

The Effect of Physical Activity on Anxiety: The Mediating Role of Subjective Well-Being and the Moderating Role of Gender

Jianing Tian¹, Hongyan Yu¹, Larry Austin²

¹Department of Physical Education, Shanghai Jiao Tong University, Shanghai, People's Republic of China; ²International Division, Shanghai Gezhi Middle School, Shanghai, People's Republic of China

Correspondence: Hongyan Yu, Department of Physical Education, Shanghai Jiao Tong University, Shanghai, People's Republic of China, Email yuhongyan@sjtu.edu.cn

Purpose: To explore the role of subjective well-being in the relationship between physical activity (PA) and anxiety and whether the model is moderated by gender.

Methods: We conducted a questionnaire survey by selecting 1153 college students from Shanghai Jiao Tong University in China, and data were analyzed using SPSS, Process, and AMOS.

Results: 1) Correlation analysis showed that PA, subjective well-being, and anxiety were significantly related. Also, we found subjective well-being to differ significantly on the demographic variable registered residence. 2) Subjective well-being played a mediating role between PA and anxiety. 3) Gender played a moderating role in the direct effect of PA on anxiety, shown by the significant difference in the path coefficients between the male and female models (male: $\beta = -0.03$, $p > 0.05$, female: $\beta = 0.10$, $p < 0.05$).

Conclusion: Subjective well-being mediated the relationship between PA and anxiety, and gender moderated the mediating model. These findings highlight the importance of PA in reducing anxiety and increasing subjective well-being in the context of an epidemic.

Keywords: subjective well-being, physical activity, anxiety, college students

Introduction

Anxiety is an extremely common mental health problem worldwide.^{1,2} Its main symptoms are irritability, nervousness, and worry, as well as symptoms of vegetative dysfunction such as hand tremors, chest tightness, frequent urination and heart palpitations.³ A sizeable population-based survey found that up to 33.7% of people are affected by anxiety disorders in their lifetime.⁴ With the continued spread of COVID-19, researchers predict that anxiety may increase further.⁵ College students are under the dual pressure of academic and epidemics as well as social stresses such as employment and postgraduate entrance examinations, making them a high-risk group for anxiety. College students with anxiety may experience decreased enthusiasm for learning and living, difficulty sleeping, and, in severe cases, even engage in self-harm⁶ and suicidal behavior.⁷ Therefore, exploring the factors and internal mechanisms that affect college students' anxiety is important.

Numerous studies have found a high correlation between physical activity (PA) and mental health levels.^{8–10} For college students, PA serves as a protective factor for health.¹¹ In previous studies, PA has been shown to be associated with anxiety and depression, stress, self-esteem, and cognitive functioning,¹² as well as contributing to the prevention and management of non-communicable diseases such as obesity, cardiovascular disease, cancer, and diabetes.¹³ The social withdrawal theory suggests a significant reduction in PA due to adolescents not engaging in peer-involving activity games, which also leads to psychological disorders such as anxiety and depression. In other words, an increase in PA helps with anxiety and other emotions.^{14–16} Many scholars have also shown through empirical studies that more PA is associated with higher emotional stability and lower anxiety levels.^{17–19} For the standard of PA required for health, the

World Health Organization (WHO) recommends that adults participate in moderate PA for at least 150 minutes per week, vigorous PA for 75 minutes per week, or a combination of both.²⁰ However, participation in PA is declining in China,²¹ with more than 83% of people aged 18 years or older being inactive.²²

Although numerous studies have found a link between PA and anxiety in college students, many scholars have explained the underlying mechanisms through mediating variables (such as self-efficacy,²³ self-system,²⁴ coping style).²⁵ However, there are still relatively few studies on the mediating variables between PA and anxiety, leaving us without a comprehensive understanding of the mechanisms underlying the effects of PA on anxiety. It is worth noting the critical variable of subjective well-being in positive psychology. Related research and theory have found it to be associated with higher PA and lower anxiety.^{26–28} Therefore, our study explores the relationship between PA and anxiety from a positive psychological perspective and proposes a moderated mediation model. This study will help us better understand the factors that influence anxiety and improve our understanding of the psychological mechanisms behind this process.

Physical Activity and Anxiety

PA is any bodily movement produced by skeletal muscles that requires energy expenditure, including physical exercise and daily activities (such as walking, working, doing housework).²⁹ Based on PA's emotional effects theory and social withdrawal theory, it can be found that PA has some ameliorative and therapeutic effects on mental health problems such as anxiety and depression.^{14–16} Several empirical studies have also demonstrated that PA can reduce levels of anxiety. In a survey of 11,110 adolescents in 10 European countries, higher levels of PA and sports participation contribute to lower levels of anxiety and depression in both males and females.¹⁸ Similarly, studies found adequate PA to be vital in coping with mental health problems among medical students in Pakistan and university students in China.^{17,30} Therefore, synthesizing the existing theoretical and empirical findings, hypothesis 1 was proposed: PA may negatively predict anxiety among college students.

Mediating Role of Subjective Well-Being

Subjective well-being (SWB) is one of the current concerns of positive psychology. It refers to an individual's overall evaluation and feelings about their life and is a comprehensive psychological indicator of the quality of an individual's life.³¹ With the development of positive psychology, People realize that enhancing subjective well-being is a critical way to promote healthy physical and mental development. According to the theory of exercise psychology, physical exercise can increase the level of subjective well-being and reduce the level of anxiety.²⁷ Several scholars have also found an association between PA and SWB, SWB and anxiety in empirical studies. Stubbe et al found that people who participated in exercise had higher subjective well-being compared to non-exercisers.²⁶ A cross-sectional study also showed that higher levels of PA helped increase adolescents' subjective well-being¹⁸ and that increased subjective well-being significantly affected lower anxiety levels.²⁸ Therefore, we proposed hypothesis 2: subjective well-being may mediate the relationship between PA and anxiety among college students.

