A statistical computational modeling study of changes in mental health of higher vocational students' physical activity participation in the context of physical education integration

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Abstract Sports interest is the internal driving force for students to actively participate in sports activities, and when students become interested in sports activities, they will devote themselves to them to improve their sports skills and fully enhance their mental health. This paper takes a number of senior vocational schools in Jiangsu province as the research object, and obtains research data by using physical activity participation scale and mental health scale as the research tools. Then a multiple linear regression model was introduced to construct a research model between the participation in sports activities and mental health level of senior vocational students. On the basis of normality verification and correlation analysis, the relationship between higher vocational students' physical activity participation and mental health level was verified by benchmark regression, and the reliability of the results was analyzed by robustness test. The results show that if the participation rate of vocational college students in sports activities increases by 1%, the mental health level of the students will rise 0.126% and there is obvious regional heterogeneity in the relationship between the two, with the southern part of Jiangsu being relatively strong and the northern part relatively weak. In the context of the integration of sports and education, higher vocational colleges should enrich the types of sports activities to provide guarantees for meeting the diverse needs of students' sports activities, thereby enhancing students' mental health levels.

Index Terms physical activity participation, mental health scale, multiple linear regression, normality verification, correlation analysis

I.   Introduction

Body-education integration refers to the combination of physical education and education of other disciplines to realize the learning objectives of related disciplines through physical activities [1], [2]. The integration of physical education can promote the overall development of students, improve the learning effect, and enhance the physical and mental health of students [3], [4]. As China's requirements for talent cultivation continue to improve, the integration of physical education has been widely implemented in major universities [5]. For higher vocational education, in the context of the integration of physical education, the participation in sports activities has a significant impact on the changes in students' mental health [6], [7].

With the development of society and the progress of education, the mental health of higher vocational students has received increasing attention [8], [9]. Physical activity, as an important part of school education, not only has a significant impact on students' physical health, but also is closely related to students' mental health [10], [11]. Moderate participation in physical activities helps students form a positive self-image and improve self-esteem and self-confidence [12]. Through participation in sports activities, students can discover their potential and strengths, thus gaining a sense of achievement and increasing self-confidence in the activities, and this positive self-evaluation and self-perception is important for students' healthy psychological growth [13]-[16]. And sports activities usually require teamwork, which helps to develop students' teamwork and responsibility [17], [18]. In team activities, students need to learn to communicate and collaborate with others to accomplish tasks together [19]. This process not only exercises students' social skills, but also makes them realize their importance in the team, thus increasing their sense of responsibility [20], [21]. It can be seen that there is a close link between physical activity participation and the mental health of higher vocational students [22]. Moderate physical activity can not only promote students' physical health development, but also have a positive impact on their psychological health [23], [24]. Therefore, schools, families and society should work together to provide more opportunities and participation platforms for physical activities for primary school students to promote their overall healthy growth [25], [26].

Higher vocational colleges and universities should actively develop diversified sports activities to mobilize students' motivation to participate in sports so as to promote students' physical and mental health development.

The article selects several vocational colleges in Jiangsu Province as the research objects, and quantifies higher vocational students' participation in sports activities from their motivation to participate in sports activities, and then quantifies students' participation in sports activities through the Chinese Physical and Mental Health Comprehensive Assessment and Diagnostic Scale. A multiple linear regression model was constructed to analyze the relationship between students' mental health as the explanatory variable and higher vocational students' participation in sports activities as the explanatory variable. Normality and correlation analyses were conducted to verify the validity of the model, and the robustness of the baseline regression results was verified, and the regional heterogeneity of the relationship between higher vocational students' participation in sports activities and their mental health level was also explored.

II.   Research methodology

In recent years, the mental health problems of higher vocational students have become more and more prominent, and physical activity, as an active lifestyle, has unique advantages in promoting the mental health of higher vocational students. However, students in higher vocational colleges and universities usually have low participation in sports activities, which prevents them from effectively exerting their role in improving mental health. It is necessary to further explore the relationship between the participation in sports activities and mental health improvement of higher vocational students, so as to provide a reliable research basis for the enhancement of mental health of higher vocational students.

II. A.Subjects of study

This research obtained the research subjects from many higher vocational colleges in Jiangsu Province, including Wuxi Institute of Technology, Jiangsu Institute of Architecture and Technology, Suzhou Vocational College, etc. The average age of all the research subjects was 17.53 years old, and the standard deviation was 1.46.

