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Original Paper

The Relationship between Physical Exercise and Subjective Well-being: a Meta-Analysis based on The Chinese Student Population

Zhengban Ran[1], Anli Zhou[1], Chenggang Ran[2], Chen Ling[1], Chaoling Qin[1]

[1] Southwestern University, 400799 Chongqing, China

[2] Chongqing College of Humanities, Science & Technology, 401524 Chongqing, China

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Abstract

Using the method of meta-analysis to explore the relationship between physical exercise and subjective well-being, after searching and screening, as of December 2023, a total of 534 subject-related literature was searched, and 46 articles were included in the literature, with 38,291 subjects, which were analyzed by the random-effects model selected from the results of the test of homogeneity, and the study found that: there is a certain degree of positive correlation between physical exercise and subjective well-being (r=0.269, 95% CI = [0.222, 0.313]), and the instrument for measuring subjective well-being can significantly affect the relationship, but the age and gender of the subjects do not have a significant effect on the two. The results of the study demonstrated a positive relationship between physical exercise and subjective well-being, supporting the goal orientation theory. A wider range of studies such as experimental studies should be included in the future to test the relationship.

Keywords

physical exercise, subjective well-being, meta-analysis

1. Preface

The rise of positive psychology has led to an increased interest in the physical and mental state of students. As one of the centers of attention in positive psychology, subjective well-being is not only an important indicator of an individual's standard of living, but it is also used to measure the level of an individual's mental health development (Chen & Ji, 2006). The improvement of students' subjective well-being will effectively increase their self-esteem level (Wang & Zhang, 2011) and facilitates goal focus and emotional control (Li & Zhang, 2011). However, the development of students' subjective

well-being in China is worrying. According to the results of the Program for International Student Assessment 2018 data from four provinces and cities in China, students in China generally have a low sense of well-being (Wang, Liu, Tian, & Liu, 2021), which can easily lead to a series of negative consequences such as students' poor academic performance and dropping out of school. In recent years, students' subjective well-being has received sustained attention from researchers.

As the material development of the society is satisfied, the healthy lifestyle is paid more and more attention to. Currently, a large number of studies have shown that physical activity is an important factor affecting subjective well-being, and the relationship between the two has been increasingly emphasized by scholars. Throughout the results of the relationship analysis, the r-value ranges from 0.098 to 0.707 have been reported, the results are very different. Therefore, the extent of the correlation between physical activity and subjective well-being and whether it is interfered by other factors in the study need to be further explored. In addition, from the existing meta-analytic literature, it is clear that physical activity is not only closely related to subjective well-being but also has a predictive effect on it (Netz, Wu, Becker, & Tenenbaum, 2005; Ginis, Jetha, Mack, & Hetz, 2010). However, the existing research mainly focuses on special groups such as the elderly, and few studies have been conducted specifically on Chinese students. Therefore, this study adopts a meta-analytic approach to analyze the relationship between physical activity and subjective well-being in the Chinese student population in a more comprehensive, accurate, and comprehensive way, and at the same time examines the moderating variables that may have an impact on both, so as to avoid the bias of individual studies due to the influence of samples and geographic regions, and to draw more accurate conclusions from an overall perspective.

2. Literature Review and Theoretical Assumptions

2.1 Literature Review

2.1.1 Concept and Measurement of Physical Activity

The Sports dictionary (1984) defines the term "physical exercise" as "the process of exercising the body and engaging in physical activity by using a variety of physical means in conjunction with the forces of nature for the purpose of improving health and strengthening the body". Zeng Qian et al, physical exercise is "a physical activity aimed at improving physical fitness, enhancing physical health, regulating mental state and enriching cultural life" (Zeng, Lan, & Xu, 2010). "Physical exercise is mainly an activity that uses physical exercises and exercise loads as physical means" (Liao & Chen, 2022). It is a physical activity that requires a certain amount of exercise, a certain intensity, and a certain amount of time. Currently, the following scales are used to test physical activity: (1) Physical Activity Rating Scale (PARS-3), which was revised by Liang Deqing et al. in 1994, examines the amount of exercise from three aspects (intensity, time and frequency of each exercise) and measures the level of physical activity by the amount of exercise. The formula for the amount of exercise is calculated as "Exercise = Intensity x Time x Frequency" (Leung, 1994). (2) The Chinese version of the

Physical Activity Questionnaire for Adolescents (PAQ-A) developed by Li Xin et al. The questionnaire consists of 9 questions, each with 5 options, which are assigned values according to the overall activity level from low to high (Li, Wang, Li, Li, Sun, Xie, & Wang, 2015). (3) The Chinese version of the Health Promotion Lifestyle Profile (HPLP-II) developed by Cao, Wenjun et al. It consists of 6 dimensions with 52 items. A 4-point scale was used, with higher scores indicating a healthier lifestyle (Cao, Guo, Ping, & Zheng, 2016). International Physical Activity Questionnaire (Short Scale), which is used to detect different intensities of physical activity among adolescents, consists of 7 questions, 6 questions on physical activity and 1 question on sedentary time (Li, 2004). Overall, the PARS-3 is the most used in China.