Moderating Effects of Gender

Gender may be a potential moderator between PA, SWB, and anxiety. Extensive demographic surveys conducted in China have shown that male groups participate in PA more frequently compared to females.²² In addition, previous studies have also found significant differences in anxiety across gender groups. Specifically, the prevalence in females is approximately twice that of males.⁴ In SWB, a review by Batz et al showed that the results of the current study on whether males and females differ in subjective well-being are very inconsistent.³² Furthermore, numerous studies have found possible gender differences in the effects of exercise on mental health.^{33–35} Therefore, we proposed hypothesis 3: Gender may moderate the impact of PA on anxiety through SWB. To our knowledge, this study is the first to simultaneously investigate gender differences in these three variables in the Chinese cultural context.

In summary, the existing studies have better explained the relationship between PA and Anxiety, PA and SWB, and SWB and Anxiety from various perspectives and pathways. However, the size, relationship, role, and overall effects among the factors are difficult to explain in the setting of separate studies. To this end, this study explored the impact of PA on anxiety, the mediating role of subjective well-being, and the moderating role of gender in college students from the

perspectives of exercise psychology and positive psychology. The results provide a research basis for systematically examining the relationships among variables and an empirical basis for improving college students' anxiety.

Methods

Participants

This study adopts a cross-sectional research design and takes college students from Shanghai Jiao Tong University (SJTU) as the survey object. All participants were recruited by random sampling. The duration of this study is from March to May 2021. We sent questionnaires and collected data from participants using the electronic "Questionnaire Star" tool. A total of 1561 questionnaires were collected, we eliminated 408 invalid questionnaires, and finally, 1153 valid questionnaires were retained, with an effective recovery rate of 73.87%. The exclusion criteria for the questionnaire consisted of non-SJTU college students, missing values in the data, and regularity or continuity in answering. The study protocol followed the guidelines of the Declaration of Helsinki, and the Science and Technology Ethics Committee of Shanghai Jiao Tong University approved it. We familiarized all participants with the experimental procedures before entering the study.

Measurement Tools

Physical Activity

We used the short form of the international physical activity questionnaire (IPAQ) to collect information on the level of PA among respondents. The IPAQ measures all physical activities, including workplace, sports, and daily activities. The World Health Organization (WHO) developed the questionnaire, which is currently one of the widely recognized and used questionnaires for measuring adult PA. Different countries have confirmed its reliability and validity.³⁶ The Chinese version of the questionnaire in China is widely used and proven valid.³⁷ The short version is structured in the same way as the long version in that it investigates the 1-week frequency and cumulative daily time spent in different intensity activities, but the content section does not have a specific division into activity types. According to the IPAQ guidelines,³⁸ MET-values of 3.3, 4, and 8 were assigned to walking, moderate-intensity, and high-intensity activities, respectively. By walking ($3.3 \times \text{walking time (min)} \times \text{walking days}$), moderate-intensity activity ($4.0 \times \text{active time (min)} \times \text{active days}$), high-intensity activity ($8.0 \times \text{active time (min)} \times \text{active days}$) add to get a total score for PA.

Subjective Well-Being

Subjective well-being was measured using the General Well-Being Schedule (GWB). The scale is a stereotyped measurement tool developed for the National Center for Health Statistics to evaluate subjects' statements of happiness. The American psychologist Fazio revised the original scale in 1977,³⁹ with a total of 33 items. Our study adopts the Chinese version modified by Duan in 1996,⁴⁰ including six dimensions and eighteen items. The six dimensions are health concerns (items 10, 15), energy (items 1, 9, 14, 17), satisfaction and interest in life (items 6, 11), and depression or a happy state of mind (items 4, 12, 18), emotional and behavioral control (items 3, 7, 13), relaxation and tension (items 2, 5, 8, 16). On the scale, 1, 3, 6, 7, 9, 11, 13, 15, and 16 are reverse scoring items. The total score is the sum of entries items (total score of 100), and the higher the score, the stronger the subjective well-being. The Cronbach's alpha coefficient for this scale in this study was 0.875.

Anxiety

Anxiety was measured using the Generalized Anxiety Disorder Scale (GAD-7) developed by Spitzer et al in 2006.⁴¹ This scale is a functional self-report anxiety questionnaire. Studies have shown that the scale has good internal consistency in the Chinese population.⁴² In the GAD-7 test, we asked participants how often they had experienced the seven symptoms of generalized anxiety disorder in the past two weeks. The response options are "not at all", "several days", "more than a week", and "almost every day", scored as 0, 1, 2, and 3, respectively. Therefore, the total score range of the GAD-7 scale is 0~21 points, of which 0~5 points are no anxiety, 6~9 points are mild, 10~14 points are moderate, and 15~21 points are severe. The Cronbach's alpha coefficient for this scale in this study was 0.938.

Statistical Analysis

We used SPSS 26.0 for correlation and demographic difference analysis of related variables. We employed Process v4.0 developed by Hayes⁴³ to conduct tests for mediating effects, and we undertook multi-group research using AMOS to test the moderating effect of gender. All tests were performed using bootstrap methods with 95% confidence intervals, bootstrap sample sizes of 5000, and a test level of 0.05.

Results

Common Method Bias Test

This study mainly used self-reporting to collect relevant data, so serious common method bias problems may exist. Therefore, after we collected the data, Harman's single-factor test was used to verify possible serious common method bias statistically. The results of the unrotated principal component factor analysis show that there are nine factors whose eigenvalues are greater than 1, and the variance explained by the first common factor is only 28.40%, which is less than the critical value standard of 40%,⁴⁴ so there was no serious common method bias problem in this study.

Descriptive Analysis

Table 1 describes the basic demographic characteristics of the study sample and the PA, subjective well-being, and anxiety scores of college students.

Demographic Difference Analysis

We used the three variables of nationality, registered residence, and age of college students were used as demographic variables for independent samples *t*-test or one-way ANOVA. Table 2 presents the results. There were no significant differences in PA level, subjective well-being, and anxiety on nationality and age. On registered residence, only the dimension of subjective well-being was significantly different ($t = 2.166$, $p < 0.031$), which showed that the SWB of urban students was higher than that of rural college students.

