ORIGINAL RESEARCH

Intensity of Physical Activity and Depressive Symptoms in College Students: Fitness Improvement Tactics in Youth (FITYou) Project

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Purpose: To investigate whether the physical activity at different intensities is correlated with depressive symptoms in college students.

Patient and Methods: This cross-sectional study was a part of the Fitness Improvement Tactics in Youth Project, which was conducted in 2017. A total of 2,820 college freshmen aged 15–24 years were included in this study, of whom 699 (24.8%) were males and 2,121 (75.2%) were females. Depressive symptoms were measured using the Self-rating Depression Scale. Physical activity was assessed using the International Physical Activity Questionnaire-Short Form. Covariates included sociodemographic, lifestyle-related, and health-related factors.

Results: A total of 560 (19.9%) college students had depressive symptoms. Total physical activity levels (METs•hour/week) were positively associated with frequency of breakfast intake ($p = 0.050$) but no other participant characteristics. Logistic regression analysis showed that the prevalence of depressive symptoms in the highest quartile of physical activity was lower than in the lowest quartile when adjusted for sex, age, ethnicity, only child, smoking status, alcohol use, breakfast frequency, daily sleep duration, body mass index, grip strength, and the number of metabolic syndrome components (odds ratios [95% confidence intervals (CI)]: 0.75 [0.58, 0.98], $p = 0.036$). Furthermore, high physical activity levels of low-intensity tended to moderately correlate to lower prevalence of depressive symptoms (odds ratios [95% CI]: Q1, 0.71 [0.55, 0.91], Q2, 0.77 [0.59, 1.01], Q3, 0.75 [0.57, 0.98], p for trend = 0.037). Associations of moderate and vigorous physical activity with depressive symptoms were not found. For secondary outcomes, sex-stratified analysis showed that similar findings were only found in females, but not males.

Conclusion: This study indicated that total physical activity and low-intensity physical activity were inversely associated with depressive symptoms in Chinese college students. All these observations showed gender differences.

Keywords: physical activity intensity, mental health, Chinese youth, cross-sectional study

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Introduction

Depressive disorders are the most common mood disorders in young adults aged 18–35 years.[1] The main clinical characteristics of depression are sadness, loss of interest, low sense of self-worth, slow response, lack of sleep or appetite, poor concentration, and severe fatigue.[2] Depression can seriously damage an individual's ability to work, learn or cope with daily life. As depression becomes more severe, it may lead to suicide.[3] For the youth, who aged between 15 and 24 years,[4] college

life is an important period in their life because they face great pressure due to academic rigour, economic stress, interpersonal relationship and future employment.[5] Data indicated that depressive symptoms are correlated with an increased prevalence of cardiovascular diseases and all-cause mortality in Chinese adults.[6] In China, the lifetime prevalence of depression was 6.9%, the prevalence of depression was higher in female, and those individuals with aged 18–34 years had a higher prevalence of depression than adults aged 35–49 years.[1] However, a meta-analysis showed that the incidence rate of depressive symptoms was 23.8% among 32,694 Chinese university students from 1997 to 2015.[7] This meta-analysis also revealed that depressive symptoms among medical students is worse than non-medical students for Chinese college students.[7] These findings suggested that effective preventive strategies are of great significance in lowering the prevalence of depressive symptoms in youth.

Some studies have reported that depressive symptoms were affected by some factors, such as higher levels of smartphone use,[8] social media use,[9] and misperceptions of weight,[10] in college students. Moreover, fewer outdoor activities and physical activities, short duration and poor quality of sleep, and less breakfast frequently were also associated with higher depressive symptoms scores in Chinese college students.[11] It is important to note that increasing evidence has shown that lifestyle interventions targeting physical activity can improve depressive symptoms in youth. Specifically, a study of 11,110 adolescents from 10 European countries showed that the frequency of physical activity was negatively correlated with depressive symptoms.[12] In addition, a study of 2,444 Chinese adolescents showed that the more physical activity performed per week, lower the prevalence of depressive symptoms.[13] So far, however, few studies have analyzed the association between exercise intensity and depressive symptoms. Tsujita et al suggested that the lower levels of physical activity could be associated with higher levels of depressive symptoms, including daily steps, duration and amount of moderate to vigorous-intensity physical activity in healthy young adults.[14] A longitudinal study of 8 weeks showed high-intensity interval training and sprint interval training similarly improved depressive symptoms in 36 healthy women.[15] Besides, a 6-week intervention study showed both high-intensity interval training and moderate continuous training can reduce depressive symptoms in university students.[16] Moreover, a randomized controlled trial of 18 sessions indicated that high-intensity interval training can improve depression, activity states, cardiovascular functions

compared to conventional moderate-intensity continuous training in 44 patients with myocardial infarction.[17] Also, an 8-week aerobic exercise of moderate-intensity could lower depressive symptoms among individuals with major depressive disorder aged 18 to 30 years.[18] These experimental studies revealed a causal relationship between exercise and depressive symptoms in youth.