2.1.2 Concept and Measurement of Subjective Well-being

Subjective well-being (SWB) refers to "an individual's overall judgment and experience of the quality of his or her life according to standards that he or she has set for himself or herself, and is an important psychological indicator of how well he or she evaluates his or her standard of living" (Zhao, Zhang, Wang, & Xie, 2008). It is specifically manifested in 3 aspects of life satisfaction, positive emotions and negative emotions. The following instruments are mainly used in China to measure subjective well-being: (1) Index of Well-Being Scale (IWB). This scale was developed by Campbell et al. in 1976 and consists of two sub-questionnaires, the General Affective Index Scale and Life Satisfaction (Campbell, 1976). (2) Subjective well-being scale (SWB) developed by Diener et al., with a total of 19 entries, consists of three subscales measuring overall life satisfaction, positive affective frequency, and negative affective frequency (Ji, 2006). (3) The A-GLS scale, a combination of the Affective Balance Scale and the General Life Satisfaction Scale (Yuan & Zhang, 2015; Liu & Ma, 2017), which covers life satisfaction, positive emotions and negative emotions, has 16 items. (4) The SWLS & PANAS Combined Scale, which consists of two parts, one measuring positive and negative emotions, with nine questions each, scored on a five-point Likert scale, and the other measuring life satisfaction, with a total of five items, scored on a seven-point scale (Chen & Yu, 2015). (5) General Well-being Schedule (GWB), which was developed by Fazio of the U.S. National Center for Statistics in 1997, and later revised by Chinese scholars to use the first 18 items, was used to measure six dimensions including worry about health, satisfaction and interest in life, control of emotions and behaviors, energy, melancholic or pleasant state of mind, and relaxation and tension (FAZIO, 1997). (6) College Students' Subjective Well-Being Scale (CS-SWB), which was developed by Ji Nan, consists of 41 questions and 8 dimensions, and uses a five-point Likert scale (Ji & Li, 2006). The current instrument used in academia to measure subjective well-being is mainly the GWB.

2.2 Theoretical Assumptions

2.2.1 Relationship between Physical Activity and Subjective Well-being

It has been hypothesized that sport has an intrinsic joy that may be responsible for the positive correlation between physical activity and subjective well-being (Chen & Ji, 2006). One study showed a significant positive correlation between physical activity and subjective well-being, and that the former

was predictive of the latter (Shang, Chen, & Xie, 2023). Dweck's Motivational Goal Orientation Theory suggests that: goal attainment leads to subjective well-being, and that goal orientation determines subjective well-being as well as acquires and maintains well-being (Chen & Yu, 2015). Individuals form different exercise needs due to different goals, and in the process of physical exercise to meet the low-level goals, resulting in self-confidence, which promotes the formation of satisfaction and positive emotions, and enhance subjective well-being, while at the same time generating the need to seek high-level goals. Meanwhile, existing studies have shown that physical activity is negatively related to negative emotions such as depression and anxiety (Wang, Wang, Zhao, & Wang, 2023; Huang, Chen, Chen, & Peng, 2023) and positively associated with positive emotions such as body esteem, self-concept, and psychological capital, as well as life satisfaction (Yan, Qian, Tao, & Jiang, 2022; Li, He, & Chen, 2020; Li, Shen, Li, & Xue, 2023). In addition, some researchers have suggested that physical activity itself contains elements of happiness, which can improve individuals' assessment of quality of life, alleviate negative emotions, promote positive emotions (Qiao, 2020), and ultimately enhance their subjective well-being.

In summary, this study proposes the hypothesis H_0: There is a degree of positive correlation between physical activity and subjective well-being.

2.2.2 Analysis of the Moderating Effect of Physical Activity and Subjective Well-being

In recent years, studies related to physical activity and subjective well-being have been widely conducted in the academic community, but the results have varied widely, this may be related to the gender and age of the study participants as well as the measurement tools.

Different measurement tools may affect the relationship between physical activity and subjective well-being. Different scales can lead to differences in the results of the study due to the different dimensions they are divided into, the different number of questions the scales contain, and the inconsistency of the scoring methods. For example, scales such as SWB and CS-SWB contain more dimensions and question items, while IWB and A-GLS have only fewer dimensions and question items, which have become parsimonious but undeniably also lose a lot of information. Therefore, this study proposes the hypothesis H_1: Measurement tools of subjective well-being play a moderating role in the relationship between physical activity and subjective well-being.

