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Psychological Mechanism of Outdoor Physical Exercise in Polluted Weather Based on Social Cognitive Theory

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ABSTRACT

Despite improved living standards, many individuals continue to engage in outdoor physical exercise despite air pollution. This study explores the psychological mechanisms that facilitate this behavior in adverse environmental conditions. Using Social Cognitive Theory as a framework, we investigate the reasons individuals choose to exercise outdoors in polluted weather compared to those who prefer cleaner conditions. Our research includes a statistical analysis of demographic data and an examination of psychological and social factors influencing exercise habits. We distributed a structured questionnaire to 300 participants, receiving 290 responses, of which 280 were valid. By analyzing these responses, we aim to uncover the psychological drivers that sustain commitment to outdoor exercise despite pollution challenges. The findings provide valuable insights into the motivations and mechanisms that encourage individuals to maintain their physical activity in less-than-ideal conditions.

KEYWORDS

Air Pollution, Outdoor Physical Exercise, Psychological Factors, Social Cognitive Theory

INTRODUCTION

Outdoor physical exercise is essential for maintaining health and well-being; however, environmental factors, particularly air pollution, pose significant challenges to individuals' willingness to engage in such activities. This study aims to explore the psychological mechanisms that influence outdoor exercise behavior in the context of air pollution, utilizing social cognitive theory (SCT) as a guiding framework (Bratman et al., 2021; Riley et al., 2021). Developed by Western psychologists, SCT provides valuable insights into understanding various human behaviors, including social and exercise behaviors. According to SCT, three primary factors influence exercise behavior: personal factors, environmental factors, and behavioral factors. *Personal factors* encompass individual self-cognition, self-motivation, intentions, attitudes (both positive and negative), and self-efficacy. *Environmental factors* include external conditions such as weather and air pollution, which can impact the feasibility of exercise. *Behavioral factors* involve aspects such as the type, intensity, and duration of physical activity. These factors interact and influence one another, making it essential to explore the psychological motivations behind exercise behaviors in adverse environmental conditions (Fan, 2024; Sundling & Jakobsson, 2023).

Air pollution is generally perceived as a significant barrier to physical exercise, negatively impacting individuals' physiological and psychological well-being. Research indicates that exercising

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in polluted environments can increase the risk of health issues and affect athletic performance. Despite these challenges, many individuals continue to engage in outdoor physical activities even under polluted conditions. This persistence may be driven by the increased difficulty and perceived challenge of exercising in such environments (Lohmann et al., 2023).

According to SCT, four key factors influence outdoor exercise behavior in polluted weather:

- *Exercise self-efficacy*, which refers to an individual's confidence in their ability to engage in physical activity despite obstacles (Kolokotsa et al., 2020)
- *Obstacle self-efficacy*, which involves the individual's perception of their ability to overcome specific challenges and barriers (Chang & Bodnar, 2024)
- *Effect expectation*, which encompasses the anticipated outcomes and benefits of exercising, significantly influencing participation (Wei-Ching, 2023)
- *Social support*, which includes both objective support (material assistance) and subjective support (emotional encouragement and recognition) and is positively correlated with exercise behavior (Gorman et al., 2021)

This study analyzes the relationship between demographic factors, air quality perceptions, and outdoor exercise behavior. Specifically, the research seeks to answer the following questions:

- What is the role of exercise self-efficacy in influencing outdoor exercise behavior in polluted conditions?
- How does obstacle self-efficacy affect individuals' decisions to engage in outdoor physical activity despite environmental challenges?
- How do effect expectations shape participation in outdoor exercise under poor air quality?
- How does social support impact individuals' persistence in outdoor exercise when faced with pollution?

By employing single-factor analysis, correlation analysis, and regression analysis, this study seeks to uncover the psychological mechanisms that drive individuals to continue exercising despite air pollution. The findings will offer valuable insights and practical guidance for promoting outdoor physical activity under challenging environmental conditions.

LITERATURE REVIEW

The relationship between environmental conditions and physical activity levels has been a research focus in public health and environmental psychology. Numerous studies have established that air pollution significantly deters individuals from engaging in outdoor exercise due to health concerns and discomfort. The psychological impacts of air pollution on exercise behavior are multifaceted, involving direct health risks and broader implications for mental well-being and social interactions.

Air pollution is widely recognized as a significant barrier to physical activity. Research indicates that exposure to high levels of pollutants, such as particulate matter, nitrogen dioxide, and ozone, can lead to various health issues, including respiratory problems, cardiovascular diseases, and decreased lung function (Meng et al., 2022; Rowell et al., 2024). These health risks create a psychological barrier, as individuals may develop a heightened sense of anxiety or fear regarding outdoor exercise in polluted environments. This fear can lead to avoidance behavior, where individuals choose to remain indoors rather than risk exposure to harmful air quality.

Recent studies have highlighted the psychological mechanisms that underlie these behaviors. For instance, a study by Huang et al. (2023) found that individuals living in urban areas with high pollution levels often experience increased stress and anxiety related to their outdoor activities. This psychological distress can diminish motivation to exercise, as individuals may perceive outdoor environments as threatening. Furthermore, the study revealed that individuals with pre-existing health conditions, such as asthma or cardiovascular issues, are particularly sensitive to air quality, further exacerbating their reluctance to engage in outdoor physical activity.

The concept of self-efficacy, a key component of SCT, plays a crucial role in understanding how individuals respond to environmental challenges. Exercise self-efficacy refers to an individual's confidence in their ability to engage in physical activity despite obstacles. Research has shown that individuals with high exercise self-efficacy are more likely to persist in their exercise routines, even when faced with adverse environmental conditions (Kolokotsa et al., 2020). Conversely, low self-efficacy can lead to avoidance behaviors, as individuals may doubt their ability to exercise safely in polluted environments.

Obstacle self-efficacy, which involves an individual's perception of their ability to overcome specific challenges and barriers, is also critical in this context. Chang and Bodnar (2024) found that individuals who believe they can navigate the challenges posed by air pollution—such as finding safe times to exercise or selecting less polluted routes—are more likely to engage in outdoor activities. Prior experiences, social support, and access to information about air quality can influence this perception.

Effect expectations, or the anticipated outcomes and benefits of exercising, significantly influence participation in physical activity. Wei-Ching (2023) emphasizes that individuals who perceive the benefits of exercise—such as improved mood, physical health, and social interaction—are more likely to engage in outdoor activities, even in less-than-ideal conditions. However, when air quality is poor, these positive expectations may be overshadowed by concerns about health risks, leading to decreased motivation to exercise outdoors.