Correlation Analysis

We performed a Bivariate Pearson correlation analysis for the three variables of PA, anxiety, and subjective well-being, and Table 3 shows the correlation coefficients. The results showed that there was a significant positive correlation between PA and subjective well-being ($r = 0.130$, $P < 0.01$) and a significant negative correlation with anxiety ($r = -0.080$, $P < 0.01$). There was a significant negative correlation between subjective well-being and anxiety ($r = -0.718$, $p < 0.01$). This result provides the basis for the subsequent test of mediating effects.

Table 1 Descriptive Data for Main Variables

Variables	Total Sample (N = 1153)
Age, M (SD)	20.03 (0.98)
Gender, n (%)	
Male	834 (72.3%)
Female	319 (27.7%)
PA (MET-min/week)	3214.16 (2121.95)
PA level, n (%) (M/F)	
Low-intensity	34 (4.1%) / 13 (4.1%)
Medium-intensity	102 (12.2%) / 55 (17.2%)
High-intensity	698 (83.7%) / 251 (78.7%)
Subjective well-being, M (SD)	79.08 (14.28)
Anxiety, M(SD)	6.56 (5.13)

Table 2 Demographic Difference Analysis

Variables	Groups	Physical Activity	Subjective Well-Being	Anxiety
Nationality	Han	3193.12±2062.83	79.21±14.38	6.50±5.10
	Other	3404.04±2598.48	77.89±13.35	7.05± 5.46
	t	-0.842	0.943	-1.094
	p	0.402	0.346	0.274
Registered residence	Urban	3197.53±2068.74	79.45±14.62	6.57±5.21
	Rural	3293.88±2364.53	77.29±12.43	6.49±4.78
	t	-0.534	2.166	0.200
	p	0.594	0.031*	0.842
Age	18 years	3547.33±2864.72	77.64±14.37	7.33±5.12
	19 years	3170.22±1919.96	78.72±13.94	6.74±5.04
	20 years	3254.28±2068.81	79.69±14.25	6.23±5.11
	21 years and older	3149.56±2271.51	78.68±14.67	6.76±5.24
	F	0.522	0.574	1.233
	p	0.667	0.632	0.296

Note: *P<0.05.

Table 3 Correlation Analysis Between Variables

Variables	Physical Activity	Subjective Well Being	Anxiety
Physical activity	1		
Subjective well being	0.130**	1	
Anxiety	-0.080**	-0.718**	1

Note: **P<0.01.

The Mediating Effect Test of Subjective Well-Being

Based on relevant literature and theory, we constructed a mediating model of PA affecting anxiety through subjective well-being. We treated the Registered Residence (RR) as a control variable based on the results of the demographic difference analysis. To test for mediating effects, we used Model 4 in the Process program. We present the results in Table 4 and Figure 1. The negative predictive effect of PA on anxiety was significant ($B = -0.0837$, $t = -2.8472$, $p = 0.0045$). However, when the mediating variable subjective well-being was put in, the predictive effect of PA on anxiety

Table 4 Mediating Model Test of Subjective Well-Being

Regression Equation (N=1153)		Fitting Indicator			Coefficient		
Outcome Variable	Predictive Variable	R	R ²	F	B	t	p
Anxiety	RR	0.0839	0.0070	4.0714	-0.0041	-0.1407	0.8881
	PA				-0.0837	-2.8472	0.0045**
SWB	RR	0.1362	0.0185	10.8659	-0.0595	-2.0354	0.0420*
	PA				0.1235	4.2282	0.0000**
Anxiety	RR	0.7120	0.5070	393.8270	-0.0466	-2.2443	0.0250*
	PA				0.0045	0.2153	0.8296
	SWB				-0.7137	-34.1335	0.0000**

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

Abbreviations: RR, Registered residence; PA, Physical activity; SWB, Subjective well-being.

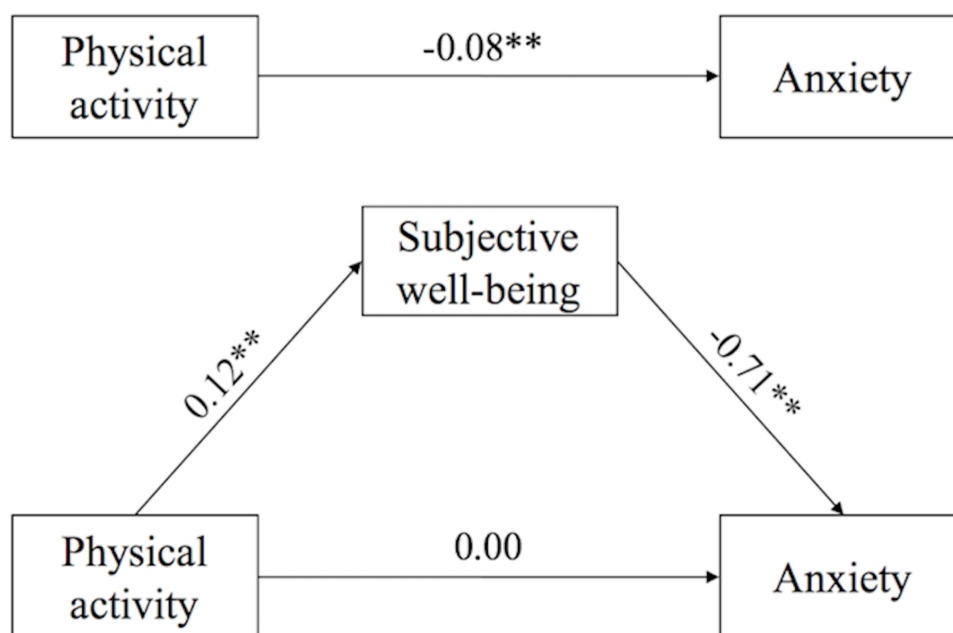


Figure 1 Meditation effect model diagram.