Table 1: Scale of Participation in Sports Activities for Vocational College Students

Variable	Indicator significance	Code
Pleasure motivation	Sports are highly entertaining	SA1
	Sports activities are interesting	SA2
	Have a great time in sports activities	SA3
	Sports activities are exciting activities	SA4
	Like the excitement brought by sports	SA5
Ability motivation	I want to acquire new sports skills	SA6
	Enjoy the challenges brought by sports	SA7
	Improve my existing skills	SA8
	Want to maintain the current technological level	SA9
Institutional motivation	Physical education is a compulsory course	SA10
	One has to deal with the physical education exam	SA11
	Want to obtain credits related to sports	SA12
Appearance motivation	I want to improve my figure	SA13
	Hope to be more attractive to others	SA14
	I want to build up my muscles to look better	SA15
	Control my weight to look better	SA16
Health motivation	Want to enhance physical fitness	SA17
	Want to be more energetic	SA18
	To improve function of cardiovascular system	SA19
	Want to be physically strong and lead a healthy life	SA20
Social motivation	Want to be with friends	SA21
	My friend hopes that I will participate	SA22
	Want to make new friends	SA23
	Like to get along with people who are interested in sports	SA24

II. B.Research tools
II. B. 1)   Physical Activity Participation Scale for Higher Education Students
For the design of sports activity participation scale for higher vocational students, this paper refers to the existing relevant literature on students' sports activity participation, and starts from the motivation of higher vocational students' sports activity participation as a way to quantify the sports activity participation of higher vocational students. The content of the sports activity participation scale for higher vocational students designed in this paper is shown in Table 1, which mainly consists of fun motivation, ability motivation, institutional motivation, appearance motivation, health motivation and social motivation. The higher vocational students' sports activity participation scale was quantified using a five-point Likert scale, i.e., 1~5 means never, not, occasionally, often, and always, respectively.

II. B. 2)   Mental Health Scale for Higher Education Students
For the scale of mental health level of higher vocational students, this paper draws on the Comprehensive Assessment and Diagnosis Scale of Physical and Mental Health State of Chinese People compiled by the Key Laboratory of Mental Health of the Institute of Psychology of the Chinese Academy of Sciences, which screens and evaluates the subhealth state of the general population from the individual's three dimensions of physiology, psychology and society. The Chinese Physical and Mental Health Comprehensive Assessment and Diagnostic Scale consists of 74 items, of which 20 are related to the physiological aspects of the individual, 40 are related to the psychological aspects (emotion, cognition, behavior, ego, etc.), and 14 are related to social adaptation. Each part of the scale is scored according to the frequency of occurrence of the situation described in the questions in the last three months, and adopts a five-level scoring method of 1~5, which are "never", "occasionally", "sometimes", "often" and "always".

This paper quantifies the mental health level of senior vocational students through the Comprehensive Assessment and Diagnosis Scale of Chinese People's Physical and Mental Health Status. The higher the physical and mental health index of the students, the worse the physical and mental health status. The lower the physical and mental health index, the better the physical and mental health status, and the higher the score of the remaining factors, the more serious the problem. The scale has been tested for validity and reliability, and can effectively differentiate between subhealthy groups and healthy groups, groups with physical illnesses, groups with mental illnesses, and mixed groups with physical and mental illnesses, and has good psychometric qualities.

II. C.Research methodology
II. C. 1)   Multiple linear regression models
In statistical analysis, multiple linear regression algorithm is a very practical algorithm, which is widely used. The core of the idea of multiple linear regression is to establish a linear relationship between the dependent variable and multiple independent variables, where the independent variables are generally two or more than two, and the multiple linear regression equation obtained through a series of calculations is the multiple linear regression model. After the establishment of the multiple linear regression model, it is necessary to analyze the significance of the linear effect of the independent variables on the dependent variable, so as to select the independent variable that has the greatest effect on the dependent variable, and assess the importance of the impact of each independent variable on the dependent variable, etc. [27].

When only one independent variable predicts the dependent variable, the purpose of linear regression is to fit all the scatter in the plot as closely as possible by a straight line. Similarly, when a dependent variable contains two or more independent variables multiple linear regression is modeled as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \cdots + \beta_m x_m + \delta \tag{1}$$

where $x_1, \cdots x_m$ are non-random variables, β_0 is a constant term, $\beta_1, \beta_2 \cdots \beta_m$ are regression coefficients, δ is a random error term that has a mathematical expectation equal to zero.