The age of the subjects may also influence the relationship between physical activity and subjective well-being. First, subjective well-being is inherently subjective, emphasizing an individual's overall assessment of his or her life (Zhao, Guo, & Xie, 2011). From the perspective of individual development, students' experience of subjective well-being changes with increasing experience, and tends to be relatively stable in high school. In addition, because Chinese students face different problems at different stages, such as neglecting physical exercise due to the pressure to advance to higher education in middle school. Therefore, physical activity at different stages may affect subjective well-being. In this study, the subject population was divided into three academic age groups: junior high school students, high school students (including vocational school students), and college students (including

junior college student, undergraduates, and postgraduates), so as to test the moderating effect of age on the relationship between the two. Based on this, the hypothesis H_2 is proposed: the age of the subjects has a moderating effect on the relationship between physical activity and subjective well-being.

Whether gender has an effect on the relationship between physical activity and subjective well-being has been controversial. Some studies have shown no significant difference between gender in the relationship between physical activity and subjective well-being, while others have shown a significant difference, and still others have shown a significant difference in positive and negative emotions under the dimension of subjective well-being. In terms of personality traits, girls are generally more delicate than boys and are more sensitive to the emotional experiences of others. The fact that females are more intense than males in sports activities may be due to the fact that females are more emotional and self-involved than males (Zhao et al., 2011). However, it has been noted that girls are not as proactive and motivated to participate in sports as boys, and that the life satisfaction, positive emotions and overall subjective well-being they derive from their participation in sports are lower than those of boys (Zhao et al., 2008). Whatever the explanation, it suggests that gender may influence the relationship. In summary, this study proposes the hypothesis H_3: Gender may moderate the relationship between physical activity and subjective well-being.

3. Research Methodology

3.1 Literature Search and Screening

In the first step, an advanced search was conducted in the databases of CNKI, Wanfang, and Wipu with the subject terms “physical exercise”, “subjective well-being”, and “students” in order to search for journals and master’s and doctoral dissertations containing such terms; the second step is to search for “physical exercise” with “subjective well-being” and “students” in the Web of Science to search for literature containing these words. The cutoff date was December 2023, and a total of 534 documents were searched.

The retrieved literature was imported using NoteExpress software and screened according to the following principles: (1) the population of the study was a group of Chinese students (excluding special groups, such as people with disabilities, left-behind children, etc.); (2) the data related to physical activity and subjective well-being were reported without obvious errors; (3) the measurement tools were clearly explained. In this study, a literature screening flowchart was established with reference to previous meta-analysis literature (Figure 1).

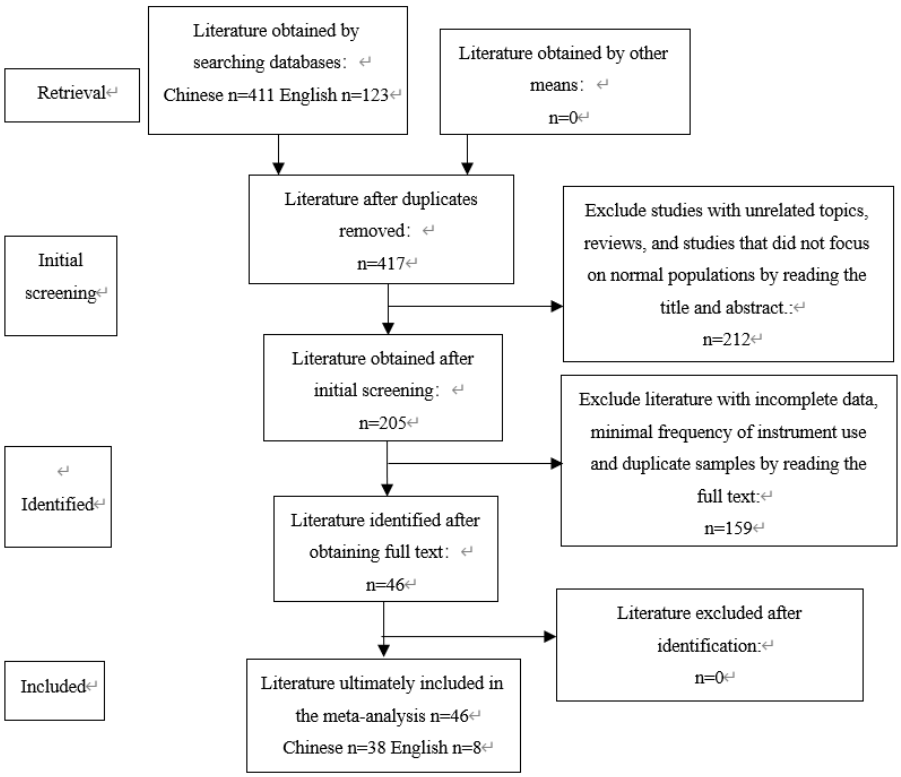

Figure 1. Flow Chart of Literature Screening

3.2 Literature Quality Assessment and Data Coding

In this study, the included literature was scored and quality assessed with reference to the Relevant Classes Meta-Analysis Literature Quality Evaluation Scale developed by Zhang et al. (2019). The criteria included the sampling method of subjects, data validity (i.e., effective recovery rate of the questionnaire), reliability of the measurement instrument, and the level of publication. The criteria for determining the literature quality score are shown in Table 1.

