	RMSEA	GFI	CFI	AGFI
Standard Value	<4	<0.08	>0.90	>0.90	>0.90
Family Companionship	1.407	0.048	0.979	0.978	0.941
Friend Companionship	2.940	0.068	0.981	0.960	0.946

Upon imposing constraints that equalize all measurement weights across groups, the multi-group analysis of social interaction patterns revealed significant differences between the constrained and unconstrained models ($\Delta x^2 = 8.279$, df = 3, $p = 0.040$). This indicates

that there are variations in the regression weights between different groups with distinct social interaction patterns.

To further examine the differences in structural parameters between groups with different social interaction patterns, this study followed Bentler's (1980) recommendation and utilized the critical ratio (Z) to test the significance of hypothesized paths between the two groups [51]. The ratio was calculated by dividing the standardized path coefficient by its standard error. A critical ratio (Z) greater than ±1.96 was considered significant at the 0.05 level. The results presented in Table 7 indicate that the difference test for the path (η1→η2) between the friend companionship group and the family companionship group was significant (Z = 1.965 > 1.96). This finding suggests that, within the context of social interaction patterns, respondents demonstrate stronger associations between family companionship and health compared to friend companionship.

Table 7. Comparison of differences in path coefficients between different groups of social interaction pattern.

Path	Family Companionship	Friend Companionship	Z
ξ1→η2	0.371 ***	0.438 ***	1.878
η1→η2	0.45 *	0.348 ***	1.965

Note: *** significance at $p < 0.001$ and * significance at $p < 0.05$.

5. Discussion

In this study, SEM was employed to investigate the intricate relationship between park environment perception, social interaction, and the health status of older adults. The results of the study indicate that social interaction plays a fully mediating role between park environment perception and the health of older adults. Specifically, there was no direct influence relationship between park environment perception and health, and the impact of park environment perception on health only occurs indirectly through the mediating variable of social interaction. These findings differed from some previous studies that showed a direct impact of park environment perception on the health of park visitors, with social interaction playing a partially mediating role [18,52,53]. Previous research primarily focused on mental health measures such as attention, stress, tension, and anxiety dimensions, suggesting that park environment perception contributes to attention restoration and stress reduction among park visitors [13,54]. However, it is important to note that in this study, the measurement model of health included both mental health and physical health indicators. Previous evidence suggests that park environment perception has a significant positive effect on mental health but lacks direct evidence of an effect on physical health [55,56]. This disparity in findings may explain the differences in the partially mediated and fully mediated relationships observed.

In the multi-group analysis, we observed a moderating effect of social interaction patterns on the mediating effect. Specifically, the group accompanied by family members exhibited a significantly stronger positive effect of social interaction on health compared to the group accompanied by friends. This suggests that social interactions involving family members are more beneficial to the health of older adults compared to interactions with non-family members. This finding contrasts with studies conducted in Western societies, where Chinese older adults prioritize family as their primary source of social support [57,58]. In Western societies, older adults tend to seek social support from groups, organizations, volunteer teams, and non-kinship networks [59].

The results of this study provide theoretical support for promoting social interaction and health among older adults by enhancing the environmental quality and perceived experience of parks. Social interaction fully mediates the relationship between perceptions of the park environment and health. Therefore, park design should focus on creating spaces conducive to social activities, offering diverse activity areas such as chess zones, dance areas, and Tai Chi zones to increase opportunities for social interaction [60,61]. Semi-outdoor or indoor service buildings should be provided to facilitate social activities under various

weather conditions, and the strategic placement of resting seats should be considered to allow for comfortable interactions [62]. To ensure that older adults gain a sufficient sense of safety, comfort, and aesthetics in the park environment, it is crucial to improve accessibility features by using non-slip materials to pave wide and flat paths, installing appropriate ramps, handrails, and guardrails, and providing seats and canopies at suitable heights [63]. Park designs should fully consider the physical characteristics and needs of older adults, such as providing adequate resting seats and proper lighting facilities [64]. Additionally, the aesthetic quality of both natural and cultural landscapes must be emphasized [65]. In summary, park planning and design should center on promoting social interaction among older adults by optimizing environmental quality, enhancing facilities, and organizing activities to create a public space conducive to their social and health needs.

However, this study has several limitations: Firstly, it relied on cross-sectional data, which restricted the ability to capture changes and establish causal relationships over time, especially for phenomena like health impacts that require long-term observation. To address this limitation, future research should consider incorporating longitudinal study designs to examine the relationships between perceptions of the park environment and health, allowing for a better understanding of the temporal dynamics involved [66,67]. Secondly, this study heavily relied on self-report measures to assess variables such as physical and mental health, perceptions of the park environment, and social interaction. While self-report assessments are commonly used due to their cost-effectiveness, ease of data collection from large populations, and good reliability and validity, they are not without limitations. Self-report measures may be subject to inaccuracies in the recollection of elderly individuals, susceptibility to subjective interference leading to evaluation bias, and potential issues related to social desirability bias [68]. Finally, the study did not specifically explore spatial variability across different park locations. Future research should consider integrating multiple assessment methods, such as incorporating instrumental measurements of objective health indicators like heart rate, blood pressure, and blood sugar [69,70], to provide a more comprehensive and accurate understanding of the health status of elderly individuals. Meanwhile, on the temporal level, future research should conduct long-term series studies to reveal long-term trends, control short-term fluctuations, evaluate interventions, explore causal relationships, and enhance predictive capabilities; on the spatial level, future studies should account for the heterogeneity of parks to gain a more comprehensive understanding of the factors that influence human health in park settings.

6. Conclusions

In the context of nine parks in Wuhan, China, SEM was employed to analyze the interplay among perceptions of the park environment, social interaction, and the health of the elderly. The research findings revealed that social interaction played a fully mediating role between perceptions of the park environment and the health of the elderly, indicating that perceptions of the park environment indirectly influence health through social interaction. Additionally, the study identified a moderating effect of social interaction patterns on the relationship between perceptions of the park environment and health. Specifically, within the sample group accompanied by family members, the impact of social activities on health was greater than in groups accompanied by friends. These findings provide theoretical support for enhancing the perceptual experience of park environments to promote social interaction among elderly individuals and thereby improve their health status.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions imposed by the privacy approval and informed consent agreements with study participants.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Selected Parks from the Main City Area of Wuhan

Park	Region	Scale
Zhongshan Park	Jianghan District	The park covers an area of 328,000 square meters, including 268,000 square meters of land and 60,000 square meters of water. It boasts a green coverage rate of 93%.
Xibeihu Park	Jianghan District	The park features a lake area of 143,900 square meters and green spaces covering 243,400 square meters.
Jiefang Park	Jiang'an District	The park covers 460,000 square meters, with 76,000 square meters of water, and a high greening rate of 85%.
Baodao Park	Jiang'an District	The park spans 160,000 square meters, including a 100,000 square meter water area.
Dijiao Park	Jiang'an District	The park covers an area of approximately 200,000 square meters, with a water area of 32,000 square meters, accounting for 16% of the total area. The park has a green coverage rate of approximately 85%.
Ziyang Park	Wuchang District	The park encompasses 295,500 square meters, with 136,700 square meters of water and 158,900 square meters of land.
Simetang Park	Wuchang District	The park features an 84,700 square meter water area and 93,200 square meters of green space.
Heping Park	Qingshan District	The park spans 520,000 square meters and boasts a 19,000 square meter rose garden.
Qingshan Park	Qingshan District	The park covers a total area of 357,000 square meters, including 326,000 square meters of land and 31,000 square meters of water, and features a high greening rate of 89.8%.

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