If n acquisitions of y and x are made and n sets of observations $y_i, x_{1i}, \cdots, x_{mi} (i = 1, 2, \cdots, n)$ are obtained, then:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} \cdots + \beta_m x_{mi} + \delta_i \tag{2}$$

expressed in terms of a matrix:

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, x = \begin{bmatrix} 1 & x_{11} & \cdots & x_{m1} \\ 1 & x_{12} & \cdots & x_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1n} & \cdots & x_{mn} \end{bmatrix}, \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_m \end{bmatrix}, \delta = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix} \tag{3}$$

At this point the model can be represented as:

$$y = X\beta + \delta \tag{4}$$

The δ is the error revealed between the data fitted to the model and the actual data [28].

II. C. 2) Model parameter estimation methods

The purpose of multiple linear regression is to solve an optimal equation by which the value of the dependent variable y can be predicted with known information x about the independent variable of the data. In this optimal equation, "optimal" is reflected in the regression coefficients, which can generally be solved by using the sum of squares of the minimization errors [29]. If the sum of differences is used as the regression coefficient solution method. In the solution process, due to the existence of positive and negative values of the difference, there will be a situation where the positive and negative cancel each other out, which will have a negative impact on the regression results, so the sum of squares of the errors will generally be used. The sum of squared errors can be expressed as:

$$Q(b) = \sum_{i=1}^{m} ((b_0 + b_1 x_{i1} + b_2 x_{i2} + \cdots + b_n x_{in}) - y_i)^2 \tag{5}$$

where $Q(b)$ is the sum of the squares of the errors of the predicted and actual values. Then the multiple linear regression is to solve for the value of the parameter vector b such that the value of $Q(b)$ in the above equation is minimized. The process by which we minimize the $Q(b)$ function as a constraint to find the optimal solution to the parameter vector is the least squares algorithm.

Define $y_i^{'}$ as the predicted value of the model corresponding to the actual outcome γ_i with the following expression:

$$\begin{cases} y_i^{'} = b_0 + b_1 x_{i1} + b_2 x_{i2} + \cdots + b_n x_{in} \\ y^{'} = \begin{bmatrix} y_1^{'} & y_2^{'} & \cdots & y_m^{'} \end{bmatrix}^T = Xb \end{cases} \tag{6}$$

Then equation (5) can be written as:

$$h(b) = \sum_{i=1}^{m} (y_{i'} - y_i)^2 \tag{7}$$

where $h(b)$ is defined to be a function so that solving for the minimum value of $Q(b)$ can be transformed into solving for the minimum value of $h(b)$. The joint equations (5) to (7), can be obtained:

$$h(b) = \sum_{i=1}^{m} (y_i^{'} - y_i)^2 = (y - yy^{'})^T (y - y^{'}) = (y - Xb)^T (y - Xb) \tag{8}$$

When $y^{'}$ is infinitely close to y, at which point $h(b)$ equals a minima denoted as δ, one obtains:

$$h(b) = (y - Xb)^T (y - Xb) = \delta \tag{9}$$

At this point its two sides are derived separately for the parameter b:

$$2X^T (y - Xb) = 0 \tag{10}$$

The final regular equation can be obtained by expanding it as:

$$b = (X^T X)^{-1} X^T y \tag{11}$$

where X^T is the transpose matrix of matrix X, and $(X^T X)^{-1}$ is the inverse matrix of $X^T X$, it can be learned that this method must be applied in the case of the existence of the inverse matrix of $X^T X$. After obtaining the formal equation shown in equation (11), the optimal parameter solution can be carried out by bringing in the known parameters, and finally the model of multiple linear regression equation can be determined and the prediction can be carried out by this model.

III. Research design

In the fast-changing social environment, the rapid development of science and technology and the accelerated pace of society pose challenges to the mental health status of individuals, and the mental health level of higher vocational students should be more concerned and emphasized. Physical activity refers to the physical exercise that is planned, organized and repeated with a certain intensity, frequency and duration for the purpose of improving physical health, with physical exercise as the content and means, and is widely regarded as a non-pharmacological intervention to improve mental health. Under the background of the integration of physical education, higher vocational colleges and universities should strengthen students' interest in participating in physical activities, in order to provide a guarantee for the promotion of students' mental health level.

