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# The Relationship between Exercise and Psychotic Symptoms in College Students: A Cross-Sectional Analysis

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## ABSTRACT

An increasing number of studies have suggested that increased physical activity is associated with less mental illness. However, the relationship between exercise and psychotic experiences (PEs) is still unknown. The purpose of this study was to explore the relationship between exercise and PEs in college students in the United States. Data from the Health Mind Survey (2020–2021 round) were analyzed. Respondents included 137,916 college students who were asked about exercise and PEs (lifetime psychotic experiences, delusions, and hallucinations). A multivariate logistic regression analysis was used to investigate the relationship between exercise and PEs while controlling for demographic characteristics. There was a significant correlation between exercise and PEs among college students. Compared to students who exercised less than one hour per week, students who exercised five or more hours per week had fewer lifetime psychotic experiences. This same finding obtained for both male and female college students. The findings from the present study indicate that exercising for five or more hours each week is most correlated with decreased PEs among college students. However, experimental studies are required to extend and confirm our findings and determine the causality of this relationship.

## KEYWORDS

Exercise; psychotic experience; mental health; delusion; hallucination; college students

## Introduction

Since the earliest study of the high incidence of schizophrenia in Chicago by Faris and Denham [1], many studies have confirmed that many adolescents with psychotic experiences (PEs) (one of the manifestations of mental abnormalities) have a greater risk of developing psychiatric disorders in adulthood [2]. Psychotic symptoms refer to subclinical symptoms such as hallucinations or delusions that are precursors to psychosis or mental disorders [3]. In the past decade, population complaints of PEs have attracted researchers' attention. A meta-analysis of 61 studies estimated that 2.5% of young adults experienced PEs annually [4]. Evidence-based research has found that the prevalence of PEs youth ranges from 8% to 24% [5,6]. Recent studies have reported that the prevalence of PEs in

college students is 16% in the U.S. [7], 24% in the United Kingdom, 13% in China, and 20% in Japan [6]. PEs are common in adolescence, often co-occur with mental disorders [8–11], and may increase the risk of depression, anxiety, and substance abuse during adolescence [12–14], and of psychosis later in life [15]. Some studies have found that PEs are correlated with various factors, such as sex, age, and mental health (depression, stress, and anxiety) [6,16]. College-aged students in particular are at the peak age of onset for mental problems, especially depression and anxiety [17–19]. They usually face a lot of social and academic pressure that can lead to psychopathology [20]. The stress from mental disorders can activate the hypothalamic pituitary adrenal axis that can result in psychosis [21,22].

Prior research has found that adolescents with psychosis are more likely to have comorbidities than those without



psychosis [23]. Psychosis is also correlated with unhealthy lifestyles, such as poor diet, lack of exercise, and smoking [24,25]. Indeed, there is accumulating evidence suggesting that exercise is positively correlated with health outcomes (e.g., depression, cognitive preservation, reduced risk of chronic disease, and associated comorbidities) in different age groups [26–32]. More specifically, studies have also found positive correlations between physical activity (PA) and mental health (e.g., depression, anxiety, and stress) and quality of life in adolescents [33–35]. A handful of studies have studied the relationship between PA and psychotic disorders in young adults [15,36]. For example, Stubbs et al. found a negative correlation between PA and psychosis in young adults living in low- and middle-income countries (LMIC) [37,38]. Additionally, Eills et al. found that exercise lasting for 10 to 12 weeks was correlated with better mental health in young people with psychosis [25]. As PEs have been found to precede the development of psychotic disorders [17], it is necessary to develop a better understanding of how to decrease the risk of PEs in adolescents, particularly college students.

To date, some research has investigated the relationship between PA, or exercise, and PEs. Exercise, as a form of PA, is structured and planned to develop and enhance physical fitness [39]. Large-scale longitudinal studies have found that engaging in sports is negatively correlated with PEs in the general population. It is unclear whether the relationship between exercise and PEs exists in college students, and whether it generalizes to students in high-income countries (e.g., the United States). The present study will address these two gaps in the literature.

## Methods

### Design and sample

For this cross-sectional study, data from the Healthy Minds Study (HMS) were retrieved and analyzed by accessing the following link (<https://healthymindsnetwork.org>). This survey was administered using an internet-based method to university students at 79 universities in the United States between 2020 and 2021. A detailed description of the survey methods can be found elsewhere [3,40]. In brief, a random sampling method was employed to obtain a sample of 4,000 respondents aged 18 or greater from each university. If a university had fewer than 4,000 students, all recruited students from that university were included. The survey response rate was 16%. The Health Sciences and Behavioral Sciences Institutional Review Board at the University of Michigan approved this HMS protocol.