Although these previous studies have demonstrated the association between physical activity intensity and depressive symptoms, further study is needed due to limited and inconsistent evidence. Therefore, the purpose of this study is to investigate whether physical activity intensity is associated with depressive symptoms in Chinese college students.

Patients and Methods
Study Participants
We utilized baseline data from the Fitness Improvement Tactics in Youth (FITYou) project for the current study. FITYou aimed to clarify the impact of socioeconomic, lifestyle, physiological status, and metabolic regulation on the health-related quality of life and health status of college students. The project was carried out in September 2017 in Shenyang, China.[19,20] A total of 4,717 college students were invited to participate in the project, of which 4,323 students provided written informed consent for data analysis (response rate = 91.6%). Additional written informed consent from a parent or legal guardian was required for participants under 18 years of age.

Of the participants, data on health checkups from 218 students were not available, 436 had missing depressive symptoms data, and 684 students were missing physical activity data. Among the remaining 2,985 students, data on sex (n=3), age (n=32), only child status (n=7), smoking status (n=14), drinking status (n=27), breakfast frequency (n=18), sleep duration (n=38), body mass index (BMI) (n=6), and Metabolic syndrome (MetS) components (n=20) were incomplete. As a consequence, data for a total of 2,820 students were eventually included in the analysis (Figure S1). The study was carried out following the Helsinki Declaration[21] to protect the rights and personal safety of participants. The research plan was approved by the Ethics Committee of the College of Education, Zhejiang University.

Assessment of Depressive Symptoms
The Self-rating Depression Scale (SDS)[22] was used to evaluate depressive symptoms. The evaluation criteria

are: "1" indicates no time or very little time, "2" indicates sometimes, "3" indicates most of the time, and "4" indicates most or all of the time. Added the total score of these 20 questions and multiply by 1.25 to get the standard score, which indicates depressive symptoms while greater than 53 according to the Chinese version of SDS.[23]

Assessment of Physical Activity

Physical activity was measured by the International Physical Activity Questionnaire-Short Form (IPAQ-SF). Participants were instructed to consider all areas of physical activity during the past week. The questionnaire asked participants to indicate how many days they spent in walking, moderate-intensity and high-intensity activities, and how long they spent in these activities daily.[24] Total physical activity was calculated by metabolic equivalents (METs)·hour/week and the calculation formula for the total physical activity per week described as (daily walking hours × days of walking per week ×3.3) + (daily moderate activity hours × days of moderate activity per week ×4.0) + (daily vigorous activity hours × days of vigorous activity per week ×8.0). Total physical activity levels were divided into quartiles for analysis based on its distribution. According to IPAQ-SF, physical activity including low-intensity (walking), moderate-intensity (moderate activity), and high-intensity (vigorous activity). Physical activity levels in three different intensity were calculated and then divided into quartiles, respectively.

Relevant Covariates

Covariates included sociodemographic, lifestyle-related, and health-related factors. Potential covariates related to demographics and lifestyle-related factors were collected by self-report questionnaire. Age was calculated based on the date of birth and ethnicity was summarized as Han or other. Lifestyle-related information was acquired through multiple-choice questions, including smoking status (current, former, or never smoking), drinking status (current drinker, non-drinker), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours). Height, weight, and grip strength were measured in health examinations by medical practitioners, and BMI was calculated from these data. The definition of each component of metabolic syndrome was based on the 2009 American Heart Association scientific statement.[25]

Statistical Analysis

Analysis of variance or X^2 test for continuous and categorical variables were used to describe the characteristics of participants based on physical activity level. Categorical variables were presented as number and percentages, and continuous variables were presented as means and standard deviations.