III. A. Data sources and research hypotheses

III. A. 1) Data sources

The data for this study came from questionnaire data. Mainly through the questionnaire star of the network survey on the previous selection of a number of senior vocational colleges and universities, in the investigated in a unified basis of real names to fill out the online questionnaire, submit the questionnaire that is to indicate that agree to participate in this study. In the questionnaire home page detailed description of the purpose of this survey, the significance of the way to fill out all the options filled out before submitting the questionnaire. Finally, 875 questionnaires were recovered, excluding 127 invalid questionnaires that were repeatedly submitted, not answered seriously or answered for less than 60s, and 748 valid questionnaires were obtained, with an effective recovery rate of 85.49%. At the same time, in order to ensure the quality of the study, in the process of analyzing the distribution of questionnaires, as far as possible to ensure that the research object in the number of people, gender, grade and other variables on a balanced basis, for different grades of students in equal proportion to the distribution.

As the survey scales used in this paper are mature scales, the Cronbach's alpha coefficients of the Physical Activity Participation Scale for Higher Vocational Students and the Mental Health Level Scale are 0.914 and 0.908, respectively, which shows that the internal consistency of their questionnaires is very good, so the questionnaires adopted in this paper have a good reliability. And the KMO values of the two scales are 0.872 and 0.853 respectively, indicating that they are suitable for factor analysis, and the result of Bartlett's test of sphericity is $P<0.01$, which indicates that the validity of the two scales is better, and both of them have reached the level of significance.

III. A. 2) Research hypotheses

The study of sports activity participation to promote mental health is an important research field in sports psychology research, "self harmony" is the school standard of mental health, sports activity participation in the influence of mental state involves personality, self-concept, self-emotion and cognitive function of psychological benefit mechanism and other research areas. Through reviewing the literature and analyzing the issue of "the impact of sports participation on college students' mental health and self-harmony", we found that long-term participation in sports activities can not only improve the theoretical system in the field of mental health research, but also improve college students' personality traits and mental health level.

Long-term physical activity improves negative emotions, enhances self-concept, strengthens self-confidence and reduces symptoms of mental illness. Some studies have shown that anaerobic exercise modalities have a positive effect on improving the treatment and prevention of psychological disorders. Aerobic exercise modalities are not the only form of physical therapy in enhancing mental health and improving mental illness, but they can help a person to improve his or her mental health and have a greater impact on changes in the overall structure of the personality. In addition, long-term participation in physical exercise has a positive impact on the respiratory, digestive, cardiovascular and other systems of college students, as well as inhibitory effects in the face of muscle aches and pains, fatigue, headaches and other aspects of performance.

Interpersonal skills not only have a positive effect on the employment of college students, but also a key means of maintaining mental health. A good interpersonal relationship can relieve their own mental stress and prevent mental health problems among college students. Under the background of the development of network era, people's communication methods have changed, and virtual communication on the Internet has become the main way for college students to communicate with the outside world. However, virtual communication lacks real feelings, which leads to college students' emotions not being fully released, and easily aggravates the suppressed emotions. Sports activities usually require collaboration and cooperation with teammates. Take team sports programs such as basketball, soccer and volleyball for example, these programs require the formation of good tacit understanding and synergy between players. In the interaction, students learn to communicate, understand and respect others, improve their social skills and interpersonal relationship skills, and break down communication barriers with their

classmates. Releasing emotions in participating in sports activities helps students build a bridge of friendship, relieves and overcomes introverted psychology, and promotes students' healthy physical and mental development.

Synthesizing the above analysis, this paper puts forward the following hypotheses:

H1: There is a significant positive effect of participation in sports activities of higher vocational students on the level of mental health.

III. B. Research Variables and Modeling
III. B. 1) Selection of research variables
(1) Explained variables. The explanatory variable of this paper is students' mental health level (MHL), which is mainly quantified by the data from the Comprehensive Assessment and Diagnostic Scale of Chinese People's Physical and Mental Health, based on the data obtained from the previous questionnaire in order to unfold the related analysis in the latter part of the paper.

(2) Explanatory variables. The explanatory variable of this paper is the degree of participation in sports activities (PSA) of higher vocational students, which is mainly quantified through the Scale of Motivation for Participation in Physical Activity of Higher Vocational Students, and the relevant data are obtained from the questionnaire.