### Exercise

Participants answered one question about exercise: “In the past one month, how many hours weekly on average did you spend exercising? (Involving any moderate or vigorous exercise, where “moderate exercise” was roughly equivalent to brisk walking or biking)”. This question had the following answer options: “<1 h”, “2–3 h”, “3–4 h” and “5 h or more”. The amount of time spent exercising each week was considered a predictor variable, which was in line with the previous study [40].

### Psychotic symptoms

Psychotic symptoms were considered the criterion variables in this study. Psychotic symptoms were assessed via the brief version of the World Health Organization Composite International Diagnostic Interview Psychosis Screen [3]. Participants were instructed to answer “yes” or “no” to the following four questions: (1) delusional mood: “A feeling something strange and unexplainable was going on that other people would find hard to believe?”; (2) delusion of

TABLE 1

### Sample characteristics

Variables	n = 137916	Mean/%	
Age	137916	23.56 ± 7.23	
Sex	Male	39387	28.6%
	Female	98269	71.3%
	Transgender	63	0.0%
	Missing	197	0.1%
Race	African American/ Black	16501	12.0
	American Indian or Alaskan Native	1577	1.1
	Asian American	19090	13.8
	Hispanic/Latino	13953	10.1
	Native Hawaiian or Pacific Islander	403	0.3
	Middle Eastern, Arab, or Arab American	2774	2.0
	White	81478	59.1
	Other	1403	1.0
	Missing	737	0.6
	International student	Yes	9137
No		128232	93.0
Missing		547	0.4
Exercise	Less than 1 h	38670	28.0
	2–h	24569	17.8
	3–4 h	16953	12.3
	≥5 h	41069	29.8
	Missing	16625	12.1
Lifetime psychotic experience	Yes	35523	25.8
	No	86556	62.8
	Missing	15837	11.5
Delusions	Yes	34728	25.2
	No	87199	63.2
	Missing	15989	11.6
Hallucinations	Yes	5291	3.8
	No	116767	84.7
	Missing	15858	11.5

reference and persecution: “A feeling that people were too interested in you or that there was a plot to harm you?”; (3) delusion of control: “A feeling that your thoughts were being directly interfered or controlled by another person, or your mind was being taken over by strange forces?”; and (4) hallucinations: “An experience of seeing visions or hearing voices that others could not see or hear when you were not half asleep, dreaming, or under the influence of alcohol or drugs?” The affirmation of any of these questions was coded as having experienced a psychotic experience in one’s lifetime, with the affirmation of questions (1), (2), or (3) coded as having experienced delusions, and the affirmation of question (4) coded as having experienced hallucinations. Each participant was also instructed to answer “yes” or “no” in response to whether they had experienced any of the above within the past year.

#### Control variables

Control variables comprised the demographic characteristics of age, sex, race, and international student status (yes/no). Sex was coded as male, female, transgender, and other. Race was coded as African American/Black, American Indian or Alaskan Native, Asian American/Asian, Hispanic/Latino (a), Native Hawaiian or Pacific Islander, Middle Eastern, Arab, or Arab American, White, and other.

#### Statistical analysis

The statistical analyses in this cross-sectional study were done with SPSS 25.0 (IBM, Armonk, NY, USA). Values of  $p < 0.05$  (two-tailed) were considered statistically significant. Descriptive statistics were used to explore the study respondents’ characteristics and prevalence of psychotic symptoms. A multivariate logistic regression analysis was used to investigate the relationship between exercise and psychotic symptoms, controlling for demographic characteristics (age, sex, race, and international student status). Less than one hour of exercise per week and no PEs were considered the reference groups in each logistic regression analysis. Odds ratios (OR) with 95% confidence intervals were considered as outcomes.