Note: ** $P < 0.01$.

became insignificant ($B = 0.0045$, $t = 0.2153$, $p = 0.8296$). The positive predictive effect of PA on subjective well-being was significant ($B = 0.1235$, $t = 4.2282$, $p = 0.0000$), as was the negative predictive effect of subjective well-being on anxiety ($B = -0.7137$, $t = -34.1335$, $p = 0.0000$). In addition, the upper and lower limits of the bootstrap 95% confidence interval for the direct effect of PA on anxiety included 0. In contrast, neither the upper nor lower limits of the indirect effect of subjective well-being included 0, indicating that PA can predict anxiety only through the mediating effect of subjective well-being.

Moderating Effect Test of Gender

We constructed a nested model to examine gender differences in the mediating effect of SWB between PA and anxiety using multiple group analysis with males and females as group variables based on the above mediating model. We first constructed an unconstrained model (Model 1) with similar model shapes for males and females and freely estimated path coefficients. Then the structural weighted model (Model 2) with equal structural coefficients for both genders, ie, constant path coefficients across groups among the three study variables, is constructed. Finally, we built the structural covariance model (Model 3) that restricts the structural covariance in the male and female models to be equal. As the results in Table 5 show, the fit metrics of both the unconstrained model (Model 1) and the constrained model (Models 2 and 3) reach acceptable levels.

However, since the unconstrained model in this study is a saturated model, it is impossible to estimate the significance probability of the p-value directly. To verify the cross-sex stability, we used the critical ratio (CR) value

Table 5 Fit Index Metrics for Multi-Group Analysis of Gender Differences

Model	χ^2	df	CFI	TLI	RMSEA
M1	0	0	1	1	0
M2	8.592	3	0.993	0.987	0.04
M3	9.455	4	0.993	0.99	0.034

Notes: M1: Unconstrained model, M2: Structural weights model, M3: Structural covariances model.

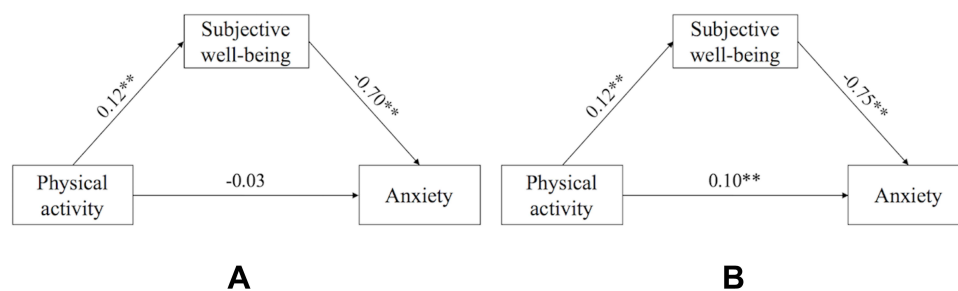


Figure 2 Multi-group structural equation model plot of gender difference.

Notes: ** $P < 0.01$; (A): male, (B): female.

as an indicator to further investigate the span of the structural model. An absolute value of CR greater than 1.96 ($p < 0.05$) indicates a significant difference between these two parameters.⁴⁵ The results showed no significant difference in the two structural paths from PA to subjective well-being ($CR = 0.04$) and subjective well-being to anxiety ($CR = -0.499$). The CR for the structural path from PA to anxiety was 2.938, which indicates a significant difference between males and females on this path. More specifically, the path coefficient for boys was $\beta = -0.03$, $p > 0.05$, while for girls it was $\beta = 0.10$, $p < 0.05$. Because of the gender differences, the structural models were plotted separately for males and females, as in Figure 2.

Discussion

We developed a mediating and moderating effects model with Chinese college students based on previous research. We used PA as a predictor variable, subjective well-being as a mediating variable, gender as a moderating variable, and anxiety as an outcome variable to systematically examine the relationship between the variables. The results found that PA had a significant negative predictive effect on anxiety and that subjective well-being had a mediating effect. Gender also had a moderating effect, as PA predicted anxiety only through subjective well-being in males. However, in females, PA not only indirectly predicted anxiety through subjective well-being but also directly predicted anxiety.

Physical Activity and Anxiety

The study showed that PA significantly and negatively predicted anxiety levels in college students, thus validating hypothesis 1, which is consistent with the results of several previous studies. For example, a review-type study by Rebar found that PA effectively reduced anxiety and depression in a non-clinical population.⁴⁶ Also, several studies in adults have found that people who engage in more PA have a lower risk or severity of being diagnosed with anxiety.^{47,48} In other words, you could also say that people with low anxiety levels may be more involved in PA because they may have more time and energy.⁴⁹ Studies have identified the lack of PA as a risk factor for psychological problems such as anxiety and depression.⁵⁰ Researchers in the college population also recommend regular participation in sports and PA to reduce anxiety and depression.¹⁹ It is worth noting that the weekly total PA level of respondents in this study was 3214.16 MET-min/week, which is similar to the findings of surveys conducted among college students in Turkey (3465.91)⁵¹ and Yangzhou, China (2923.39).⁵² However, our study had a large percentage of high-intensity PA (82.3%); this may be due to the large size of the school, where bicycles are the primary mode of transport and students need to cycle quickly between buildings every day. At the same time, our school's physical education classes require students to run at least 2 km after school every day, which counts as 10 points towards their physical education grade;⁵³ this is a characteristic of the PA variable for college students in our model.