Social support is another critical factor influencing exercise behavior in polluted environments. Gorman et al. (2021) highlight that both objective support (material assistance) and subjective support (emotional encouragement) can positively correlate with exercise behavior. Individuals who receive encouragement from friends, family, or community groups are more likely to persist in their exercise routines, even when faced with environmental challenges. This support can help mitigate the psychological impacts of air pollution, fostering a sense of community and shared responsibility for health.

The interplay between environmental factors and psychological constructs is further complicated by demographic variables. Research indicates that age, socioeconomic status, and health conditions can significantly influence how individuals perceive and respond to air quality issues (Cheng et al., 2022; Tota et al., 2024). For instance, older adults or those with pre-existing health conditions may be more sensitive to air pollution and, as a result, may be less likely to engage in outdoor exercise, regardless of their psychological or social support levels. This variability underscores the need for targeted interventions that consider individual differences in resilience and coping strategies (Jin et al., 2022).

Moreover, the psychological impacts of air pollution extend beyond individual behavior to broader societal contexts. Public health initiatives must address the environmental barriers directly while also considering the psychological and social dimensions of exercise behavior. For example, creating safe and accessible indoor exercise environments can provide alternatives for individuals deterred from outdoor exercise due to air quality concerns. Promoting community centers or gyms that offer programs tailored to individuals who may be affected by pollution can help maintain physical activity levels during high pollution periods (Bernasconi et al., 2022; Ciuti et al., 2015; Yang, et al., 2024).

Community awareness and education regarding the health impacts of air pollution and the benefits of physical activity are also essential (Manisalidis et al., 2020). By providing individuals with information about safe exercise practices during high pollution days, communities can empower residents to make informed decisions about their physical activity. This could include recommendations for optimal times to exercise outdoors when air quality is better or promoting alternative indoor activities that can be pursued during poor air quality days.

In summary, air pollution significantly impacts outdoor exercise behavior through various psychological mechanisms, including self-efficacy, obstacle self-efficacy, effect expectation, and social support. The interplay between these factors and individual demographic characteristics creates a complex landscape that influences how individuals navigate the challenges of exercising in polluted environments. Future research should continue to explore these dynamics, focusing on the interplay between environmental factors, individual variability, and community support systems. By doing so, we can develop more effective public health strategies that encourage individuals to maintain their physical activity levels, ultimately contributing to their overall health and well-being.

MATERIALS AND METHODS

Research Object

The study employed a quantitative research design utilizing a questionnaire method to gather participant data. A total of 300 questionnaires were distributed randomly to individuals across various demographics to ensure a diverse sample. The sampling process involved selecting participants from different community centers, gyms, and outdoor recreational areas to capture a wide range of perspectives on outdoor exercise behavior in polluted conditions. After the distribution, 290 questionnaires were successfully recovered, resulting in an effective response rate of 96.6%. Among these, 280 questionnaires were deemed valid for analysis, ensuring a robust dataset for the study.

Based on SCT, the research subjects were categorized into three groups: those who engage in outdoor physical exercise regardless of weather conditions, those who only exercise outdoors in favorable weather, and those who do not participate in outdoor physical activity at all. As shown in Figure 2, Group 1 consisted of 67 individuals who continued to exercise outdoors even in polluted conditions. Group 2 included 114 participants who only exercised outdoors when the weather was good, while Group 3 was made up of 99 people who did not engage in outdoor physical exercise. Figures 1 and 2 visually represent the classification and grouping of the survey participants.

Figure 1. Classification of respondents

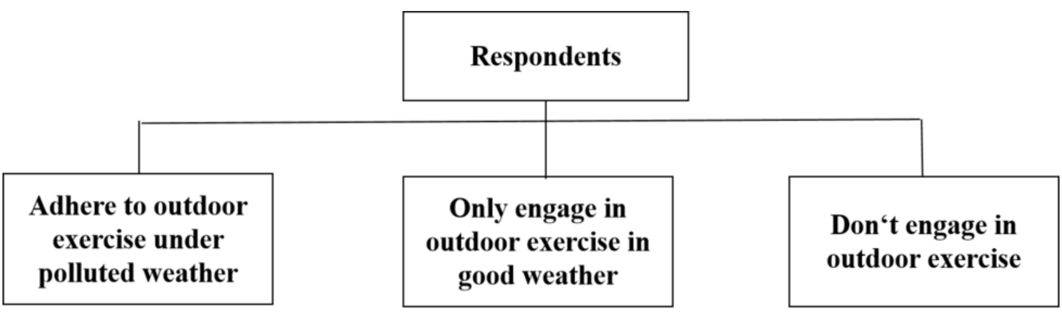
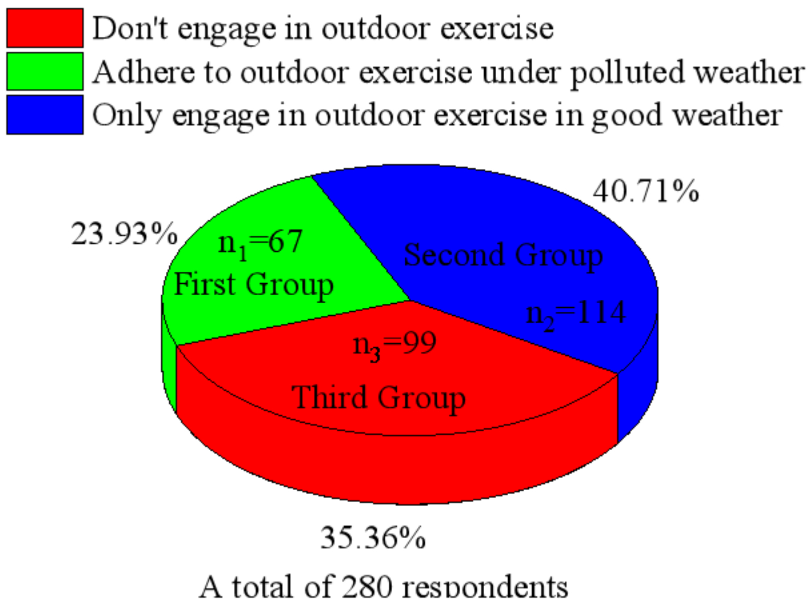


Figure 2. Number and grouping of respondents



The demographic variables of the three groups of respondents are analyzed. Difference statistical analysis and descriptive statistical methods are adopted to compare the differences among the demographic variables of the three groups of respondents. One-way analysis of variance (ANOVA) was adopted to analyze the psychosocial factors (air quality cognition, exercise self-efficacy, obstacle self-efficacy, effect expectation, and social support) of the three groups and to explore the statistical difference between the social cognitive psychological factors and exercise behavior of Groups 1 and 2.