(3) Control variables. For the diversity of sports activities in higher vocational colleges and universities in the context of the integration of physical education, this paper chooses school size (SS), physical activity input (ISA), physical education teacher level (STL), number of physical education teachers (STN), regional economic level (REL), and mental health guidance level (MHG). Each of these control variables was obtained through the official website of each surveyed institution, and the regional economic level was obtained from the GZ statistical yearbook data.

III. B. 2) Research modeling
Based on the various research variables given in the previous section, in order to verify hypothesis 1, the effect of participation in sports activities of higher vocational students on the level of students' mental health, combined with the multiple linear regression model, this paper sets the fixed model as follows:

$$MHL = \alpha_0 + \alpha_1 PSA + \alpha_2 \sum Control + \varepsilon \tag{12}$$

where MHL is the explanatory variable, i.e., the mental health level of higher education students, and PSA is the explanatory variable, i.e., the participation of higher education students in sports activities. $Control$ is each control variable, α_0 is the constant term, $\alpha_1 \sim \alpha_2$ is the regression coefficient of each variable, and ε is the random disturbance term.

IV. Findings
Physical activity can significantly improve the physical and mental effects of exercisers, but most of the research has been focused on how physical activity improves the physical effects, while the psychological effects have been relatively understudied. Positive self-regulation through participation in sports activities is mainly realized through the regulation of the physical self, which is specifically manifested in the improvement of physical ability, skills and changes in appearance to realize the recognition of oneself, and then improve the level of students' mental health.

IV. A. Normality verification and correlation analysis
IV. A. 1) Normality verification
Firstly, the normality test of quantitative data was carried out for the data related to students' mental health level (MHL), higher education students' participation in physical activity (PSA), school size (SS), investment in physical activity (ISA), physical education teacher level (STL), number of physical education teachers (STN), regional economic level (REL), and mental health guidance level (MHG). test, and its specific results are shown in Table 2.

As can be seen from the table, the S-W test results of students' mental health level (MHL), higher education students' participation in physical activity (PSA), school size (SS), investment in physical activity (ISA), level of physical education teachers (STL), number of physical education teachers (STN), regional economic level (REL), and level of mental health guidance (MHG) did not show significance (P>0.05). 0.05). This indicates the acceptance of the original hypothesis (original hypothesis: the data of the variables are normally distributed), which suggests that the data of the variables obtained in this paper have the qualities of normality and can be used in multiple regression analysis to show the degree of influence between the variables.

Table 2: Normality test and analysis results

Variable	Means	STD	Skewness	Kurtosis	Shapiro-Wilk test	
					W	P
MHL	3.514	1.162	0.358	-1.153	0.935	0.317
PSA	1.769	1.329	0.324	-0.367	0.968	0.865
SS	8.031	0.875	0.319	-1.128	0.872	0.114
ISA	4.276	0.667	-0.405	-0.074	0.885	0.438
STL	3.517	0.914	0.684	-0.009	0.943	0.525
STN	2.916	1.081	0.226	0.331	0.952	0.653
REL	5.993	0.738	0.427	-0.827	0.937	0.557
MHG	3.278	0.663	0.683	0.916	0.956	0.694

IV. A. 2) Correlation analysis

Before conducting the main regression, the correlation between the variables was examined in this paper's architectural STATA econometric software, and Table 3 shows the results of Pearson's correlation analysis for each variable. In the table, ***, ** and * indicate that the correlation coefficients are significant at the 1%, 5% and 10% levels, respectively, and the same below.

From the correlation coefficient matrix, it can be seen that the correlation coefficient between higher vocational students' participation in sports activities (PSA) and students' mental health level (MHL) is 0.176, which shows a significant positive correlation. There is a significant positive correlation between higher vocational students' physical activity participation (PSA) and school size (SS), physical activity investment (ISA), physical education teacher level (STL), number of physical education teachers (STN), regional economic level (REL), and mental health guidance level (MHG). There is a positive correlation between school size (SS), physical activity input (ISA), physical education teacher level (STL), number of physical education teachers (STN), regional economic level (REL), mental health guidance level (MHG) and students' mental health level (MHL). The results of Pearson's correlation coefficient analysis can only be used as a preliminary reference and cannot provide precise results. In order to more accurately reveal the intrinsic relationship between the variables, it is necessary to further test them in subsequent regression analyses, so as to ensure the rigor and scientificity of the study.