PA may act through a range of different psychological and physiological mechanisms. Potential mechanisms may be (1) PA activates the hypothalamic-pituitary-adrenal (HPA) axis to increase the circulating levels of glucocorticoids, thereby regulating anxiety.^{23,54} (2) PA upregulates brain-derived neurotrophic factors that promote neurogenesis and angiogenesis.⁵⁵ (3) PA improves the function of brain regions associated with anxiety, such as improving hippocampal function and volume.^{56,57} (4) PA alleviates anxiety by improving the endogenous cannabinoid system and regulating

neurotransmitters such as dopamine and 5-hydroxytryptamine.⁵⁸ (5) PA reduces anxiety sensitivity by producing physiological responses similar to those of a high anxiety state (eg, increased heart rate).⁵⁹ However, this study proposes a mediated model with moderation to explore the underlying mechanism of action.

Analysis of the Mediating Effect of Subjective Well-Being

The study showed that PA had a negative predictive effect on anxiety in college students. With the inclusion of the variable subjective well-being, the direct impact of PA on anxiety is no longer significant but affects anxiety indirectly through subjective well-being. The results of this test verified the validity of hypothesis 2. The study's results showed that PA enhances one's satisfaction and subjective evaluation of the quality of life and promotes pleasant and optimistic emotions to keep college students active and cheerful.^{60,61} The increase in the dimension of subjective well-being helps college students look at things more positively and optimistically while promoting the improvement of mental health and less negative emotions such as depression and anxiety.⁶² In terms of model pathways, previous meta-analyses have found that PA interventions can increase individuals' subjective well-being, with PA of 30 ~ 45 min three times per week producing the most significant effect.⁶³ Similarly, subjective well-being negatively predicted anxiety levels in the mainland Chinese sample.⁶² These also support the validity of the model in this study. From the demographic characteristics of the main variables in the model, compared to the national normative data score of 73.86 for subjective well-being,⁶⁴ the college students in our study scored 79.08, indicating a higher level of subjective well-being than the national level. In addition, there are differences in subjective well-being by registered residence, which is consistent with the findings of the current study.⁶⁵ This may be because college students of different registered residences are in different socioeconomic and cultural contexts. Urban students have access to more material and cultural resources compared to their rural counterparts.⁶⁶ Moreover, when urban students enter university, the environment in which they live does not change much, which makes them have a stronger sense of self-confidence and well-being.⁶⁷ To the best of our knowledge, current research on the relationship between PA, subjective well-being, and anxiety has only been examined among female college students.⁶⁸ Although female college students are a high prevalence group for anxiety, we cannot ignore male college students in their adolescent years.

On the intrinsic physiological mechanism of subjective well-being as a mediating variable, the Dsouza study concluded that people who exercise regularly have higher levels of happiness, possibly due to higher levels of endorphins in their bodies, which trigger positive emotions.⁶⁹ Also, a study by Iwon suggests that regular PA is associated with higher levels of subjective well-being, possibly due to PA promoting the release of dopamine,⁷⁰ which alleviates negative emotions such as depression and anxiety. PA is of great importance to college students. It can enhance physical and mental health, improve subjective well-being, and relieve and prevent anxiety.

Analysis of the Moderating Effect of Gender

The study found significant differences in the direct path coefficients in the mediation model through multiple group analysis; hypothesis 3 holds. While male and female college students can indirectly predict anxiety through subjective well-being, PA for female college students can also directly predict anxiety levels. Notably, PA positively predicted anxiety among female college students, meaning that the higher the PA level, the more severe the anxiety. According to the inverted U-shaped arousal theory, we found that high-intensity PA leads to high arousal states; however, both too high and too low arousal will lead to negative mental or physical performance.^{71,72} Due to gender differences, females possess higher anxiety sensitivity levels than males,^{33,73} and high levels of PA are more likely to be perceived as a stressor. Also, epidemiological studies have shown that women are at higher risk of developing anxiety disorders during different life stages, such as puberty and menstruation.^{74,75} These periods of increased risk coincide with periods of strong hormonal fluctuations, which implies a role for gonadal hormones in the attack and persistence of anxiety disorders in women.⁷⁶ So, hormones are also one of the factors that influence gender differences. Next, previous research studies have found that various conditions limit women's participation in sport, such as low-income levels,⁷⁷ less peer support,⁷⁸ and low physical fitness,⁷⁹ which may have contributed to lower participation and tendency to exercise. Finally, the position of females in the general environment of Chinese society is also different

from that of males. Chinese culture gives females a quiet and dignified character role, so compared to males, females may receive less social support and recognition for participating in PA.⁸⁰ Therefore, high levels of PA may bring psychological stress and burden, leading to anxiety. The results provide some guidance for teachers in their teaching and training.

Limitations and Implications

There are some limitations and shortcomings in this study. (1) We used a cross-sectional study design to examine the correlations and mechanisms of action among variables, and we could not determine causal relationships. Longitudinal intervention experiments need to be conducted in the future to investigate the causal relationships among variables further. (2) The mediation model established in this study had a low pass-through coefficient, and the pass-through coefficient of subjective well-being on PA affecting anxiety was only -0.0882 , suggesting that new variables need to be added to explain the mechanism of action between PA and anxiety. (3) The measurement of PA in this study used self-reported data, which is prone to recall bias. We recommend future studies to measure with the help of instrumentation such as accelerometers and pedometers. (4) The survey population was only students from one university. Because of the vast area of China and the noticeable cultural differences between regions, we need future studies of university student groups from other locations.

This study also has some important implications. Studies have shown that PA enhances subjective well-being and thus reduces anxiety levels among college students, which shows the need to improve subjective well-being among college students in physical education and extracurricular physical activities. In the context of the epidemic, we recommend that teachers receive professional training on promoting the amount of PA involved in teaching to reduce anxiety. More importantly, the effect of PA on anxiety may be enhanced if teachers are trained to promote students' subjective well-being. Furthermore, the relationship between PA and anxiety was inconsistent among male and female college students, and this difference helped to provide teachers with a better understanding of how to conduct and develop instruction in a gender-specific manner.

Conclusion

In the present study, we investigated the relationship between PA and anxiety, focusing on the predictive role of subjective well-being in a sample of Chinese university students. Results indicated that subjective well-being mediated the relationship between PA and anxiety, and gender moderated the mediating model. These findings highlight the importance of PA in reducing anxiety and increasing subjective well-being in the context of an epidemic.