Logistic regression analysis was used to obtain a linear trend between physical activity level and depressive symptoms, and data were shown as odds ratios and 95% confidence intervals (CIs). Covariance analysis includes three statistical models adjusted according to covariates, taking the relationship between gender and physical activity intensity into account. Model 1 adjusted for sex, age, ethnicity, and only child status. Model 2 added lifestyle-related variables including smoking status, alcohol use, breakfast frequency, and daily sleep duration. Model 3 adjusted for model 2 plus BMI, grip strength, and the number of metabolic syndrome components. All tests were two-tailed, and a p-value <0.05 was considered statistically significant. IBM SPSS Statistics 22.0 software for MAC (IBM Corp, Armonk, NY, USA) was used for the statistical analysis in this study.

Results
Participants' Characteristics

Participant characteristics according to physical activity level are summarized in Table 1. A total of 2,820 college freshmen aged 15–24 years were included in this study, of whom 699 (24.8%) were males and 2,121 (75.2%) were females. There were no significant differences in BMI, smoking status, alcohol use, sleep duration, and metabolic syndrome components among students with different physical activity levels. The number of people who ate breakfast 6–7 times a week occupied the highest proportion among all levels of physical activity, and the lowest frequency was 4–5 times a week.

Association Between Total Physical Activity Levels and Depressive Symptoms

Table 2 shows the relationship between physical activity levels and depressive symptoms in participants before and after adjusting for potential covariates. In the univariate model, participants with physical activity at the Q2 level had the lowest prevalence of depressive symptoms, while participants at the Q3 level had relatively more depressive symptoms (p for trend = 0.008). In general, higher physical activity levels were associated with a lower prevalence of depressive symptoms.

Table 1 Participants' Characteristics According to Physical Activity Levels in College Freshmen (n=2820)

Variable [a]	Quartiles of Total Physical Activity Levels				
	Q1	Q2	Q3	Q4	p value [b]
Range, METs·hour/week	<27.0	27.0–58.0	58.1–113.0	>113.0	
Participants, no. (%)	699 (24.8)	710 (25.2)	703 (24.9)	708 (25.1)	
Sex (female), no. (%)	525 (75.1)	547 (77.0)	508 (72.3)	541 (76.4)	0.164
Age (years) (SD)	18.1 (0.85)	18.1 (0.80)	18.1 (0.75)	18.1 (1.01)	0.550
Han ethnicity, no. (%)	586 (83.8)	601 (84.6)	591 (84.1)	584 (82.5)	0.727
Only child, yes (%)	410 (58.7)	410 (57.7)	397 (56.5)	400 (56.5)	0.810
BMI (kg/m^2) (SD)	21.8 (4.0)	21.7 (3.9)	21.8 (4.2)	21.6 (3.8)	0.650
Smoking status					
Never, no. (%)	674 (96.4)	686 (96.6)	667 (94.9)	683 (96.5)	
Former, no. (%)	11 (1.6)	11 (1.5)	21 (3.0)	8 (1.1)	
Current, no. (%)	14 (2.0)	13 (1.8)	15 (2.1)	17 (2.4)	0.209
Alcohol use (yes), no. (%)	76 (10.9)	86 (12.1)	91 (12.9)	93 (13.1)	0.557
Breakfast (times/week)					
<4, no. (%)	155 (22.2)	114 (16.1)	132 (18.8)	118 (16.7)	
4–5, no. (%)	111 (15.9)	111 (15.6)	99 (14.1)	106 (15.0)	
6–7, no. (%)	433 (61.9)	485 (68.3)	472 (67.1)	484 (68.4)	0.050
Sleep duration (hours/day)					
<6, no. (%)	173 (24.7)	173 (24.4)	169 (24.0)	168 (23.7)	
6–7, no. (%)	264 (37.8)	263 (37.0)	259 (36.8)	273 (38.6)	
7–8, no. (%)	192 (27.5)	216 (30.4)	209 (29.7)	203 (28.7)	
≥8, no. (%)	70 (10.0)	58 (8.2)	66 (9.4)	64 (9.0)	0.961
Grip strength, kg (SD)	26.7 (7.8)	26.8 (7.8)	27.4 (8.5)	27.0 (8.1)	0.281
MetS components, no. (SD)	1.2 (0.47)	1.2 (0.49)	1.2 (0.49)	1.2 (0.42)	0.216

Notes: [a]Categorized variables were presented as number and percentages, and continuous variables were presented as means standard deviations); [b]Analysis of variance or X^2 test, as appropriate.
Abbreviations: BMI, body mass index; MetS, metabolic syndrome.