Regression analysis and correlation analysis were employed to examine the statistical relationships between the social cognitive psychological factors and outdoor exercise behavior in Groups 1 and 2. Correlation analysis was first used to identify potential linear relationships between variables such as exercise self-efficacy, obstacle self-efficacy, effect expectation, social support, and outdoor exercise behavior. Pearson's correlation coefficient was calculated to determine the strength and direction of these associations. In contrast, regression analysis was conducted to explore how well these psychosocial factors, specifically effect expectation, predicted outdoor exercise behavior. A multiple linear regression model was used to assess the contribution of each predictor, adjusting for potential confounding demographic variables. The choice of these methods was grounded in SCT, which posits that psychological factors (e.g., self-efficacy, outcome expectations) influence an individual's behavior, including health-related activities like outdoor exercise. Using regression and correlation analyses, we sought to determine whether SCT could provide a reasonable framework for understanding how psychosocial factors influence exercise behavior under different environmental conditions, including polluted weather.

Statistical measures like *p*-values and correlation coefficients are commonly used to assess the significance of a relationship between variables. A *p*-value below 0.05 indicates that the relationship is statistically significant, meaning there is enough evidence to reject the null hypothesis (no relationship). The correlation coefficient (r) quantifies the strength and direction of a relationship between two variables, with values ranging from -1 (perfect negative) to 1 (perfect positive). A correlation of 0.3 or higher is typically considered moderate to strong, suggesting a meaningful relationship.

In regression analysis, key statistics include *B* (unstandardized beta coefficient), which indicates the change in the dependent variable for a one-unit change in a predictor, and β (standardized beta coefficient), which shows the change in standard deviations. The *T*-statistic tests whether the coefficient is significantly different from zero, with a larger absolute value suggesting significance, while the *P*-value indicates the statistical significance of the coefficient (typically, a *P*-value less than 0.05 is considered significant). The value R^2 represents the proportion of variance in the dependent variable explained by the model, with higher values indicating a better fit. The *F*-statistic tests the overall model's significance, and *F* value change measures the improvement in model fit when adding predictors. These statistics collectively assess both the strength and significance of the model and its individual predictors.

Method

There are mainly six types of questionnaires.

- **Demographic variables table** (Medina Luis et al., 2020): collects information about respondent gender, age, education level, and income, with gender and age being the primary demographic variables
- **Exercise self-efficacy scale** (Haghighi et al., 2018): designed by Macaulay and assesses a subject's confidence in exercising for more than 40 minutes, five times a week. A six-month study analyzed this exercise behavior. The questions are scored from 0 (*giving up directly*) to 100 (*full confidence*). The total confidence score is obtained by summing the responses and dividing by the number of questions.
- **Obstacle self-efficacy scale** (Li et al., 2023): evaluates individuals' confidence in their ability to persist in specific activities, such as outdoor exercise. It consists of five items and employs Likert's five-point scoring method, with scores ranging from 1 (*no confidence*) to 5 (*extremely confident*).
- **Effect expectation scale** (Xie et al., 2023): designed by Resnick et al., uses Likert's five-point scoring method, with scores ranging from 1 (totally disagree) to 5 (totally agree)
- **Social support scale** (Yu et al., 2024): comprises 10 items, each with a distinct scoring method. The total score is calculated by summing the scores of all items. The scale utilizes Likert's five-point scoring method, with responses ranging from 1 (*none*) to 5 (*full support*). It demonstrates clear logic and unity among the items and shows good internal consistency.
- **Air quality questionnaire** (Jiang et al., 2024): focuses on three primary questions, as follows.
    1. What do you think of the perennial air quality in your area?
    2. Do you pay attention to the air quality index on the days when you engage in outdoor physical exercise?
    3. When air pollution is serious, can indoor exercise achieve the same effect as outdoor exercise?

The reliability analysis of the demographic variable scale, exercise self-efficacy scale, obstacle self-efficacy scale, effect expectation scale, and social support scale has been verified in many studies. Therefore, only the reliability of the air quality questionnaire is tested to avoid the waste of resources caused by repeated research. The air quality questionnaire is distributed to 50 subjects and redistributed 10 days later to test–retest reliability. Table 1 shows the results.

Table 1. Test–retest reliability of air quality cognition questionnaire

Question	People with the same answers	People with different answers	*R* value	*P* value
1	48	2	0.861	$P < 0.01$
2	49	1	0.884	$P < 0.01$
3	47	3	0.857	$P < 0.01$

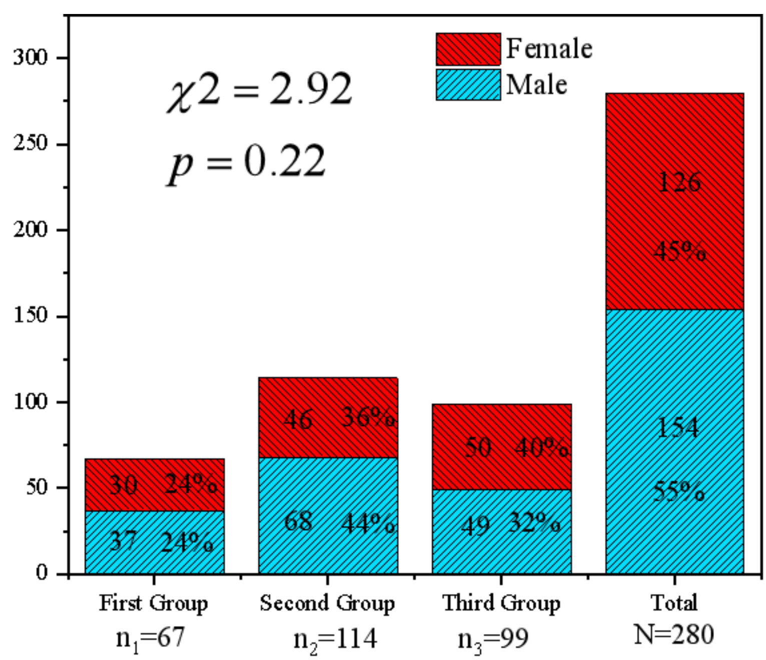
Note: The R value represents the Pearson correlation coefficient, indicating the degree of consistency between the two test administrations. A higher R value signifies stronger reliability. The P value indicates the statistical significance of the observed correlation, with values less than 0.01 indicating a highly significant result. The data suggest strong test-retest reliability for the Air Quality Cognition Questionnaire.

Analysis of Demographic Variables

Gender Results

Figure 3 illustrates the demographic distribution of the 280 participants, consisting of 154 individuals who identified as male (55% of the total respondents) and 126 individuals who identified as female (45% of the total respondents). Among these, Group 1 comprised 67 participants, including 37 individuals who identified as male (55.2%) and 30 individuals who identified as female (44.8%). Group 3 included 99 participants, consisting of 49 individuals who identified as male (49.5%) and 50 individuals who identified as female (50.5%). A chi-square test was conducted, yielding a *p*-value of 0.22, which is greater than 0.05. This result indicates that the gender distribution across groups was consistent, with no significant difference observed.