Table 3: The Pearson correlation analysis results of each variable

Variable	MHL	PSA	SS	ISA	STL	STN	REL	MHG
MHL	1.000	-	-	-	-	-	-	-
PSA	0.176***	1.000	-	-	-	-	-	-
SS	0.084***	0.152***	1.000	-	-	-	-	-
ISA	0.128***	0.023***	0.035***	1.000	-	-	-	-
STL	0.137***	0.045***	0.128***	0.052*	1.000	-	-	-
STN	0.029***	0.037***	0.027***	0.113**	0.083***	1.000	-	-
REL	0.115***	0.078****	0.093***	0.045***	0.006	0.008*	1.000	-
MHG	0.011**	0.063***	0.045***	0.009*	0.017*	0.021***	0.085***	1.000

In addition, in order to avoid the existence of multicollinearity among the variables in the multiple linear regression model, which then affects the results of multiple regression, this paper adopts the VIF method to test whether there is multicollinearity among the variables in the model. Table 4 shows the results of VIF test. From the results of the table, it can be seen that the VIF value of each variable is <5, and there is no complete multicollinearity between the variables, among which the VIF value of school size (SS) is the largest, but it does not exceed 2.5. Therefore, there is a significant correlation between the variables in the model, but there is no multicollinearity, and it will not have an impact on the results of the main regression.

IV. B. Regression results and robustness tests
IV. B. 1) Benchmark regression results
The base regression is based on the fixed effects model established in this paper, and at the same time, the regression model is regressed on whether or not to add control variables, whether or not to control for time effects and individual effects, respectively, in order to obtain more comprehensive results. Table 5 shows the results of the base regression. The t-statistics are in parentheses in the table.

Table 4: VIF test result

Variable	MHL	PSA	SS	ISA
VIF	1.104	2.158	2.243	1.792
1/VIF	0.906	0.463	0.446	0.558
Variable	STL	STN	REL	MHG
VIF	1.638	1.547	1.039	1.212
1/VIF	0.611	0.646	0.962	0.825

As can be seen from the table, the regression coefficients for higher education students' participation in physical activity (PSA) are positive and significant at the 1% level of significance regardless of whether the time and individual effects are controlled for or not, and whether or not the control variables are added, and H1 is verified. This regression result proves that the participation in physical activity of higher vocational students positively enhances the mental health level of students.

The regression conditions in columns (1) and (2) are more relaxed and are the regression results without controlling for time and individual effects. The regression coefficient of higher education students' physical activity participation (PSA) on students' mental health level (MHL) is 0.275 in column (1), and the regression coefficient of higher education students' physical activity participation (PSA) on students' mental health level (MHL) is 0.214 in column (2). From the first two columns of the table, it can be seen that whether or not the control variable is added, higher education students' participation in sports activities (PSA) is positively related to students' mental health level (MHL) at the 1% significance level. And purely from the regression coefficients, the positive effect of higher vocational students' participation in sports activities (PSA) on students' mental health level (MHL) appears to be reduced after the inclusion of control variables.

Columns (3) and (4) are regression results controlling for time effects and individual effects with more stringent conditions. In column (3), without adding control variables, the t-value between higher education students' physical activity participation (PSA) on students' mental health level (MHL) is 6.742, and the regression coefficient is 0.168, which has been positively correlated at the 1% significance level. The regression in column (4) adds control variables to column (3) with a main regression coefficient of 0.126 and a t-value of 3.241, which is still positively correlated at the 1% significance level, consistent with the hypothesis. In this case, if the participation of higher vocational students in sports activities is deepened by 1%, the level of students' mental health will increase by 0.126%, and the greater the participation of higher vocational students in sports activities, the stronger the improvement of their mental health. Meanwhile, comparing the regression coefficients before and after adding no control variables and adding control variables, it can be seen that the regression coefficients of the independent variables will become smaller after adding control variables, which indicates that the control variables will, to a certain extent, reduce the impact of the participation in sports activities of higher vocational students on the level of students' mental health.