Table 2 Association Between Total Physical Activity Levels and Depressive Symptoms in College Freshmen (n=2820)

	Quartiles of Total Physical Activity Levels				
	Q1, n=699	Q2, n=710	Q3, n=703	Q4, n=708	p value [a]
Range, METs·hour/week	<27.0	27.0–58.0	58.1–113.0	>113.0	
Depressive symptoms, no.	169	124	137	130	
Non-adjusted model	1.00 (ref)	0.66 (0.51, 0.86)	0.76 (0.59, 0.98)	0.71 (0.55, 0.91)	0.008
Adjusted model 1 [b]	1.00 (ref)	0.66 (0.51, 0.86)	0.77 (0.60, 0.99)	0.70 (0.54, 0.90)	0.007
Adjusted model 2 [c]	1.00 (ref)	0.70 (0.53, 0.91)	0.80 (0.62, 1.03)	0.73 (0.56, 0.95)	0.033
Adjusted model 3 [d]	1.00 (ref)	0.70 (0.54, 0.92)	0.80 (0.62, 1.04)	0.75 (0.58, 0.98)	0.050

Notes: [a]p value was obtained by using logistic regression analysis, and data were shown as odds ratios and 95% confidence interval; [b]Adjusted for sex (male, female), age (continuous variable), ethnicity (Han ethnicity, others), and only child (yes, no); [c]Adjusted for model 1 plus smoking status (never, former, current), alcohol use (yes, no), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours); [d]Adjusted for model 2 plus body mass index (continuous variable), grip strength (continuous variable), and number of metabolic syndrome components.

Table 3 Sex-Specific Association Between Total Physical Activity Levels and Depressive Symptoms in College Freshmen (n=2820)

Males	Quartiles of Total Physical Activity Levels				
	Q1, n=174	Q2, n=163	Q3, n=195	Q4, n=167	p value [a]
Depressive symptoms, no.	34	19	38	28	
Non-adjusted model	1.00 (ref)	0.54 (0.30, 1.00)	1.00 (0.60, 1.67)	0.83 (0.48, 1.44)	0.182
Adjusted model 1 [b]	1.00 (ref)	0.55 (0.30, 1.02)	1.03 (0.61, 1.72)	0.83 (0.48, 1.45)	0.184
Adjusted model 2 [c]	1.00 (ref)	0.57 (0.31, 1.07)	0.99 (0.58, 1.70)	0.82 (0.46, 1.45)	0.278
Adjusted model 3 [d]	1.00 (ref)	0.55 (0.29, 1.04)	1.02 (0.60, 1.76)	0.85 (0.48, 1.52)	0.223
Females	Q1, n=525	Q2, n=547	Q3, n=508	Q4, n=541	
Depressive symptoms, no.	135	105	99	102	
Non-adjusted model	1.00 (ref)	0.69 (0.51, 0.92)	0.70 (0.52, 0.94)	0.67 (0.50, 0.90)	0.017
Adjusted model 1 [b]	1.00 (ref)	0.66 (0.52, 0.92)	0.77 (0.53, 0.95)	0.70 (0.49, 0.89)	0.017
Adjusted model 2 [c]	1.00 (ref)	0.73 (0.54, 0.98)	0.74 (0.55, 1.00)	0.70 (0.52, 0.94)	0.064
Adjusted model 3 [d]	1.00 (ref)	0.74 (0.55, 1.00)	0.74 (0.54, 1.00)	0.72 (0.53, 0.97)	0.083

Notes: [a]p for linear trend was obtained by using logistic regression analysis, and data were shown as odds ratios and 95% confidence interval; [b]Adjusted for age (continuous variable), ethnicity (Han ethnicity, others), and only child (yes, no); [c]Adjusted for model 1 plus smoking status (never, former, current), alcohol use (yes, no), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours); [d]Adjusted for model 2 plus body mass index (continuous variable), grip strength (continuous variable), and number of metabolic syndrome components.

The trend was significant and similar after adjusting all potential covariates (p for trend =0.050), but as the number of adjusted covariates increased, the significance gradually decreased. Regarding the sex-specific association between total physical activity levels and depressive symptoms shown in Table 3, the relationship between physical activity level and depressive symptoms in males was insignificant in the univariate model (p for trend=0.182), while higher physical activity level was significantly associated with a lower prevalence of depressive symptoms in females (p for trend = 0.017).