Table 1. Literature Quality Scoring Criteria

Type of standard	Project classification	score
Sampling method	random sample	2
	non-random sample	1
	Unreported	0
Data efficiency	0.9≤effective rate	2
	0.8≤effective rate < 0.9	1
	Effectiveness rate <0.8 or not reported	0
Reliability of measurement tools	0.8 ≤ confidence level	2
	0.7≤credibility<0.8	1

	Confidence <0.7 or not reported	0
	CSSCI (with extensions) and SSCI	2
Publication level	Peking University core	1
	General and unpublished	0

According to the scoring criteria in Table 1, the total score of each piece of literature was finally calculated, and the higher the total score obtained by a piece of literature, the higher the quality of that piece of literature. Literature was evaluated independently by two trained raters, and the consistency Kappa value was calculated after the completion of the evaluation, which was based on the formula: Cohen's kappa: k=(PO-PE)/(1-PE). The kappa value in this study was 0.97. Kappa values of 0.75 and above were considered to be very good agreement (Zeng & Li, 2023). Therefore, the level of consistency between the two reviews in this study is judged to be very good.

Data coding of the final included literature was performed using Excel 2021, which included basic information about the literature, the level of subjects surveyed, correlation coefficients, measurement tools, and gender (in the form of male ratio) (such Table 2). If the original article in Table 2 reported the correlation coefficients between physical activity and subjective well-being it was entered directly, and if it was not in the original literature but reported the correlation coefficients between physical activity and the various sub-dimensions of subjective well-being, it was entered after calculating r according to formula (1).

$$r_i = (e^{2z} - 1)/(e^{2z} + 1) \ldots\ldots\ldots\ldots (1) \quad \text{thereinto,} \quad Z = 0.5 * \ln\frac{1+r}{1-r}$$

r_i denotes the final recorded correlation coefficients after the correlation coefficients of the subdimensions of physical activity and subjective well-being were calculated, and r represents the correlation coefficients of the sub-dimensions in the original literature. The process of coding was also done independently by two researchers to get 2 copies of the final coded results, and if there were inconsistencies in the results then they needed to be checked against the data in the original literature and corrected (Zhang & Liu, 2020).

Table 2. Basic Data for Entry of Original Documents

serial number	author	year	Total sample size	correlation coefficient	investigation level	males	Article Type	Subjective wellbeing measurement tool	Literature quality score
1	Zang, Z. L.	2009	189	0.186	university student	0.48	dissertation	GWB	5
2	Yuan, G. Y.	2009	1385	0.11	Junior high and high school students	0.41	periodicals	SWB-C	6
3	Geng, Y.	2011	448	0.141	university student	0.49	dissertation	SWB	3
4	Song, F.	2011	466	0.231	Junior high and high school students	0.52	dissertation	PA-SWB	5
5	Lin, B.	2012	584	0.537	senior high school student	0.55	dissertation	SWB-C	6
6	Han, H. J.*	2012	956	0.118	university student	0.51	periodicals	SWB	7
7	Chen, Y. T.	2013	320	0.243	university student	0.38	periodicals	GWB	8
8	Wang, H. T.	2014	556	0.32	university student	0.58	dissertation	IWB	6
9	Meng, X. L.	2015	721	0.46	university student	0.56	periodicals	SEES	9
10	Yuan, G. Y.	2015	1538	0.17	Junior high and high school students	0.4	periodicals	A-GLS	8
11	Chen, Z. Y.	2015	330	0.201	university student	0.48	periodicals	SWLS、PANAS	8
12	Wu, H.	2015	430	0.198	university student	0.51	dissertation	SWB	7

13	Li, J	2017	91	0.26	university student	0.51	periodicals	SWB	7
14	Zou, R.	2017	727	0.309	university student	0.49	dissertation	SWB-Z	5
15	Liu, H.	2017	1646	0.19	Junior high, high school students	0.57	periodicals	A-GLS	7
16	Liu, Z. J.	2017	1217	0.455	university student	0.6	dissertation	CS-SWB	3
17	Zhang, L. L.	2018	369	0.142	university student	0.49	periodicals	IWB	3
18	Zhang, H. M.	2020	341	0.252	university student	0.72	periodicals	SEES	3
19	Zhang, F. Y.	2021	521	0.15	university student	0.39	periodicals	IWB	4
20	Zhou, W. Y.	2021	344	0.19	University students, graduate students	0.39	periodicals	GWB	5
21	Wang, Z. Q.	2021	930	0.257	university student	0.32	periodicals	IWB	3
22	Yang, F.	2021	368	0.139	senior high school student	0.48	dissertation	SWB-H	8
23	Shang, Y	2021	671	0.15	university student	0.78	periodicals	GWB	7
24	Ding, Z	2021	1725	0.279	university student	0.43	periodicals	IWB	6
25	Li, X. B.	2022	728	0.48	university student	0.54	dissertation	SWLS、PANAS	5
26	Chen, L.	2022	1960	0.109	university student	0.43	dissertation	IWB	6
27	Huang, M. R.	2022	1135	0.256	university student	0.46	dissertation	SWB	6
28	Yuan, S	2022	1198	0.105	university student	0.56	periodicals	GWB	8