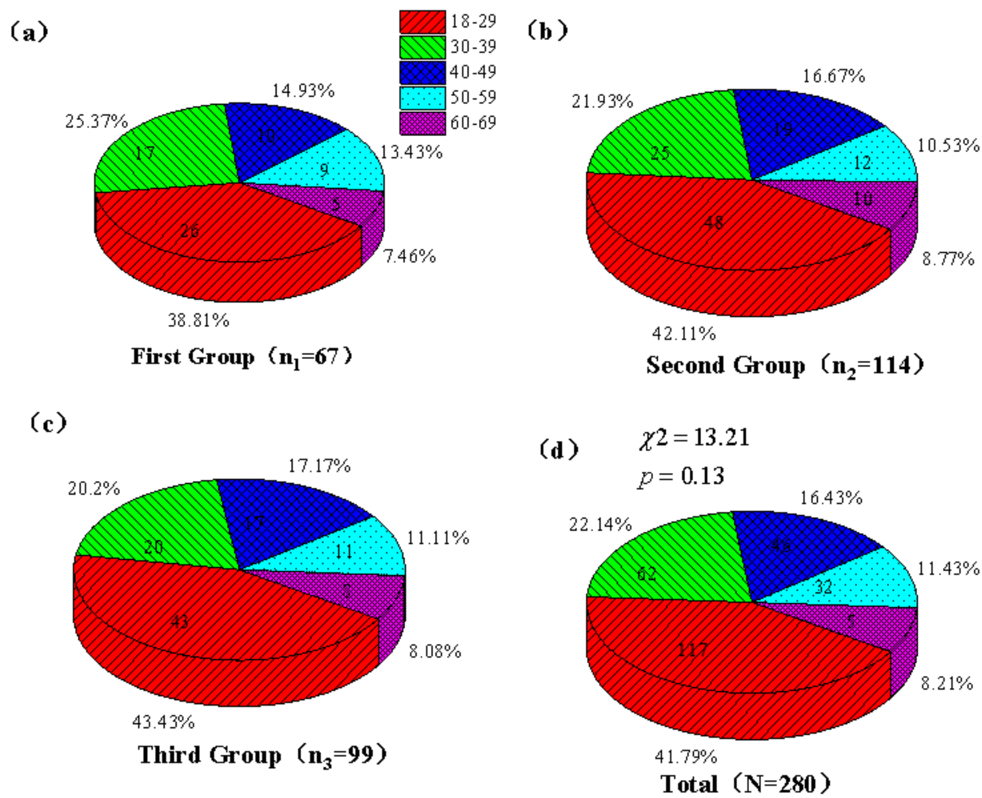
Figure 3. Gender distribution of respondents



Age Distribution

Figure 4 illustrates the respondents in this survey were categorized into five age groups: 18–29 years, 30–39 years, 40–49 years, 50–59 years, and 60–69 years. Figure 4 illustrates that, within the three groups, the number of participants in each age category decreases as age increases. The largest group is the 18–29 age group, with 117 participants, accounting for 41.79% of the total respondents. Conversely, the 60–69 age group has the fewest participants, accounting for just 8.21% of the total. A chi-square test was performed, yielding a *p*-value of 0.11, which is greater than 0.05, indicating little age-related variation between groups.

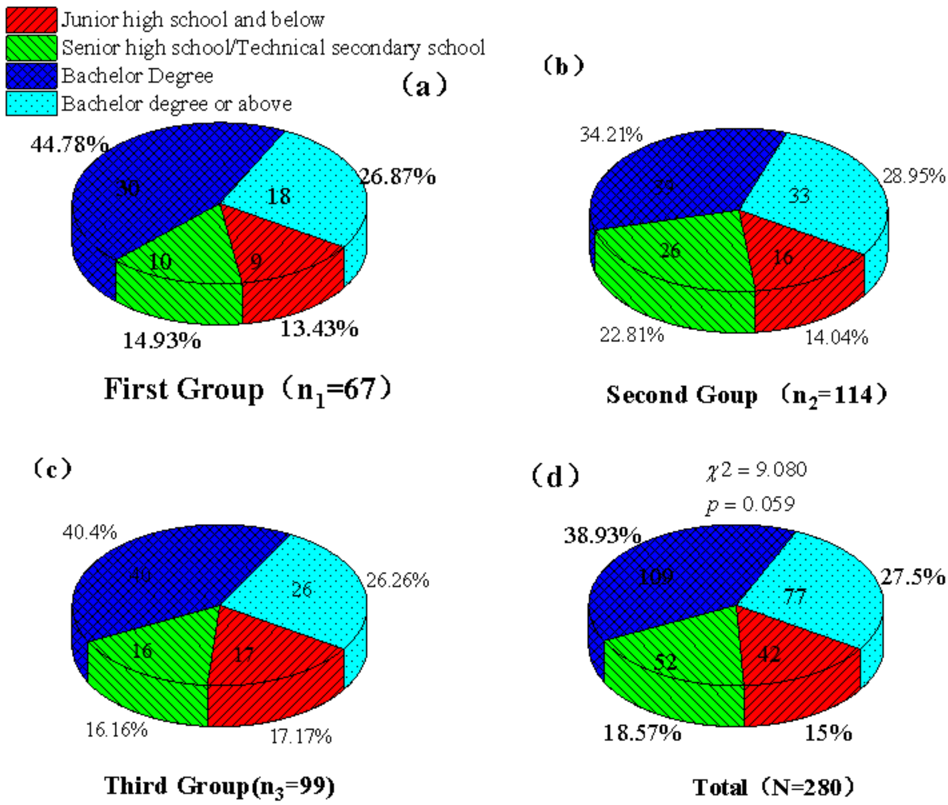
Figure 4. Age distribution of respondents: (a) group 1, (b) group 2, (c) group 3, and (d) total



Educational Level

Figure 5 illustrates the distribution of respondent education levels, categorized into four groups: junior high school and below, senior high school or technical secondary school, bachelor's degree, and above bachelor's degree. The majority of respondents had relatively high levels of education, with 66.43% holding a bachelor's degree or higher. A chi-square test yielded a *p*-value of 0.059, which is greater than 0.05. This suggests that the distribution of education levels across groups was relatively consistent, with no significant differences observed.