Table 5: Regression Analysis Results of the model

Variable	Model (1)	Model (2)	Model (3)	Model (4)
(Con_)	0.029***(8.729)	0.035***(9.173)	0.005***(5.419)	0.023***(5.275)
PSA	0.275***(4.814)	0.214***(4.958)	0.168***(6.742)	0.126***(3.241)
SS	-	0.039***(4.751)	-	0.007***(7.713)
ISA	-	0.009***(3.175)	-	0.006***(4.687)
STL	-	0.028***(7.248)	-	0.025***(9.432)
STN	-	0.007***(3.129)	-	0.021***(3.478)
REL	-	0.025***(6.103)	-	0.009***(3.339)
MHG	-	0.013***(7.162)	-	0.015***(8.092)
Time	NO	NO	YES	YES
Individuals	NO	NO	YES	YES
R2	0.0092	0.1487	0.2516	0.3471

IV. B. 2) Robustness Tests

The results of the baseline regression analysis reveal a significant positive relationship between the participation in physical activities of higher vocational students and the level of students' mental health. In order to further enhance the credibility and persuasiveness of the conclusions, a series of methods will be adopted in this section to conduct

the robustness test, including changing the way variables are defined, eliminating some special samples that may have abnormal effects, and analyzing them by using alternative regression models, so as to ensure the reliability of the obtained research conclusions.

(1) Replacement of explanatory variables

Replacing explanatory variables can examine the robustness of variable selection to the research conclusions, and if the research conclusions remain consistent with the main regression after replacing the explanatory variables, then it indicates that the conclusions of this paper have a high degree of robustness. To ensure the reliability of the baseline regression results, this section draws on existing research to construct the participation interest (API) and participation enthusiasm (APE) of higher vocational students' physical activities separately for robustness testing.

The participation interest of higher vocational students in sports activities is measured by whether students engage in extracurricular sports activities, and if the amount of extracurricular sports activities is more than 500 hours, it is assigned a value of 1. If the amount of extracurricular sports activities is less than 500, the sample is assigned a value of 0. Participation interest enthusiasm of higher vocational students in sports activities is measured by the number of times students actively participate in sports activities, and the number of times students participate in sports activities more than 30 times in a semester is assigned a value of 1. The number of sports activities over 30 times was assigned a value of 1, and vice versa below 30 times was assigned a value of 0.

Table 6 shows the results of the regression using interest in participation (API) and enthusiasm for participation (APE) as alternative explanatory variables for higher vocational students' sports activities. In this case, the regression coefficients of participation interest (API) and enthusiasm for participation (APE) in sports activities of higher education students on the mental health level (MHL) of the students were 0.039 and 0.031, respectively, and were significantly positively correlated at the 1% level. Therefore, it can be seen that the regression results are still basically consistent with the baseline regression results after the robustness test was conducted by replacing the measurement of the explanatory variables, indicating that the findings of the study are still robust after replacing the measurement of the explanatory variables.

Table 6: Change the robustness test of explanatory variables

Variable	Model (1)	Model (2)
(Con_)	0.024***(5.814)	0.028***(5.692)
API	0.039***(6.915)	-
APE	-	0.031***(5.624)
SS	0.005***(3.257)	0.016***(8.647)
ISA	0.031***(5.891)	0.035***(4.329)
STL	0.018***(6.239)	0.029***(3.741)
STN	0.026***(4.517)	0.012***(4.738)
REL	0.012***(3.392)	0.004***(3.175)
MHG	0.017***(3.908)	0.027***(7.421)
Time	YES	YES
Individuals	YES	YES
R2	0.0647	0.0651

(2) Deletion of part of the sample and replacement of explanatory variables

The extreme values present in the sample may have a significant impact on the statistical results, thus making the findings deviate from the real situation and further affecting the robustness of the findings. In order to ensure the reliability of the findings, it was decided in this section to adopt the method of deleting some of the special samples to conduct the robustness test. First, since students' participation in physical activities is not mandatory, this section draws on related studies and chooses to re-run the regression by removing the sample with zero participation in physical activities. In addition, the mental health level of students in this paper is obtained by using the Comprehensive Assessment and Diagnostic Scale of Physical and Mental Health of Chinese People, in order to better demonstrate the robustness of the regression results, this paper adopts the SCL-90 scale to obtain the level of students' mental health as a means of replacing the explanatory variables. Table 7 shows the robustness test results of excluding some samples and replacing the explanatory variables, where models (1)~(2) are the regression results of excluding some samples and replacing the explanatory variables, respectively.