29	Wang. K	2022	826	0.31	university student	0.46	periodicals	SWB	9
30	Tian, J	2022	1153	0.13	university student	0.72	periodicals	GWB	6
31	Zhou, H.*	2022	722	0.189	university student	0.54	periodicals	SWLS、PANAS	8
32	Wen, X.	2022	503	0.234	University students, graduate students	0.53	dissertation	GWB	8
33	Lin, S.	2022	770	0.43	university student	0.6	periodicals	SWLS、PANAS	9
34	Yao, S. J.	2022	1510	0.236	junior high student	0.48	dissertation	IWB	8
35	Shang, Y.*	2023	1056	0.098	junior high student	0.49	periodicals	SWLS、PANAS	7
36	Gao, Y.	2023	755	0.153	university student	0.31	periodicals	GWB	5
37	Zhang, C. L.	2023	845	0.199	university student	0.41	periodicals	A-SWB	6
38	Sun, Z. C.	2023	916	0.293	university student	0.55	periodicals	GWB	4
39	Xu, Y. F.	2023	1202	0.473	junior high student	0.45	dissertation	A-SWB	7
40	He, X. R.	2023	284	0.267	senior high school student	0.5	dissertation	SWB-C	6
41	Cao, C. Y.	2023	1319	0.313	senior high school student	0.5	dissertation	A-SWB	5
42	Yu, Z. K.	2023	266	0.35	university student	0.52	dissertation	SWB	6
43	Han, C. Y.	2023	975	0.314	university student	0.51	dissertation	CS-SWB	7
44	Yao, S	2023	1510	0.236	junior high student	0.48	periodicals	IWB	8

45	Wang, S. C.	2023	585	0.427	university student	0.53	dissertation	SWB	5
46	Wang, F. S.	2018	1200	0.707	university student	0.52	dissertation	SWB	7

Note. The correlation coefficients of the literature marked * in the table are calculated for each sub-dimension;

Measurement tools without a specific term use initials instead.

4. Results

4.1 Literature Characterization and Quality Assessment

A total of 46 articles were included in this study, comprising 46 independent samples totaling 38,291 individuals. There were 38 articles in Chinese and 8 articles in English, covering middle school students, high school students and college students. The actual mean value of the quality assessment scores was 6.2, and overall the studies were quite variable, with a slight downward trend (Figure 2). 15 of the 46 articles scored lower than the theoretical mean of 6, so the impact of these 15 articles on the overall study results should be treated with caution.

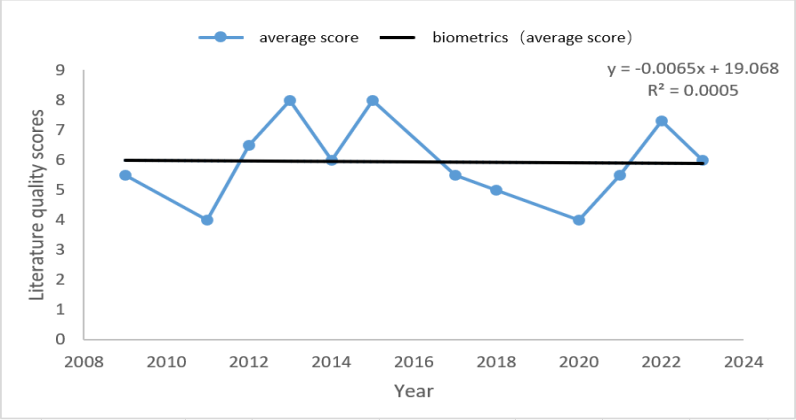

Figure 2. Trends in the Quality of Literature

4.2 Homogeneity Test

The raw literature data information was imported into Comprehensive Meta-Analysis Version 3.7 (CMA3.7) for meta-analysis. Before conducting the meta-analysis, one of the fixed-effects model or random-effects model was selected. The fixed-effects model assumes that the true effect values should be the same across all studies and that errors between outcomes are caused only by random errors, while the random-effects model allows for the true effect values to vary across all studies, and the results will be affected not only by random errors, but also by differences in the characteristics of the study population. The choice of model can be made in two ways: either the choice can be judged subjectively, or it can be judged using the Q test as well as the I^2 test. The premise of the Q test is the