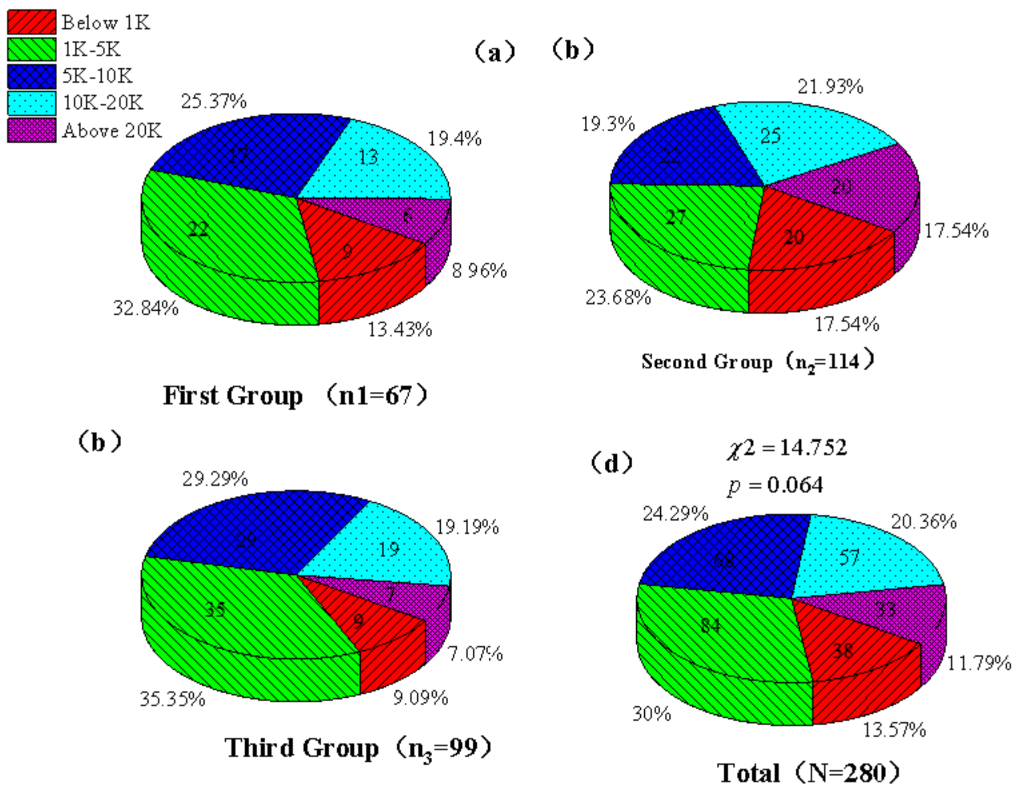
Figure 5. Distribution of educational level of respondents: (a) group 1, (b) group 2, (c) group 3, and (d) total



Income Level

Figure 6 displays the distribution of respondent income, categorized into five levels: below 1,000 RMB, 1,000–5,000 RMB, 5,001–10,000 RMB, 10,001–20,000 RMB, and above 20,000 RMB. The largest proportion of respondents falls within the 1,000–5,000 income range, representing 30% of the total. The lowest proportions are found in the below-1,000 and above-20,000 categories. Most respondents (74.65%) fall within the 1,000–20,000 range. A chi-square test revealed a p-value of 0.064, which is greater than 0.05, indicating that the distribution of income levels is relatively consistent across groups, with no significant differences in income proportions among the respondents.

Figure 6. Distribution of income level of respondents: (a) group 1, (b) group 2, (c) group 3, and (d) total



Analysis of the Relationship Between Outdoor Exercise Behavior and Psychosocial Factors in Polluted Conditions

Correlation Analysis

A Pearson correlation test was conducted to explore the relationships between outdoor exercise levels and psychosocial factors among individuals who continue to engage in outdoor exercise despite air pollution. This analysis involved the following factors.

- Independent variables: psychosocial factors (exercise self-efficacy, obstacle self-efficacy, effect expectation, social support, and air quality awareness)
- Dependent variable: exercise level
- Covariates: demographic variables (e.g., age, gender, education, income) were included to control for their potential confounding effects

Table 2 presents a summary of the correlation analysis results.

Table 2. Correlation analysis of exercise behavior of people who still insist on outdoor exercise under the condition of air pollution

	Exercise level	Exercise self-efficacy	Obstacle self-efficacy	Effect expectation	Social support	Air quality awareness
Exercise level		0.01	-0.03.	-0.02.	0.18*.	-0.08.
Exercise self-efficacy			-0.04.	0.06.	0.03.	0.03.
Obstacle self-efficacy					-0.21*.	0.08.
Effect expectation			0.23*.		-0.20*.	0.09.
Social support						-0.01.

*$P < 0.05$; **$p < 0.01$.

From the correlation analysis, we observe a significant positive correlation between exercise level and social support ($r = 0.18$, $p < 0.05$), indicating that individuals with higher levels of social support are more likely to engage in outdoor exercise, even in polluted conditions. However, other psychosocial factors, such as exercise self-efficacy, air quality awareness, and obstacle self-efficacy, do not show statistically significant correlations with exercise behavior in this sample. This suggests that while these factors may influence exercise behavior, their effects could be mediated by other variables not accounted for in this analysis, or their impact may be less pronounced in environments with pollution.

Regression Analysis

A linear regression analysis was conducted with exercise level as the dependent variable and social support as the independent variable, aiming to explore whether psychosocial factors can predict the exercise behavior of individuals who continue to engage in outdoor exercise under polluted weather conditions. The results of the regression analysis are presented in Table 3.

Table 3. Prediction and analysis of psychosocial factors on exercise level

	B	β	*T*	*P*	R^2	*F* value change
Social support	0.06	0.03	1.75	0.34		

*$P < 0.05$; **$p < 0.01$.

Note:B: Unstandardized regression coefficient, representing the change in the dependent variable for a one-unit change in the predictor variable.β: Standardized regression coefficient, which shows the strength and direction of the relationship between the predictor and the dependent variable in standard deviation units.T: t-value, used to determine the significance of the predictor variable. P: p-value, indicating the statistical significance of the predictor (typically, a p-value < 0.05 is considered significant).

R^2: Coefficient of determination, representing the proportion of variance in the dependent variable explained by the independent variables. F value change: Change in the F-statistic between models, used to assess whether the addition of a new predictor significantly improves the model.

The data in the table show that social support does not significantly predict the exercise level of individuals who exercise outdoors in polluted conditions ($p = 0.34$, which is greater than the 0.05 threshold for significance). The *B* value of 0.06 suggests a very small effect, and the β coefficient of

0.03 indicates an almost negligible influence of social support on exercise behavior in this context. This indicates that social support alone does not provide a meaningful explanation for exercise levels under polluted weather conditions, suggesting that other factors might be more influential or that the relationship could be more complex than indicated by this model.