#### Results

The study’s sample consisted of 137,916 college students with a mean age of  $23.56 \pm 7.23$ . The sample characteristics are presented in Table 1. Seventy one per cent of the students were female. With regard to exercise, 28% of the students exercised less than one hour a week, 18% exercised two to three hours a week, 12% exercised three to four hours a week, and 30% exercised five or more hours a week. With regard to lifetime psychotic experiences, 26% of students

TABLE 2

Association between exercise and psychotic symptoms estimated by multivariate logistic regression

Variables	Lifetime psychotic experience				Delusions				Hallucinations				
	<i>p</i>	OR	95% CI		<i>p</i>	OR	95% CI		<i>p</i>	OR	95% CI		
Age	0.00	0.964	0.962	0.966	0.00	0.964	0.961	0.966	0.00	0.964	0.961	0.966	
Sex	Reference				Reference				Reference				
	Female												
	Male	0.31	0.99	0.96	1.01	0.36	0.99	0.96	1.02	0.36	0.99	0.96	1.02
	Transgender	0.00	4.72	2.46	9.04	0.00	4.39	2.31	8.34	0.00	4.39	2.31	8.34
International students	No	0.21	0.97	0.91	1.02	0.30	0.97	0.92	1.03	0.30	0.97	0.92	1.03
Race	Reference				Reference				Reference				
	African American/Black												
	American Indian or Alaskan Native	0.19	1.08	0.96	1.21	0.22	1.08	0.96	1.21	0.22	1.08	0.96	1.21
	Asian American	0.00	0.66	0.62	0.69	0.00	0.66	0.63	0.69	0.00	0.66	0.63	0.69
	Hispanic/Latino	0.00	0.82	0.78	0.87	0.00	0.82	0.78	0.87	0.00	0.82	0.78	0.87
	Native Hawaiian or Pacific Islander	0.37	1.11	0.89	1.38	0.31	1.12	0.90	1.39	0.31	1.12	0.90	1.39
	Middle Eastern, Arab, or Arab American	0.00	0.74	0.67	0.82	0.00	0.75	0.68	0.83	0.00	0.75	0.68	0.83
	White	0.00	0.65	0.63	0.68	0.00	0.65	0.63	0.68	0.00	0.65	0.63	0.68
	Other	0.01	1.19	1.05	1.34	0.02	1.17	1.03	1.32	0.02	1.17	1.03	1.32
Exercise	Reference				Reference				Reference				
	<1 h												
	2–3 h	0.00	0.91	0.88	0.95	0.00	0.92	0.89	0.95	0.00	0.88	0.81	0.95
	3–4 h	0.00	0.85	0.82	0.89	0.00	0.86	0.82	0.89	0.00	0.80	0.74	0.85
	5 h or more	0.00	0.85	0.83	0.88	0.00	0.86	0.83	0.89	0.00	0.77	0.71	0.85

reported lifetime psychotic experiences, with 25% reporting delusions, and 4% reporting hallucinations.

**Table 2** depicts the results of the multivariate logistic regression analysis on the relationship between exercise and psychotic symptoms. Five or more hours of weekly exercise was significantly correlated with lower odds of lifetime psychotic experience (OR = 0.85, 95% CI [0.83, 0.88]) compared to less than one hour of weekly exercise, when controlling for all covariates. This correlation was consistent across the subtypes of psychotic experience: delusions (OR = 0.86, 95% CI [0.83, 0.89]) as well as hallucinations (OR = 0.77, 95% CI [0.71, 0.85]), controlling for all covariates.

**Table 3** displays the results of the multivariate logistic regression analysis on the relationship between exercise and psychotic symptoms by sex. Male students who exercised five or more hours per week had significantly lower odds of lifetime psychotic experience (OR = 0.85, 95% CI [0.80, 0.90]), including delusions (OR = 0.85, 95% CI [0.80, 0.91]) and hallucinations (OR = 0.76, 95% CI [0.63, 0.90]), compared to men who exercised less than one hour a week, when controlling for all covariates. Similarly, female students who exercised five or more hours a week also had significantly lower odds of lifetime psychotic experience (OR = 0.85, 95% CI [0.82, 0.89]), including delusions (OR = 0.86, 95% CI [0.83, 0.89]), and hallucinations (OR = 0.76, 95% CI [0.69, 0.83]), compared to women who exercised less than one hour a week, when controlling for all covariates.

## Discussion

To the best of our knowledge, this is the largest study to date to have explored the relationship between exercise and PEs among college students in the U.S. In summary, our study

found that exercising five or more hours a week was inversely related to the risk of PEs (lifetime PE, delusions, and hallucinations) in college students compared to exercising less than one hour a week, when adjusting for all variables. This finding held when comparing male students to female students.