assumption that the effect values of the study must obey a chi-square distribution, and that they are heterogeneous if $p < 0.05$; the I^2 is a measure of the percentage of variation (heterogeneity) in the total variation due to the individual studies that is not due to sampling error (Zhang et al., 2019). If $I^2 < 40\%$ is for low heterogeneity, $40\% < I^2 < 60\%$, moderate heterogeneity, $60\% < I^2 < 75\%$, higher heterogeneity, and $I^2 < 75\%$ is for high heterogeneity, and the higher the heterogeneity, the more appropriate the choice of random effects model. In this study, after the previous combing, it was found that the relationship between physical activity and subjective well-being may be affected by the measurement tool, the age of the subjects, and the gender, so the random effect model was chosen; moreover, the Q-test result in Table 3 was 1047.949 ($p < 0.01$), and $I^2 = 95.706\% > 75\%$. This indicates that 92.706% of the variance in the relationship between physical activity and subjective well-being is caused by differences in the true effect values between studies, making it more appropriate to choose a random-effects model. It also signals that differences in the characteristics of the study groups may affect the differences in effect sizes, and thus further research is needed to investigate the moderating variables that affect the relationship.

Table 3. Results of Homogeneity Test

model	Number of studies	homogeneity				Tau Squared			
		Q value	df (Q)	p	I-square	Tau Squared	SE	variance	Tau
stochastic model	46	1047.949	45	0.000	95.706	0.027	0.007	0.000	0.165

4.3 Publication Bias Test

Publication bias refers to the fact that the published literature does not fully represent the study as a whole, mainly due to the fact that the researcher failed to collect all the unpublished literature, manuscripts, etc. and include them in the analysis, which will affect the reliability of the meta-analysis results. Two common methods to test publication bias are funnel plot and Egger's test. The essence of funnel plot is a scatter plot, the horizontal coordinate indicates the size of the effect value, the vertical coordinate indicates the number of sample size, if the points in the plot converge into a roughly symmetrical inverted funnel, it means there is no publication bias. As shown in Figure 3, the effect values of the funnel plot mainly reside at the top of the plot and are not more evenly distributed on both sides of the total effect values. However, due to the strong subjectivity of funnel plots and the fact that asymmetric funnel plots do not necessarily cause publication bias, and publication bias does not necessarily cause asymmetric funnel plots (Xiang, Xiao, Zhao, & Hou, 2021). Therefore, further Egger's linear regression test was needed, Further tests revealed that the result of Egger's test was not significant, with an intercept of 0.5537, 95% CI of [-4.58, 5.69], $p > 0.05$, which indicated that the study did not suffer from serious publication bias, suggesting that this meta-analysis was more stable.

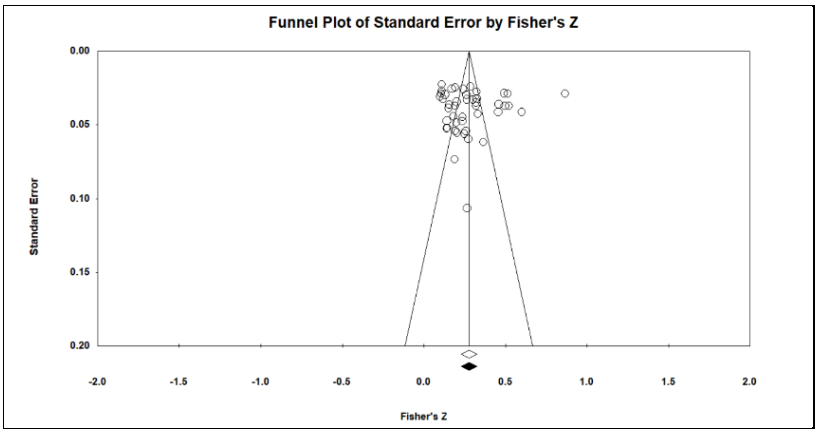

Figure 3. Funnel Diagram

4.4 Main Effects Test

From the results of the homogeneity test, a random effects model was chosen to analyze the degree of overall association between physical activity and subjective well-being, and the results are shown in Table 4. The correlation coefficients of the two r=0.269, 95%CI=[0.222, 0.313], and do not contain 0. It indicates that there is a positive correlation between the two and supports the hypothesis H_0. The sensitivity analysis of the effect values in the present study found that: after excluding any one of the study, the effect value r ranged from 0.256 to 0.272; also according to the forest plot after excluding three highly heterogeneous literatures at the same time (Lin. B, 2012; Li. X. B, 2022; Wang. F. S, 2018), the effect value of physical activity and subjective wellbeing was 0.243, $p < 0.01$; and also according to the quality scores (Table 1), after deleting 15 literatures with scores lower than 6, the effect value was 0.256, $p < 0.01$. All of the above results indicate a certain stability of the effect value.