Analysis of the Relationship Between Outdoor Exercise Behavior Under Good Weather Conditions and Psychosocial Factors

Correlation Analysis

To explore the relationship between outdoor exercise behavior and psychosocial factors, we conducted a Pearson correlation analysis on Group 2. The analysis includes psychosocial factors as independent variables, outdoor exercise level as the dependent variable, and demographic variables as covariates. The demographic variables were controlled for in order to isolate the effects of psychosocial factors on outdoor exercise behavior. The results are summarized in Table 4.

Table 4. Correlation analysis of exercise behavior of people who insist on outdoor exercise only in good weather

	Exercise level	Exercise self-efficacy	Obstacle self-efficacy	Effect expectation	Social support	Air quality awareness
Exercise level		0.01	-0.03.	0.21*.	-0.15	0.01
Exercise self-efficacy			-0.07.	-0.08.	-0.00	0.04
Obstacle self-efficacy					-0.09	0.09
Effect expectation			0.06*.		-0.14	0.11
Social support						0.02

*$P < 0.05$; **$p < 0.01$.

The correlation analysis revealed that there is a significant positive correlation between outdoor exercise level and effect expectation ($r = 0.21$, $p < 0.05$), suggesting that individuals who anticipate greater benefits from exercise are more likely to engage in outdoor exercise when the weather is favorable. However, no significant correlations were found between exercise level and other psychosocial factors, such as exercise self-efficacy, obstacle self-efficacy, and social support. This indicates that these factors may not play a significant role in predicting outdoor exercise behavior for this group.

Regression Analysis

Building on the correlation analysis, a regression analysis was conducted to examine whether effect expectation significantly predicts outdoor exercise levels among participants who engage in outdoor exercise only under good weather conditions. The regression results are presented in Table 5.

Table 5. Prediction analysis of psychosocial factors on exercise level

	B	β	T	P	R^2	F value change
Social support	3.16	0.25	2.01	0.03*	0.35	17.77**

*$P < 0.05$; **$p < 0.01$.

The regression results indicate that effect expectation is a significant predictor of outdoor exercise level ($p = 0.03$, $p < 0.05$), with individuals with higher expectations about exercise benefits more likely to engage in outdoor exercise under good weather conditions. Specifically, the B value of 3.16 suggests that, for each unit increase in effect expectation, the exercise level increases by 3.16 units on the scale used. The β coefficient of 0.25 indicates a moderate effect, with effect expectation explaining 35% of the variance in outdoor exercise behavior ($R^2 = 0.35$). Additionally, the F value of 17.77 ($p < 0.01$) shows that the regression model is highly significant, fitting the data well and accounting for a substantial portion of the variability in exercise behavior.

RESULTS AND ANALYSIS

Analysis of Exercise Level and Air Quality Cognition of Respondents

A one-way Analysis of Variance (ANOVA) was conducted to examine the differences in psychosocial factors(including air quality cognition, exercise self-efficacy, obstacle self-efficacy, effect expectation, and social support)among the three groups of respondents. On this basis, multiple Turkey tests are conducted on the indicators with significant differences. Table 6 and Figure 7 show the results of one-way ANOVA of social psychosocial factors. Table 7 and Figure 8 show the results of the air quality cognition analysis of the respondents.

Table 6. Results of one way ANOVA of psychosocial factors of respondents (± standard deviation)

	Group 1	Group 2	Group 3	*P*-value
Exercise level	±11.23.	±14.13.	±10.28.	
Exercise self-efficacy	±2.56.	±4.01.	±3.27.	< 0.05
Obstacle self-efficacy	±1.57.	±2.78.	±4.65.	< 0.05
Effect expectation	±3.88.	±4.77.	±4.44.	< 0.05
Social support	±2.91.	±2.65.	±13.67.	< 0.05

Figure 7. Analysis results of exercise level of respondents (M)

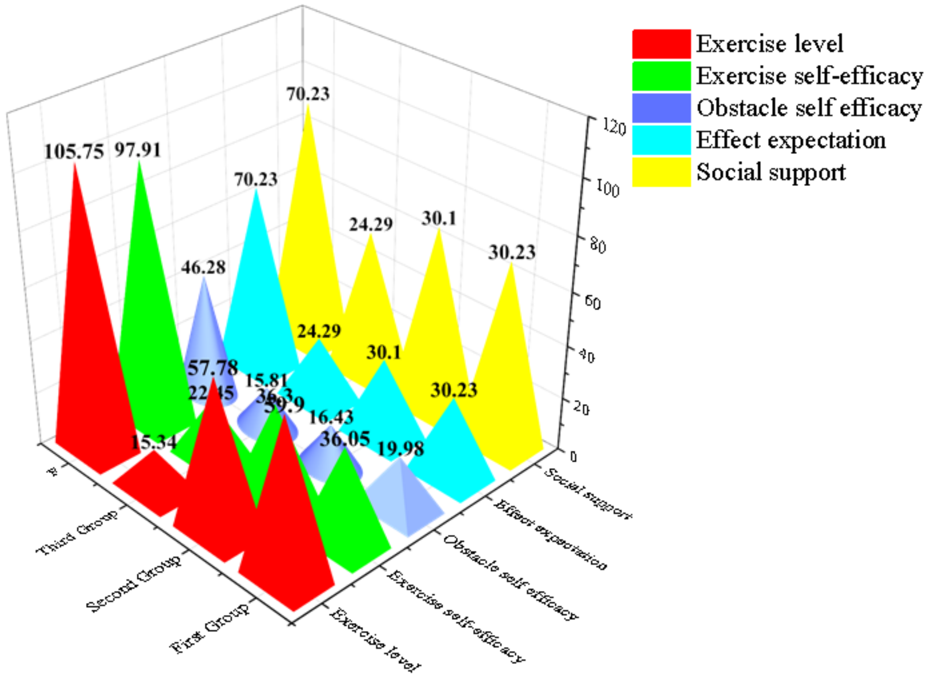
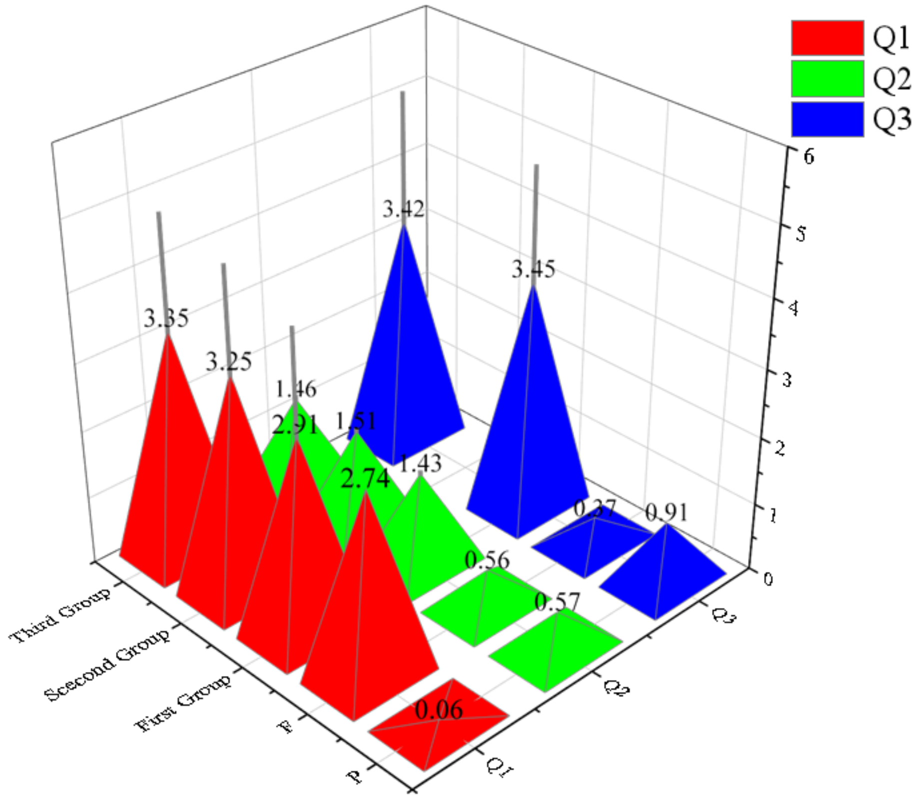