The finding of low lifetime PE risk in college students being strongly correlated with five or more hours of weekly exercise is in line with prior research [41]. For instance, a meta-analysis of 20 studies suggested that individuals with schizophrenia who engaged in 90 or more minutes of weekly exercise could significantly reduce their PE [41]. Firth et al. also found that 10-week of exercise produced a positive improvement in psychotic symptoms [42], and previous studies have reported that exercise alleviates hallucinations in the general population and in adults with psychiatric disorders [43,44]. Similarly, a cross-sectional study found that less exercise or being immobile was correlated with poor mental health and delusions in patients with psychotic disorders [45], and a longitudinal study by Suetani et al. also found that not exercising during adolescence was correlated with an increased risk of delusional ideation in the six subsequent years [46]. This study's findings indicated that college students in particular who exercised for five or more hours a week had a low risk of experiencing delusions and hallucinations.

Despite the fact that the effective mechanism of exercise on psychosis is unknown, several explanations may be plausible. From a psychological perspective, previous studies have proposed that diverting attention from negative stimuli could enhance mental health during and after exercise [47,48]. Moreover, exercise is characterized by the development of close social relationships (e.g., communication opportunities and cooperation) and mutual

TABLE 3

Association between exercise and psychotic symptoms estimated by multivariate logistic regression in sex

	Male				Female				Other			
	<i>p</i>	OR	95% CI		<i>p</i>	OR	95% CI		<i>p</i>	OR	95% CI	
<b>Lifetime psychotic experience</b>												
<1 h		Reference				Reference				Reference		
2–3 h	0.082	0.94	0.88	1.01	0.000	0.91	0.87	0.95	0.145	7.84	0.49	12.52
3–4 h	0.000	0.86	0.80	0.93	0.000	0.86	0.83	0.90	0.991	1.01	0.10	10.18
5 h or more	0.000	0.85	0.80	0.90	0.000	0.85	0.82	0.89	0.935	0.92	0.13	6.59
<b>Delusions</b>												
<1 h		Reference				Reference				Reference		
2–3 h	0.144	0.95	0.88	1.02	0.000	0.91	0.87	0.95	0.000	0.91	0.88	0.95
3–4 h	0.000	0.87	0.80	0.94	0.000	0.85	0.81	0.89	0.000	0.85	0.82	0.89
5 h or more	0.000	0.85	0.80	0.91	0.000	0.86	0.83	0.89	0.000	0.85	0.83	0.88
<b>Hallucinations</b>												
<1 h		Reference				Reference				Reference		
2–3 h	0.000	0.83	0.71	0.98	0.010	0.89	0.81	0.97	0.871	1.21	0.13	11.63
3–4 h	0.000	0.87	0.77	0.99	0.000	0.78	0.70	0.87	0.779	0.68	0.05	9.96
5 h or more	0.000	0.76	0.63	0.90	0.000	0.76	0.69	0.83	0.339	0.31	0.03	3.38

support between individuals, which could play an essential role in the correlation between exercise and psychotic symptoms [49]. From a physiological perspective, neurobiological chemicals may be an important variable in psychotic symptoms. Some research has suggested that mental problems (e.g., stress and depression) are correlated with decreased brain derived neurotrophic factor (BDNF) levels [50,51]. In contrast, exercise can contribute to the regulation of BDNF levels to normal or pre-stress levels, although the stress-induced increase can result in the downregulation of BDNF levels. Furthermore, exercise has also been found to increase the release of endorphins that produce a relaxation effect and increase the availability of hormones to reduce psychotic symptoms [52], producing a possible explanation for this study's finding that greater exercise is correlated with fewer psychotic symptoms.

The findings from the present study may raise concerns that college students are at high risk for psychotic experiences, and that college mental counselors should encourage greater weekly exercise to improve student mental health. Several weaknesses in this study should caution against such a causal recommendation. First, the correlational nature of this study prevents the identification of a causal relationship between exercise and psychotic symptoms. Second, this study focuses exclusively on a sample of college students in the U.S., thus further studies need to assess whether this correlation generalizes to older populations and those of other high-income countries. Third, the survey relied on self-report questionnaires that might under or overestimate the relationship between psychotic symptoms and exercise [53]. Fourth, the response rate was 16%, which may have resulted in sampling bias and generalization limitations.

## Conclusion

This study adds to an emerging body of literature interested in identifying and reducing psychotic symptoms as precursors to the development of psychotic disorders, by showing that exercising five or more hours a week is correlated with fewer psychotic symptoms among college students.

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