Table 4. Stochastic Model Analysis of the Relationship between Physical Activity and Subjective Well-being

model	Number of studies	N	Effect values and 95% confidence intervals			bilateral test	
			point estimate	lower limit	upper limit	Z	p
stochastic model	46	38291	0.269	0.222	0.313	10.995	0.000

4.5 Moderating Effects Test

In this study, subgroup analyses were conducted according to the two moderating variables of the measurement tool and the age of the subjects, respectively. For H_1 , the effect values of physical activity and subjective well-being were subgrouped according to the research measurement tool, the variance between groups was calculated and Q-test based on ANOVA was performed, if the results

were significant then H_1 was accepted, otherwise was not accepted; For H_2 , similarly the effect values of physical activity and subjective well-being were subgrouped according to the school age of the subjects and Q-test was performed, if the results were significant then H_2 was accepted, otherwise it was not accepted. Since male ratio is a continuous variable, for H3, meta-regression analysis was used to test the moderating effect of gender on physical activity and subjective well-being. The regression equation was established with the male ratio as the predictor variable and the effect value of the relationship between physical activity and subjective well-being as the dependent variable, and if the equation was significant, H_3 was accepted, and vice versa was not accepted.

Table 5. Test of the Moderating Effect of Measurement Instruments on the Relationship between Physical Activity and Subjective Well-being

moderator variable	heterogeneity test			form	K	95% confidence interval			bilateral test	
	Qa	df	p			point estimate	lower limit	upper limit	Z	p
measuring tool	13.77	6	0.032	CS-SWB	2	0.387	0.241	0.516	4.923	0.000
				A-GLS	2	0.18	0.147	0.214	10.28	0.000
				GWB	9	0.184	0.137	0.231	7.495	0.000
				IWB	8	0.222	0.17	0.272	8.196	0.000
				SEES	2	0.363	0.145	0.548	3.177	0.001
				SWB	9	0.323	0.146	0.48	3.49	0.000
				SWLS$PANAS	5	0.287	0.121	0.438	3.333	0.001

Note. K represents the number of independent effect values; Qa represents the statistic for the heterogeneity test.

Table 6. Tests of the Moderating Effect of School Age Group on the Relationship between Physical Activity and Subjective Well-being

moderator variable	heterogeneity test			form	K	95% confidence interval			bilateral test	
	Qa	df	p			point estimate	lower limit	upper limit	Z	p
school age group	0.359	2	0.836	junior high student	4	0.267	0.113	0.408	3.342	0.001
				university student	34	0.273	0.215	0.329	8.921	0.000
				senior high school student	4	0.324	0.155	0.475	3.667	0.000

Note. K represents the number of independent effect values; Qa represents the statistic for the heterogeneity test

Table 7. Moderation Analysis of the Relationship between Physical Activity and Subjective Well-being in the Male Ratio

	ratio	SE	95% confidence interval		Z	p
			lower limit	upper limit		
males	0.26	0.28	-0.28	0.81	0.95	0.34

(1) As can be seen in Table 5, the instrument for measuring subjective well-being plays a moderating role in its relationship with physical activity. The results of its subgroup analysis were significant with a Q-value of 13.770, $p < 0.05$, thus accepting H_1. By further analysis, it was found that the lowest correlation was measured with A-GLS as the instrument (0.180), higher ones with SWLS & PANAS, SEES & SWB (0.287, 0.363, 0.323), and the highest was measured with the CS-SWB combination tool (0.387).

(2) According to Table 6, the moderating effect of different school age groups on the relationship between physical activity and subjective well-being is not significant. The result shows its Q-value is 0.359, $p=0.836 > 0.05$, thus rejecting H_2. However, further observation reveals that the degree of correlation measured in the category of high school students is significantly higher than that of junior high school students and college students (0.324, 0.267, and 0.273, respectively).

(3) Table 7 shows that the male ratio failed to significantly predict the relationship between physical activity and subjective well-being with a coefficient of 0.26, $Z=0.95$, $p=0.34>0.05$, and 95% confidence interval of [-0.28, 0.81], indicating that the moderating effect of gender on the relationship between physical activity and subjective well-being is not significant, thus rejecting H_3.

5. Discussion

5.1 Main Effects of Physical Activity and Subjective Well-being

The present study analyzed and answered the question of the degree of correlation between physical activity and subjective well-being through meta-analysis of 46 studies in recent years in China, and the results showed that physical activity and subjective well-being showed a certain degree of positive correlation, i.e., the level of subjective well-being of individuals with a higher level of physical activity was higher than that of the general population. This result is consistent with the results of several studies and confirms the findings of the present study H_0. However, although the causal relationship between the two cannot be confirmed, it can be shown that individuals' physical activity can improve their subjective well-being. This result is consistent with the goal orientation theory of achievement. Individuals continue to increase their subjective well-being in the process of "goal-forming exercise needs - exercising to increase self-confidence - developing satisfaction and positive emotions - increasing subjective well-being - seeking higher goals", which also explains the predictive function of physical exercise on subjective well-being. At the same time, individuals with higher subjective

well-being have a more positive evaluation of themselves, and are able to devote more energy to physical activity to better accomplish their exercise goals. Physical exercise has become an important method of individual happiness and promoting group cohesion. But on the other hand, the research results show that the correlation between the two is only at an average level, and excessive physical load may even lead to the decline of individual subjective well-being. Therefore, it is important to grasp the degree of personal physical exercise and continuously promote the continuous improvement of personal happiness for the overall improvement of national happiness index.