Table 7. Results of cognitive ANOVA of air quality of respondents (± standard deviation)

Question	Group 1	Group 2	Group 3	*P*-value
1	±1.45	±1.45	±1.56	0.06
2	±0.56	±0.56	±0.56	0.57
3	±1.57	±1.58	±1.76	0.91

Figure 8. Cognitive analysis results of air quality of respondents (*M*)



There is little difference in air quality cognition among the three respondent groups for Question 1 ($p = 0.06$), Question 2 ($p = 0.57$), and Question 3 ($p = 0.91$). However, significant differences were found in exercise self-efficacy ($p < 0.05$), exercise effect expectation ($p < 0.05$), obstacle self-efficacy ($p < 0.05$), and social support ($p < 0.05$). Post-hoc Tukey's tests were conducted to further explore these differences.

Effect of Exercise Self-Efficacy on Outdoor Exercise Behavior

A post-hoc Tukey's test was conducted to examine the differences in exercise self-efficacy among the three groups. Table 8 shows no significant difference in exercise self-efficacy between Groups 1 and 2 ($p > 0.05$). However, there were significant differences between Groups 1 and 3 and Groups 2 and 3. Specifically, the difference between Groups 1 and 3 was 13.6 ($p < 0.05$), indicating that Group 1 had significantly higher scores than Group 3. Similarly, the difference between Groups 2 and 3 was 13.85 ($p < 0.05$), showing that Group 2's score was also significantly higher than that of Group 3.

Table 8. Post-hoc multiple turkey test results of exercise self-efficacy

	Group 1	Group 2	Group 3
Group 1		-0.25 (0.53)	13.6* (0.00)
Group 2			13.85* (0.00)
Group 3			

*$P < 0.05$; **$p < 0.01$.

Effect of Barrier Self-Efficacy on Outdoor Exercise Behavior

A post-hoc Tukey's test was conducted to examine the differences in obstacle self-efficacy among the three groups. The results presented in Table 9 indicate significant differences in barrier self-efficacy scores between groups. Specifically, Group 1 showed significantly higher barrier self-efficacy scores than both Group 2 (difference = 3.55, $p < 0.05$) and Group 3 (difference = 4.17, $p < 0.05$). There was no significant difference between Groups 2 and 3 regarding barrier self-efficacy (difference = 0.62, $p > 0.05$), suggesting that these groups have similar levels of perceived barriers to outdoor exercise. Thus, Group 1 demonstrated significantly higher self-efficacy in overcoming barriers to outdoor exercise compared to the other two groups, while Groups 2 and 3 did not differ significantly from each other.

Table 9. Post-hoc multiple turkey test results of obstacle self-efficacy

	Group 1	Group 2	Group 3
Group 1		3.55* (0.00)	4.17* (0.00)
Group 2			0.62 (0.25)
Group 3			

*$P < 0.05$; **$p < 0.01$.

The Impact of Effect Expectation on Outdoor Exercise Behavior

A post-hoc multiple Turkey analysis was conducted to examine the differences in effect expectation scores among the three respondent groups. The results are presented in Table 10.

Table 10. Post-hoc multiple turkey test results of effect expectation

	Group 1	Group 2	Group 3
Group 1		0.12 (0.47)	5.92* (0.00)
Group 2			5.79* (0.00)
Group 3			

*$P < 0.05$; **$p < 0.01$.

The effect expectation scores between Groups 1 and 2 were nearly identical, with a non-significant difference (difference = 0.12, $p = 0.47$), suggesting that the level of effect expectation does not differ meaningfully between these two groups. A significant difference is observed between Group 1 and Group 3 (difference = 5.92, $p < 0.05$). This indicates that Group 3 had a significantly lower level of effect expectation compared to Group 1. Similarly, Group 2 also showed a significant difference in effect expectation compared to Group 3 (difference = 5.79, $p < 0.05$), with Group 3 again exhibiting lower effect expectation scores. In summary, Groups 1 and 2 had nearly identical and significantly higher effect expectation scores than Group 3, which demonstrated the lowest level of effect expectation. No significant difference was found between Groups 1 and 2.

Influence of Social Support on Outdoor Exercise Behavior

A post-hoc multiple Turkey analysis was conducted to examine the differences in social support scores among the three respondent groups. The results are presented in Table 11.

Table 11. Post-hoc multiple turkey test results of social support

	Group 1	Group 2	Group 3
Group 1		-0.008 (0.93)	14.21*(0.00)
Group 2			14.27*(0.00)
Group 3			

*$P < 0.05$; ** $p < 0.01$.

The difference in social support levels between Group 1 and Group 2 is minimal, with a value of -0.008 ($p = 0.93$). Since the p-value is greater than 0.05, we conclude that there was no statistically significant difference in social support between these two groups. A significant difference was observed between Group 1 and Group 3 (difference = 14.21, $p < 0.05$), with Group 3 reporting much lower levels of social support compared to Group 1. Similarly, Group 2 also showed a significant difference in social support levels compared to Group 3 (difference = 14.27, $p < 0.05$), indicating that Group 3 had significantly lower social support than Group 2. In conclusion, Groups 1 and 2 exhibited similar, higher levels of social support compared to Group 3, which had significantly lower levels of social support. No significant difference in social support was found between Groups 1 and 2.