Association Between Physical Activity Intensity and Depressive Symptoms

Table 4 shows the relationship between physical activity intensity and depressive symptoms before and after adjusting for covariates. There was a significant association between low-intensity physical activity and depressive symptoms after adjusting all covariates (p for trend =0.037). However, this result was not seen among those who engaged in moderate-intensity (p for trend = 0.461) and vigorous-intensity physical activity (p for trend = 0.608). Similarly, the sex-specific analysis showed that low-intensity physical activity levels were inversely associated with depressive symptoms in female students (Table 6). There was no significant correlation between physical activity intensity and depressive symptoms in male students (Table 5).

Discussion

In this cross-sectional study, we investigated the relationship between physical activity and depressive symptoms among college freshmen. Results indicated that students with higher total physical activity levels tended to have a lower prevalence of depressive symptoms after adjusting for all potential confounding factors. Moreover, higher low-intensity physical activity level is associated with a lower prevalence of depressive symptoms. All these observations showed gender differences.

Many studies supporting that a higher level of physical activity is inversely associated with depressive symptoms,[26,27] which was consistent with our results. A follow-up study of 2,134 college students showed that insufficient physical activity was significantly associated with depressive symptoms.[26] Furthermore, a study including 43,499 college students indicated that physically active students experienced lower rates of depressive symptoms.[27] Similar to our study, the results of these two large-scale studies show a weak correlation between physical activity level and depressive symptoms, suggesting that increased physical activity engagement contributes to lower the prevalence of depressive symptoms in youth. On the other hand, previous findings on the relationship between physical activity intensity and depressive symptoms were inconsistent. Motl et al reported that low-intensity exercise is effective in improving depressive symptoms among sedentary older adults,[28] which supported the results of the current

Table 4 Association Between Physical Activity Intensity and Depressive Symptoms in College Freshmen (n=2820)

Physical Activity Intensity	Quartiles of Physical Activity at Different Intensity Levels				
Low intensity	**Q1, n=773**	**Q2, n=774**	**Q3, n=651**	**Q4, n=622**	***p* value** [a]
Range, METs·hour/week	<9.9	9.9–23.1	23.2–46.2	>46.2	
Depressive symptoms, no.	184	138	121	117	
Non-adjusted model	1.00 (ref)	0.70 (0.54, 0.89)	0.73 (0.57, 0.95)	0.74 (0.57, 0.96)	0.014
Adjusted model 1 [b]	1.00 (ref)	0.70 (0.54, 0.89)	0.72 (0.55, 0.93)	0.72 (0.55, 0.93)	0.010
Adjusted model 2 [c]	1.00 (ref)	0.71 (0.56, 0.92)	0.77 (0.59, 1.00)	0.74 (0.57, 0.97)	0.035
Adjusted model 3 [d]	1.00 (ref)	0.71 (0.55, 0.91)	0.77 (0.59, 1.01)	0.75 (0.57, 0.98)	0.037
Moderate intensity	**Q1, n=731**	**Q2, n=665**	**Q3, n=730**	**Q4, n=694**	
Range, METs·hour/week	<3.3	3.3–9.3	9.4–26.0	>26.0	
Depressive symptoms, no.	168	127	133	132	
Non-adjusted model	1.00 (ref)	0.79 (0.61, 1.03)	0.75 (0.58, 0.96)	0.79 (0.61, 1.02)	0.100
Adjusted model 1 [b]	1.00 (ref)	0.79 (0.61, 1.03)	0.76 (0.59, 0.98)	0.79 (0.61, 1.02)	0.121
Adjusted model 2 [c]	1.00 (ref)	0.87 (0.67, 1.13)	0.79 (0.61, 1.02)	0.86 (0.66, 1.12)	0.334
Adjusted model 3 [d]	1.00 (ref)	0.89 (0.68, 1.16)	0.81 (0.62, 1.05)	0.88 (0.68, 1.14)	0.461
Vigorous intensity	**Q1, n=833**	**Q2, n=673**	**Q3, n=655**	**Q4, n=659**	
Range, METs·hour/week	<0.1	0.1–12.0	12.1–32.0	>32.0	
Depressive symptoms, no.	169	126	126	139	
Non-adjusted model	1.00 (ref)	0.91 (0.70, 1.17)	0.94 (0.72, 1.21)	1.05 (0.82, 1.35)	0.698
Adjusted model 1 [b]	1.00 (ref)	0.92 (0.71, 1.19)	0.96 (0.74, 1.24)	1.10 (0.85, 1.42)	0.596
Adjusted model 2 [c]	1.00 (ref)	0.97 (0.75, 1.27)	0.99 (0.76, 1.29)	1.12 (0.87, 1.46)	0.727
Adjusted model 3 [d]	1.00 (ref)	0.99 (0.76, 1.29)	1.01 (0.77, 1.31)	1.17 (0.90, 1.51)	0.608