5.2 Moderating Effects of Physical Activity and Subjective Well-being

The results of the meta-analysis revealed that the correlation coefficients between physical activity and subjective well-being measured by different subjective well-being measurement tools differed significantly, with the lowest correlation measured by the A-GLS as the tool, the higher ones measured by SWLS & PANAS, SEES & SWB, and the highest one measured by the combination tool of CS-SWB. It was demonstrated that different measurement tools can cause differences in results, verifying that the lower correlation coefficients measured by the H_1. The low correlation coefficients measured by the A-GLS scale may be related to its small number of questions and the way it is scored. This scale has only 16 questions, which will inevitably lose some necessary information compared to other scales, and its internal validity will be reduced. Moreover, the scale is scored on a "yes or no" scale, with "yes" on the positive affective items and "no" on the negative affective items scored 1 point each, and the final result is obtained by subtracting the negative score from the positive score and adding a factor of 5 to the positive score. Compared with the Likert scale used in other scales, this scoring method is more susceptible to the influence of extremes, and its reliability is obviously insufficient. The higher correlation coefficients measured by the combined SWLS & PANAS scale and the CS-SWB scale may be due to the fact that the combined scale is more comprehensive, with a greater number of items and a broader range of dimensions. The SWLS & PANAS combined scale consists of two parts, and is a more comprehensive assessment of subjective well-being in terms of the two dimensions of sense of positivity and life satisfaction (Zhou, & Zhou, 2022). The CSSWB scale, on the other hand, consists of more questions and broader dimensions, which not only takes into account internal factors such as personal emotions and feelings of satisfaction, but also involves external influences, which can more comprehensively and accurately reflect the level of subjective well-being. This suggests that future researchers should not only consider the simplicity of the scale and the convenience of its operation when using measurement tools, but should also choose a more comprehensive scale, so as to avoid reducing the reliability and validity of the scale due to its simplicity, which may affect the results of the study.

The results of the study showed that the moderating effect of subjects' school age on physical activity and subjective well-being was not significant. In this study, the subjects were divided into three school-age groups: middle school students, high school students, and college students, and the results showed that the differences among the three groups were not significant, failing to validate H_2. This

may be due to the fact that only eight articles in the included literature differentiated between middle school and high school students, while four articles did not differentiate between the two groups, resulting in an error. The correlation between physical activity and subjective well-being measured in high school students is higher than that of college students and junior high school students, which may be due to the fact that students in high school are in a transitional period of psychological development and have a large range of psychological fluctuations, which is different from that of the other two groups. Therefore, in the future, we can wait for more research results from the academic community to further study whether there is a significant difference between the high school group and the other groups.

The meta-analysis also found that the moderating effect of gender on the relationship between physical activity and subjective well-being was not significant, fails to support H_3. This result suggests that the stability of the interrelationship between physical activity and subjective well-being may cross gender boundaries and be prevalent across different gender groups. Although it has been mentioned that girls are less active and motivated than boys in the process of participating in physical activities, and have lower life satisfaction, positive emotions and overall subjective well-being through participation in physical activities than boys. However, because girls' personality traits, such as emotional level and empathy, are generally better than boys', they are more likely to experience the emotional changes of others and have richer emotional experiences during physical activity. To a certain extent, this compensates for the disadvantage of women's psychological resilience, resulting in a less significant moderating effect of gender on the relationship between physical activity and subjective well-being.

5.3 Research Shortcomings and Prospects

(1) An unavoidable problem with meta-analysis is data omission. Although this study collected as much literature as possible, in reality some unpublished literature is difficult to be collected. (2) When screening and including the original literature, this study only considered the correlation coefficients of the two variables, as well as the correlation of the combinations, which is a cross-sectional study, and did not take into account other data, such as the experimental data, which may lead to bias in the results. Future research could further strengthen longitudinal studies such as experiments to verify the relationship between the two.

6. Conclusion

Through meta-analysis method to analyze 46 papers, the study found that: (1) physical activity and subjective well-being have a certain degree of positive correlation; (2) gender, age do not have a moderating effect on the relationship between physical activity and subjective well-being. (3) The testing tools for subjective well-being can significantly regulate the relationship between physical activity and subjective well-being, and future research should pay attention to the selection of research measurement tools.

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