Effect of Air Quality Cognition on Outdoor Exercise Behavior

A multiple Turkey analysis was conducted to examine the differences in exercise mode conversion among the three respondent groups. The results are presented in Table 12, showing the pairwise differences in exercise mode conversion, along with the corresponding p-values.

Table 12. Post-hoc multiple turkey test results of exercise mode conversion

	Group 1	Group 2	Group 3
Group 1		0.10 (0.40)	0.27* (0.01)
Group 2			0.17 (0.13)
Group 3			

*$P < 0.05$; **$p < 0.01$.

There is no significant difference in the exercise mode conversion between Group 1 and Group 2 (difference = 0.10, $p = 0.40$). Since the p-value is greater than 0.05, this indicates that the change in exercise mode was similar between these two groups. A significant difference is observed between Group 1 and Group 3 (difference = 0.27, $p = 0.01$). Group 1 had a significantly higher level of exercise mode conversion compared to Group 3. The difference between Group 2 and Group 3 was not statistically significant (difference = 0.17, $p = 0.13$), suggesting that the exercise mode conversion between these two groups is comparable. In conclusion, Group 1 showed significantly higher exercise mode conversion compared to Group 3, while there was no significant difference between Group 1 and Group 2 or between Group 2 and Group 3.

DISCUSSION

The findings of this study reveal critical insights into the relationship between outdoor exercise behavior and the social and psychological factors that typically motivate individuals to engage in physical activity, particularly under polluted conditions. Despite the initial hypothesis that factors such as self-efficacy, outcome expectations, and social support would significantly influence outdoor exercise behavior, the results indicated no significant relationships in the context of air pollution. This outcome is particularly noteworthy, as it challenges the prevailing assumptions about the role of psychological and social constructs in motivating exercise in adverse environmental conditions.

One possible explanation for the absence of significant relationships could be the overwhelming impact of environmental factors, particularly air quality, which may act as a primary deterrent to outdoor exercise. Research has consistently shown that individuals perceive air pollution as a significant barrier to physical activity, often prioritizing their health and safety over psychological factors (Bratman et al., 2021; Lohmann et al., 2023). In polluted environments, the immediate health risks associated with outdoor exercise may overshadow the motivational influences of self-efficacy and social support. Individuals may feel that regardless of their confidence or the encouragement they receive from their social networks, the potential health risks of exercising outdoors in poor air quality are too great to ignore.

Limitations

Furthermore, the study's reliance on self-reported measures of exercise behavior and psychosocial factors may have introduced bias, potentially obscuring the true nature of these relationships. Self-reported data can be influenced by various factors, including social desirability bias, where individuals may overstate their exercise levels or the extent of their social support. This bias can lead to overestimating the positive influences of psychological factors on exercise behavior. Additionally, recall bias may affect the accuracy of self-reported exercise frequency and duration, particularly in individuals who may not regularly engage in physical activity. Future research should consider incorporating objective measures of physical activity, such as wearable fitness trackers or accelerometers, to provide a more accurate assessment of exercise levels and better understand the interplay between environmental conditions and psychological factors.

To enhance the reliability of future research, it is recommended that subsequent studies incorporate objective behavioral measures, such as data collected from wearable fitness trackers or accelerometers. These devices can provide accurate and continuous data on exercise frequency, duration, and intensity, thereby reducing the potential biases associated with self-reports. Wearable devices offer several advantages over self-reported measures, including the ability to monitor steps taken, distance traveled, and active minutes throughout the day, as well as capturing the intensity of physical activity. This objective data can help mitigate biases associated with self-reporting, such as social desirability bias and recall bias. By integrating these objective measures, researchers can gain a clearer understanding of how psychosocial factors, such as exercise self-efficacy and social support, interact with actual exercise behaviors in polluted environments. This approach not only enhances the validity of the research findings but also provides a more comprehensive view of the factors influencing outdoor exercise behavior.

Practical Implications

The lack of significant findings also raises questions about the variability in individual responses to air pollution. While some individuals may possess high self-efficacy and strong social support networks, others may not experience the same level of resilience when faced with environmental challenges. This variability could be influenced by demographic factors, such as age, socioeconomic status, and health conditions, which may affect how individuals perceive and respond to air quality issues. For instance, older adults or those with pre-existing health conditions may be more sensitive to air pollution and, as a result, may be less likely to engage in outdoor exercise, regardless of their psychological or social support levels.

Moreover, the implications of these findings extend beyond individual behavior to broader societal contexts, particularly in the realms of sports, preventive healthcare, and the environment-human interface. Understanding that social and psychological factors may not significantly influence outdoor exercise behavior under polluted conditions suggests a need for targeted interventions that address environmental barriers directly.

Recommendations for Public Health Initiatives

To mitigate the effects of air pollution on outdoor exercise, public health initiatives could focus on creating safe and accessible indoor exercise environments, especially during periods of high pollution. This could involve promoting community centers or gyms that offer programs tailored to individuals who may be deterred from outdoor exercise due to air quality concerns. Additionally, local governments could implement policies that improve air quality, such as increasing green spaces, promoting public transportation, and reducing vehicle emissions.

Furthermore, fostering community awareness and education regarding the health impacts of air pollution and the benefits of physical activity is essential. By providing individuals with information about safe exercise practices during high pollution days, communities can empower residents to make informed decisions about their physical activity. This could include recommendations for optimal times to exercise outdoors when air quality is better or promoting alternative indoor activities that can be pursued during poor air quality days.

CONCLUSION

This study reveals that while psychological factors such as self-efficacy, outcome expectations, and social support are often considered critical motivators for outdoor exercise, their influence diminishes significantly in poor air quality. The findings suggest that environmental factors, particularly air pollution, serve as primary deterrents to physical activity, overshadowing the motivational effects of psychological constructs. This challenges the prevailing assumptions about the role of social and psychological factors in promoting exercise under adverse conditions.

The variability in individual responses to air pollution highlights the need for targeted public health interventions that address environmental barriers directly. Future research should explore the interplay between environmental conditions and psychological factors more comprehensively, potentially incorporating objective measures of physical activity to enhance the accuracy of findings.

Moreover, public health initiatives should focus on creating safe indoor exercise environments, especially during high pollution periods, to encourage physical activity. By understanding the limitations of psychological influences in polluted settings, we can develop more effective strategies to promote healthier lifestyles, ensuring that individuals remain active despite environmental challenges. This approach supports individual health and contributes to broader societal efforts in combating the negative impacts of air pollution on public health.

DATA AVAILABILITY

The figures and tables used to support the findings of this study are included in the article.

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