Notes: [a]*p* for linear trend was obtained by using logistic regression analysis, and data were shown as odds ratios and 95% confidence interval; [b]Adjusted for sex (male, female), age (continuous variable), ethnicity (Han ethnicity, others), and only child (yes, no); [c]Adjusted for model 1 plus smoking status (never, former, current), alcohol use (yes, no), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours); [d]Adjusted for model 2 plus body mass index (continuous variable), grip strength (continuous variable), and number of metabolic syndrome components.
Abbreviation: METs, metabolic equivalents.

study. However, some other studies have confirmed that moderate-to-high intensity physical activity, rather than low-intensity, is associated with depressive symptoms.[29,30] It can be considered that the reason for this discrepancy may be due to the inconsistency in the assessment of physical activity intensity and lack of control of potential confounding factors. First, these previous studies evaluated physical activity intensity by self-reported feeling of fatigue[29] or walking speed,[31] which was different from the assessment method by the standardized scale of physical activity in our study. Our evaluation of physical activity intensity took into account the effects of duration and frequency of physical activity, which helps to improve the objectivity and comprehensiveness of physical activity intensity assessment. Moreover, another study by Cahuas et al[30] used the same evaluation method of physical activity intensity, but some potential confounding factors, such as

sociodemography, lifestyle, and health status, were not controlled. Thus, it is necessary to standardize and unify the evaluation methods of variables and analysis models in future work to get better comparability.

In addition, there was a gender difference in observed findings of this study, with no significant association of total physical activity level and physical activity intensity with depressive symptoms. In fact, physical activity is an important factor in improving body shape,[32] which may contribute to a lower prevalence of depressive symptoms. It is possible that young women, who are more aware of body shape than men, experience more emotional improvement and stress relief. For instance, body image concern existed to a certain extent in males and females of college students, notably in females.[33] Studies found that body image dissatisfaction may be contributors for depressive symptoms.[34,35] Thus, considering that college females

Table 5 Association Between Physical Activity Intensity and Depressive Symptoms in Male College Freshmen (n=699)

Physical Activity Intensity	Quartiles of Physical Activity at Different Density Levels				
Low intensity	**Q1, n=224**	**Q2, n=220**	**Q3, n=144**	**Q4, n=111**	***p* value [a]**
Range, METs·hour/week	<9.9	9.9–23.1	23.2–46.2	>46.2	
Depressive symptoms, no.	43	33	26	17	
Non-adjusted model	1.00 (ref)	0.74 (0.45, 1.22)	0.93 (0.54, 1.59)	0.76 (0.41, 1.41)	0.633
Adjusted model 1 [b]	1.00 (ref)	0.77 (0.46, 1.26)	0.94 (0.55, 1.62)	0.76 (0.41, 1.40)	0.674
Adjusted model 2 [c]	1.00 (ref)	0.77 (0.46, 1.29)	0.97 (0.55, 1.69)	0.80 (0.43, 1.51)	0.736
Adjusted model 3 [d]	1.00 (ref)	0.76 (0.45, 1.27)	0.97 (0.55, 1.71)	0.82 (0.43, 1.55)	0.721
Moderate intensity	**Q1, n=165**	**Q2, n=161**	**Q3, n=197**	**Q4, n=176**	
Range, METs·hour/week	<3.3	3.3–9.3	9.4–26.0	>26.0	
Depressive symptoms, no.	35	23	28	33	
Non-adjusted model	1.00 (ref)	0.62 (0.35, 1.10)	0.62 (0.36, 1.06)	0.86 (0.50, 1.46)	0.227
Adjusted model 1 [b]	1.00 (ref)	0.61 (0.35, 1.06)	0.61 (0.36, 1.06)	0.84 (0.49, 1.43)	0.228
Adjusted model 2 [c]	1.00 (ref)	0.64 (0.35, 1.16)	0.61 (0.35, 1.07)	0.86 (0.49, 1.49)	0.265
Adjusted model 3 [d]	1.00 (ref)	0.70 (0.38, 1.29)	0.73 (0.40, 1.32)	1.54 (0.70, 3.39)	0.114
Vigorous intensity	**Q1, n=149**	**Q2, n=156**	**Q3, n=177**	**Q4, n=217**	
Range, METs·hour/week	<0.1	0.1–12.0	12.1–32.0	>32.0	
Depressive symptoms, no.	25	25	23	46	
Non-adjusted model	1.00 (ref)	0.95 (0.52, 1.74)	0.74 (0.40, 1.37)	1.33 (0.75, 1.34)	0.190
Adjusted model 1 [b]	1.00 (ref)	0.94 (0.51, 1.73)	0.74 (0.40, 1.37)	1.35 (0.79, 2.33)	0.175
Adjusted model 2 [c]	1.00 (ref)	1.09 (0.58, 2.05)	0.71 (0.38, 1.34)	1.38 (0.79, 2.42)	0.149
Adjusted model 3 [d]	1.00 (ref)	1.19 (0.63, 2.24)	0.75 (0.39, 1.42)	1.54 (0.87, 2.72)	0.092