Ethics Statement

The study was approved by the Human Science and Technology Ethics Review Committee of Shanghai Jiao Tong University, No. E2021100I. Subjects were fully informed of the content and purpose of the survey before participating. All participants provided written informed consent.

Acknowledgments

The authors would like to thank the article editor and anonymous reviewers for their valuable and thoughtful comments and suggestions.

Funding

This work was supported by the Shanghai Jiao Tong University Teaching Development Fund Project (No. CTLD22J0007).

Disclosure

The authors report no conflicts of interest in this work.

References

- Steel Z, Marnane C, Iranpour C, et al. The global prevalence of common mental disorders: a systematic review and meta-analysis 1980–2013. *Int J Epidemiol*. 2014;43(2):476–493. doi:10.1093/ije/dyu038
- Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390(10100):1211–1259. doi:10.1016/S0140-6736(17)32154-2
- Tuma AH, Maser JD. *Anxiety and the Anxiety Disorders*. New York: Routledge; 2019.
- Bandelow B, Michaelis S. Epidemiology of anxiety disorders in the 21st century. *Dialogues Clin Neurosci*. 2022;17(3):327–335. doi:10.31887/DCNS.2015.17.3
- Santomauro DF, Herrera AMM, Shadid J, et al. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet*. 2021;398(10312):1700–1712. doi:10.1016/S0140-6736(21)02143-7
- O'Connor RC, Rasmussen S, Hawton K. Predicting deliberate self-harm in adolescents: a six month prospective study. *Suicide Life Threat Behav*. 2009;39(4):364–375. doi:10.1521/suli.2009.39.4.364
- Liu CH, Stevens C, Wong SH, Yasui M, Chen JA. The prevalence and predictors of mental health diagnoses and suicide among US college students: implications for addressing disparities in service use. *Depress Anxiety*. 2019;36(1):8–17. doi:10.1002/da.22830
- Paluska SA, Schwenk TL. Physical activity and mental health. *Sports Med*. 2000;29(3):167–180. doi:10.2165/00007256-200029030-00003
- Biddle SJ, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. *Br J Sports Med*. 2011;45(11):886–895. doi:10.1136/bjsports-2011-090185
- VanKim NA, Nelson TF. Vigorous physical activity, mental health, perceived stress, and socializing among college students. *Am J Health Promot*. 2013;28(1):7–15. doi:10.4278/ajhp.111101-QUAN-395
- Eime RM, Young JA, Harvey JT, Charity MJ, Payne WR. A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *Int J Behav Nutr Phys Act*. 2013;10(1):1–21. doi:10.1186/1479-5868-10-98
- Landers DM, Arent SM. Physical activity and mental health. 2007.
- World Health Organization. Physical activity: key facts; 2018. Available from: <https://www.who.int/news-room/fact-sheets/detail/physical-activity>. Accessed June 10, 2022.
- Vasey MW, Dadds MR. *An Introduction to the Developmental Psychopathology of Anxiety*. Oxford; UK: Oxford University Press (OUP); 2001:3–26.
- Anderson RJ, Brice S. The mood-enhancing benefits of exercise: memory biases augment the effect. *Psychol Sport Exerc*. 2011;12(2):79–82. doi:10.1016/j.psychsport.2010.08.003
- Ruby MB, Dunn EW, Perrino A, Gillis R, Viel S. The invisible benefits of exercise. *Health Psychol*. 2011;30(1):67. doi:10.1037/a0021859
- Wu X, Tao S, Zhang Y, Zhang S, Tao F. Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. *PLoS One*. 2015;10(3):e0119607. doi:10.1371/journal.pone.0119607
- McMahon EM, Corcoran P, O'Regan G, et al. Physical activity in European adolescents and associations with anxiety, depression and well-being. *Eur Child Adolesc Psychiatry*. 2017;26(1):111–122. doi:10.1007/s00787-016-0875-9
- Lee E, Kim Y. Effect of university students' sedentary behavior on stress, anxiety, and depression. *Perspect Psychiatr Care*. 2019;55(2):164. doi:10.1111/ppc.12296
- Powell KE, Paluch AE, Blair SN. Physical activity for health: what kind? How much? How intense? On top of what? *Annu Rev Public Health*. 2011;32:349–365. doi:10.1146/annurev-publhealth-031210-101151
- Lu C, Stolk RP, Sauer PJ, et al. Factors of physical activity among Chinese children and adolescents: a systematic review. *Int J Behav Nutr Phys Act*. 2017;14(1):1–10. doi:10.1186/s12966-017-0486-y
- CDC C. The report of 2010 behavioral risk factors surveillance of PRC; 2011. Available from: https://www.chinacdc.cn/zxdt/201109/t20110906_52141.htm. Accessed June 15, 2022.
- Anderson E, Shivakumar G. Effects of exercise and physical activity on anxiety. *Front Psychiatry*. 2013;4:27. doi:10.3389/fpsy.2013.00027
- Kayani S, Kiyani T, Kayani S, Morris T, Biasutti M, Wang J. Physical activity and anxiety of Chinese university students: mediation of self-system. *Int J Environ Res Public Health*. 2021;18(9):4468. doi:10.3390/ijerph18094468
- Chen J. *Effects of Physical Activity on Anxiety Among College Students: Mediating Effects of Coping Styles* [Master]. Guangzhou University; 2019.
- Stubbe JH, de Moor MH, Boomsma DI, de Geus EJ. The association between exercise participation and well-being: a co-twin study. *Prev Med*. 2007;44(2):148–152. doi:10.1016/j.ypmed.2006.09.002
- Buckworth J, Dishman RK, Tomporowski PD. *Exercise Psychology*. Human Kinetics; 2013.
- Machado L, Souza CTN, Nunes RO, de Santana CN, Araujo CF, Cantilino A. Subjective well-being, religiosity and anxiety: a cross-sectional study applied to a sample of Brazilian medical students. *Trends Psychiatry Psychother*. 2018;40:185–192. doi:10.1590/2237-6089-2017-0070
- Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep*. 1985;100(2):126. doi:10.2307/20056429
- Khidri FF, Riaz H, Bhatti U, et al. Physical activity, dietary habits and factors associated with depression among medical students of Sindh, Pakistan, during the COVID-19 pandemic. *Psychol Res Behav Manag*. 2022;15:1311–1323. doi:10.2147/PRBM.S364540
- Diener E. Subjective well-being. The science of well-being. *Soc Indicators Res Series*. 2009;37:11–58. doi:10.1007/978-90-481-2350-6_2
- Batz C, Tay L. Gender differences in subjective well-being. In: *Handbook of Well-Being*. Salt Lake City, UT: DEF Publishers; 2018.
- Medina JL, DeBoer LB, Davis ML, et al. Gender moderates the effect of exercise on anxiety sensitivity. *Ment Health Phys Act*. 2014;7(3):147–151. doi:10.1016/j.mhpa.2014.08.002
- Hunt-Shanks T, Blanchard C, Reid RD. Gender differences in cardiac patients: a longitudinal investigation of exercise, autonomic anxiety, negative affect and depression. *Psychol Health Med*. 2009;14(3):375–385. doi:10.1080/13548500902866939
- Bhui K, Fletcher A. Common mood and anxiety states: gender differences in the protective effect of physical activity. *Soc Psychiatry Psychiatr Epidemiol*. 2000;35(1):28–35. doi:10.1007/s001270050005

36. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35(8):1381–1395. doi:10.1249/01.Mss.0000078924.61453.Fb
37. Macfarlane DJ, Lee CC, Ho EY, Chan KL, Chan DT. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *J Sci Med Sport.* 2007;10(1):45–51. doi:10.1016/j.jsams.2006.05.003
38. Committee IR. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ)-short and long forms; 2005. Available from: [http://www/ipaqkise/scoringpdf](http://www.ipaqkise/scoringpdf). Accessed October 26, 2022.
39. Fazio AF. A concurrent validation study of the NCHS general well-being schedule. Vital and health statistics. series 2, data evaluation and methods research. 1977;1–53.
40. Duan J. Analysis of the general well-being scale test results in the Chinese students. *Chin J Clin Psychol.* 1996;4(56):7.
41. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* 2006;166(10):1092–1097. doi:10.1001/archinte.166.10.1092
42. Zeng Q-Z, He Y-L, Liu H, et al. Reliability and validity of Chinese version of the Generalized Anxiety Disorder 7-item (GAD-7) scale in screening anxiety disorders in outpatients from traditional Chinese internal department. *Chin Ment Health J.* 2013;27:163–168.
43. Hayes AF. An index and test of linear moderated mediation. *Multivariate Behav Res.* 2015;50(1):1–22. doi:10.1080/00273171.2014.962683
44. Podsakoff PM, MacKenzie SB, Lee J-Y, Podsakoff NP. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol.* 2003;88(5):879. doi:10.1037/0021-9010.88.5.879
45. Arbuckle J. *Amos 5.0 Update to the Amos User's Guide*. Marketing Department, SPSS Incorporated; 2003.
46. Rebar AL, Stanton R, Geard D, Short C, Duncan MJ, Vandelanotte C. A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychol Rev.* 2015;9(3):366–378. doi:10.1080/17437199.2015.1022901
47. Azevedo Da Silva M, Singh-Manoux A, Brunner EJ, et al. Bidirectional association between physical activity and symptoms of anxiety and depression: the Whitehall II study. *Eur J Epidemiol.* 2012;27(7):537–546. doi:10.1007/S10654-012-9692-8
48. De Mello MT, de Aquino Lemos V, Antunes HKM, Bittencourt L, Santos-Silva R, Tufik S. Relationship between physical activity and depression and anxiety symptoms: a population study. *J Affect Disord.* 2013;149(1–3):241–246. doi:10.1016/j.jad.2013.01.035
49. Ströhle A. Physical activity, exercise, depression and anxiety disorders. *J Neural Transm.* 2009;116(6):777–784. doi:10.1007/s00702-008-0092-x
50. Teychenne M, Costigan SA, Parker K. The association between sedentary behaviour and risk of anxiety: a systematic review. *BMC Public Health.* 2015;15(1):1–8. doi:10.1186/s12889-015-1843-x
51. Karaca E, Toprak D, Dogan N, Ersoy N, Ersoy G. Evaluation of physical activity levels and anthropometric measurements in Turkish adults. *Age.* 2021;18(40):41. doi:10.23751/pn.v23i1.9074
52. Chen H, Wang C, Lu T, Tao B, Gao Y, Yan J. The relationship between physical activity and college students' mobile phone addiction: the chain-based mediating role of psychological capital and social adaptation. *Int J Environ Res Public Health.* 2022;19(15):9286. doi:10.3390/ijerph19159286
53. Yu H, An S, Tao Y, Austin L. Correlation and change in physical activity and physical fitness across four years of college students after one year of COVID-19 lockdown. *Healthcare.* 2022;10:1691. doi:10.3390/healthcare10091691
54. Wegner M, Helmich I, Machado S, Nardi A, Arias-Carrion O, Budde H. Effects of exercise on anxiety and depression disorders: review of meta-analyses and neurobiological mechanisms. *CNS Neurol Disord Drug Targets.* 2014;13(6):1002–1014. doi:10.2174/1871527313666140612102841
55. Kandola A, Hendrikse J, Lucassen PJ, Yücel M. Aerobic exercise as a tool to improve hippocampal plasticity and function in humans: practical implications for mental health treatment. *Front Hum Neurosci.* 2016;10:373. doi:10.3389/fnhum.2016.00373
56. Voss MW, Vivar C, Kramer AF, van Praag H. Bridging animal and human models of exercise-induced brain plasticity. *Trends Cogn Sci.* 2013;17(10):525–544. doi:10.1016/j.tics.2013.08.001
57. Firth J, Stubbs B, Vancampfort D, et al. Effect of aerobic exercise on hippocampal volume in humans: a systematic review and meta-analysis. *Neuroimage.* 2018;166:230–238. doi:10.1016/j.neuroimage.2017.11.007
58. Tantimonaco M, Ceci R, Sabatini S, et al. Physical activity and the endocannabinoid system: an overview. *Cell Mol Life Sci.* 2014;71(14):2681–2698. doi:10.1007/s00018-014-1575-6
59. Smits JA, Berry AC, Rosenfield D, Powers MB, Behar E, Otto MW. Reducing anxiety sensitivity with exercise. *Depress Anxiety.* 2008;25(8):689–699. doi:10.1002/da.20411
60. Chen K, Yang J, Dong L, Xia Q. Effect of physical exercise on adolescents' psychological stress, coping styles and subjective well-being. *J Chengdu Sport Univ.* 2013;39:75–79. doi:10.15942/j.jcsu.2013.10.003
61. Chen Z, Yu P. The influence of physical exercise on subjective well-being of college students: an intermediary effect of per relationship. *J Capital Univ Phys Educ Sports.* 2015;27(02):165–171. doi:10.14036/j.cnki.cn11-4513.2015.02.015
62. Malone C, Wachholtz A. The relationship of anxiety and depression to subjective well-being in a mainland Chinese sample. *J Relig Health.* 2018;57(1):266–278. doi:10.1007/s10943-017-0447-4
63. Xu L. Effects of physical activity on subjective well-being — evidence from the meta-analysis of experiment studies. *China Sport Sci.* 2014;34(10):29–38. doi:10.16469/j.css.2014.10.007
64. Han Y, Li Z, Luo Y, Gao M, Dong X. Analysis of influencing factors and the status of subjective well-being of elderly patients with myocardial infarction in community. *Med Res Educ.* 2021;38(03):56–61. doi:10.3969/j.issn.1674-490X.2021.03.010
65. Xie X. Research on the difference of college student' subjective well-being and its influencing factors from the perspective of urban-rural. *Jiangxi Univ Financ Econ.* 2020. doi:10.27175/d.cnki.gjxcu.2020.000910
66. Zhu X, Liu J. An empirical study on the path of subjective socioeconomic status influencing college students' well-being. *J Henan Univ.* 2019;59(06):106–115. doi:10.15991/j.cnki.411028.2019.06.015
67. Chen X, Li M. Subjective well-being and mental health of undergraduate students. *J Chongqing Univ.* 2014;20(03):178–183. doi:10.11835/j.issn.1008-5831.2014.03.026
68. Yang J, Sun X, Chen A, Zhu F. Mediating effects of coping style and subjective well-being: experimental study on influences of exercise on the mental health of female college students. *Sports Sci.* 2011;32(05):95–99. doi:10.13598/j.issn1004-4590.2011.05.024
69. Dsouza J, Chakraborty A, Veigas J. Biological connection to the feeling of happiness. *J Clin Diagn Res.* 2020;14(10). doi:10.7860/JCDR/2020/45423.14092
70. Iwon K, Skibinska J, Jasielska D, Kalwarczyk S. Elevating subjective well-being through physical exercises: an intervention study. *Front Psychol.* 2021;12. doi:10.3389/fpsyg.2021.702678