Notes: [a]*p* for linear trend was obtained by using logistic regression analysis, and data were shown as odds ratios and 95% confidence interval; [b]Adjusted for sex (male, female), age (continuous variable), ethnicity (Han ethnicity, others), and only child (yes, no); [c]Adjusted for model 1 plus smoking status (never, former, current), alcohol use (yes, no), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours); [d]Adjusted for model 2 plus body mass index (continuous variable), grip strength (continuous variable), and number of metabolic syndrome components.
Abbreviation: METs, metabolic equivalents.

may have more satisfaction with body image than males, young women may gain more mental health benefits from physical activity. Furthermore, it is also important to note that male participants only made up nearly a quarter of the total sample size, the limited sample size may be another factor leading to insignificant results between physical activity intensity and depressive symptoms in male students.

The mechanism of depressive symptoms is not fully understood, but some biological mechanisms and psychological factors are recognized.[36] Studies have shown that chronic inflammation throughout the body may contribute to depressive symptoms.[37] A study of 73,131 people found that increased C-reactive protein levels were associated with an increased risk of psychological distress and depression in cross-sectional analysis and were also associated with an increased depression hospitalization risk in a prospective analysis.[38] In addition, neuroinflammation, especially microglia activation, may

play an important role in the development of depressive symptoms.[39] Reichenberg et al found a temporary increase in anxiety and depression in healthy men by injecting them with *Salmonella abortus equi* endotoxin to activate microglia.[40] Thus, both peripheral inflammation and neuroinflammation have a certain effect on depressive symptoms, while exercise plays a significant role in reducing inflammation. A meta-analysis showed that exercise reduced the C-reactive protein levels regardless of an individual's age and gender, and this effect was more pronounced in people with a lower BMI or body fat percentage.[41] Also, a study in mice with neuropathic pain found that 2 weeks of low-intensity exercise inhibited peripheral and central nervous system inflammation.[42] The vascular disease also may affect depressive symptoms, especially the presence of focal vascular lesions and high white matter signalling.[43] A cross-sectional and longitudinal study on the relationship between senile depression and white matter

Table 6 Association Between Physical Activity Intensity and Depressive Symptoms in Female College Freshmen (n=2121)

Physical Activity Intensity	Quartiles of Physical Activity at Different Density Levels				
Low intensity	**Q1, n=549**	**Q2, n=554**	**Q3, n=507**	**Q4, n=511**	**p value [a]**
Range, METs ·hour/week	<9.9	9.9–23.1	23.2–46.2	>46.2	
Depressive symptoms, no.	141	105	95	110	
Non-adjusted model	1.00 (ref)	0.68 (0.51, 0.90)	0.67 (0.50, 0.90)	0.70 (0.53, 0.94)	0.013
Adjusted model 1 [b]	1.00 (ref)	0.69 (0.52, 0.91)	0.66 (0.49, 0.89)	0.69 (0.52, 0.93)	0.013
Adjusted model 2 [c]	1.00 (ref)	0.71 (0.53, 0.95)	0.73 (0.54, 0.98)	0.71 (0.53, 0.96)	0.050
Adjusted model 3 [d]	1.00 (ref)	0.69 (0.52, 0.93)	0.72 (0.53, 0.97)	0.71 (0.53, 0.96)	0.041
Moderate intensity	**Q1, n=566**	**Q2, n=504**	**Q3, n=533**	**Q4, n=518**	
Range, METs ·hour/week	<3.3	3.3–9.3	9.4–26.0	>26.0	
Depressive symptoms, no.	133	104	105	99	
Non-adjusted model	1.00 (ref)	0.85 (0.63, 1.13)	0.80 (0.60, 1.07)	0.77 (0.57, 1.03)	0.285
Adjusted model 1 [b]	1.00 (ref)	0.86 (0.64, 1.15)	0.81 (0.60, 1.08)	0.77 (0.57, 1.03)	0.292
Adjusted model 2 [c]	1.00 (ref)	0.95 (0.70, 1.27)	0.83 (0.62, 1.12)	0.84 (0.62, 1.13)	0.534
Adjusted model 3 [d]	1.00 (ref)	0.97 (0.72, 1.30)	0.87 (0.64, 1.18)	0.97 (0.64, 1.47)	0.826
Vigorous intensity	**Q1, n=684**	**Q2, n=517**	**Q3, n=478**	**Q4, n=442**	
Range, METs ·hour/week	<0.1	0.1–12.0	12.1–32.0	>32.0	
Depressive symptoms, no.	144	101	103	93	
Non-adjusted model	1.00 (ref)	0.91 (0.69, 1.21)	1.03 (0.77, 1.37)	1.00 (0.75, 1.34)	0.872
Adjusted model 1 [b]	1.00 (ref)	0.91 (0.68, 1.21)	1.02 (0.77, 1.36)	0.99 (0.74, 1.33)	0.888
Adjusted model 2 [c]	1.00 (ref)	0.95 (0.71, 1.28)	1.06 (0.80, 1.43)	1.01 (0.75, 1.36)	0.924
Adjusted model 3 [d]	1.00 (ref)	0.95 (0.71, 1.28)	1.08 (0.81, 1.45)	1.03 (0.76, 1.40)	0.888

Notes: [a]p for linear trend was obtained by using logistic regression analysis, and data were shown as odds ratios and 95% confidence interval; [b]Adjusted for sex (male, female), age (continuous variable), ethnicity (Han ethnicity, others), and only child (yes, no); [c]Adjusted for model 1 plus smoking status (never, former, current), alcohol use (yes, no), breakfast frequency (<4, 4–5, 6–7 times/week), and daily sleep duration (<6, 6–7, 7–8, ≥8 hours); [d]Adjusted for model 2 plus body mass index (continuous variable), grip strength (continuous variable), and number of metabolic syndrome components.
Abbreviation: METs, metabolic equivalents.

integrity found that decreased white matter integrity is associated with advanced depression and predicts future symptoms.[44] Nevertheless, six months of biking was associated with increased white matter integrity in healthy people.[45] These previous reports support our findings that higher levels of physical activity were associated with less depressive symptoms.

The present study has some limitations. First, the physical activity measurements were obtained by self-report questionnaire, which may lead to recall bias. Objective measured physical activity by the accelerometer may better reflect the actual level of physical activity. Second, the data are from cross-sectional surveys, so we can not determine the causal relationship between physical activity and depressive symptoms. Third, our sample is limited to Chinese college freshmen, and it is not clear whether the findings apply to other populations.

Conclusion

In conclusion, our study found that high total physical activity levels are associated with a lower prevalence of depressive symptoms in Chinese college freshmen. More participation in low-intensity physical activity may contribute to a lower prevalence of depressive symptoms. These findings revealed the importance of physical activity participation in mental health promotion in youth. Future prospective and experimental studies will be needed to confirm the relationship between physical activity intensity and depressive symptoms.

Abbreviations

BMI, body mass index; CI, confidence interval; IPAQ-SF, International Physical Activity Questionnaire-Short Format; METs, metabolic equivalents; MetS, metabolic syndrome; ORs, odds ratios; SDS, Self-rating Depression Scale.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

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Author Contributions

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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