71. McMorris T, Graydon J. The effect of incremental exercise on cognitive performance. *Int J Sport Psychol.* **2000**;51:27–35.
72. Yerkes RM, Dodson JD. The relation of strength of stimulus to rapidity of habit-formation. *J Compar Neurol Psychol.* **1908**;18:459–482. doi:10.1002/cne.920180503
73. McLean CP, Anderson ER. Brave men and timid women? A review of the gender differences in fear and anxiety. *Clin Psychol Rev.* **2009**;29(6):496–505. doi:10.1016/j.cpr.2009.05.003
74. Pigott TA. Anxiety disorders in women. *Psychiat Clin.* **2003**;26(3):621–672.
75. Van Veen JF, Jonker BW, Van Vliet IM, Zitman FG. The effects of female reproductive hormones in generalized social anxiety disorder. *Int J Psychiatry Med.* **2009**;39(3):283–295. doi:10.2190/PM.39.3.e
76. Maeng LY, Milad MR. Sex differences in anxiety disorders: interactions between fear, stress, and gonadal hormones. *Horm Behav.* **2015**;76:106–117. doi:10.1016/j.yhbeh.2015.04.002
77. Parks SE, Housemann RA, Brownson RC. Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *J Epidemiol Commun Health.* **2003**;57(1):29–35. doi:10.1136/jech.57.1.29
78. Reimers AK, Schmidt SC, Demetriou Y, Marzi I, Woll A. Parental and peer support and modelling in relation to domain-specific physical activity participation in boys and girls from Germany. *PLoS One.* **2019**;14(10):e0223928. doi:10.1371/journal.pone.0223928
79. Hamilton K, White KM, Cuddihy T. Using a single-item physical activity measure to describe and validate parents' physical activity patterns. *Res Q Exerc Sport.* **2012**;83(2):340–345. doi:10.1080/02701367.2012.10599865
80. Wang L. 24-hour movement of children and adolescents aged 5–18: current situation, influencing factors, and healthy impact. *Chin Sport Sci Technol.* **2022**;58(01):46–56. doi:10.16470/j.csst.2021050

Psychology Research and Behavior Management

Dovepress

Publish your work in this journal

Psychology Research and Behavior Management is an international, peer-reviewed, open access journal focusing on the science of psychology and its application in behavior management to develop improved outcomes in the clinical, educational, sports and business arenas. Specific topics covered in the journal include: Neuroscience, memory and decision making; Behavior modification and management; Clinical applications; Business and sports performance management; Social and developmental studies; Animal studies. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/psychology-research-and-behavior-management-journal>