As can be seen from the table, even after proposing some special samples as well as replacing the explanatory variables, higher vocational students' participation in physical activity (PSA) still shows a significant positive

correlation on students' mental health at the 1% level, which indicates that the benchmark regression results of this paper have good robustness.

Table 7: Delete special samples and replace the explained variables

Variable	Model (1)	Model (2)
(Con_)	0.031***(3.581)	0.037***(3.276)
PSA	0.026***(8.274)	-
PSA	-	0.028***(7.795)
SS	0.014***(4.183)	0.012***(4.271)
ISA	0.028***(3.952)	0.026***(5.024)
STL	0.009***(5.041)	0.017***(4.283)
STN	0.015***(3.882)	0.015***(4.512)
REL	0.017***(3.953)	0.011***(3.398)
MHG	0.021***(4.315)	0.025***(6.314)
Time	YES	YES
Individuals	YES	YES
R2	0.0572	0.0561

IV. B. 3) Heterogeneity test

The previous regression results show that regional economic level has a significant positive effect on the participation in sports activities and mental health of higher vocational students. Based on this, this paper further expands the research sample and divides Jiangsu Province into three expanded regions: southern Jiangsu, central Jiangsu, and northern Jiangsu. Due to the differences in economic level of different regions, this may also make the influence of higher vocational students' participation in sports activities on mental health level heterogeneous in different regions. Based on the multivariate linear regression model, the regression was conducted to explore the effect of higher vocational students' physical activity participation on mental health level by region, and the specific results are shown in Table 8. P-values are in parentheses in the table.

It can be seen from the table that the participation in physical activities (PSA) of vocational college students in different regions has a significant positive impact on the mental health level of students at the 1% level. Among them, the regression coefficients in southern Jiangsu, central Jiangsu and northern Jiangsu were 0.791, 0.514 and 0.393 respectively, and the positive influence in southern Jiangsu was greater. This also fully demonstrates that the economic level in the southern part of Jiangsu Province is relatively high. Schools are willing to provide students with more diverse types of sports activities, thereby effectively enhancing students' participation in sports activities. Relatively speaking, their mental health level is also higher. The economic level in northern Jiangsu is relatively low, which fails to effectively meet the diverse needs of students for sports activities, resulting in lower participation of students in sports activities and a smaller impact on mental health compared to the central and southern regions. There are also some differences in the extent to which each control variable affects students' mental health in different regions, which will also affect the development of mental health among vocational college students to some extent.

Table 8: The result of Heterogeneity test

Variable	Model (1) - southern Jiangsu	Model (2) - central Jiangsu	Model (3) - northern Jiangsu
(Con_)	5.372***(0.005)	3.492**(0.017)	6.159***(0.002)
PSA	0.791***(0.004)	0.514**(0.043)	0.393***(0.007)
SS	0.152**(0.028)	0.358***(0.000)	0.035***(0.004)
ISA	0.005*(0.071)	0.016***(0.002)	0.031***(0.001)
STL	0.093***(0.002)	0.181***(0.006)	0.023**(0.038)
STN	0.013**(0.019)	0.014**(0.015)	0.002***(0.000)
REL	0.191***(0.000)	0.117***(0.002)	0.115***(0.001)
MHG	0.157***(0.001)	0.083***(0.001)	0.083***(0.003)
Time	YES	YES	YES
Individuals	YES	YES	YES
Chi-square	205.48	312.67	127.81

Based on the results of the above analysis, the northern Jiangsu region needs to further increase the investment in sports activities, expand the diversity of sports activities, so as to ensure that students can better get pleasure in sports activities, enhance the interest and enthusiasm of students' participation in sports activities, so as to improve students' participation in sports activities, and to provide a guarantee for the enhancement of students' mental health level.
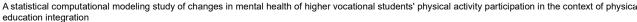
V. Conclusion

In this paper, the research data were obtained by using the Physical Activity Participation Scale and the Mental Health Scale of Higher Vocational Students, and a multiple linear regression model was established to analyze the influence of higher vocational students' participation in physical activity on students' mental health level. The data analysis showed that for every 1 percentage point increase in the participation in sports activities of higher vocational students, the mental health level of students increased significantly by 0.126 percentage points. Higher vocational colleges and universities need to further strengthen the investment in sports activities and attract students through diversified types of sports activities, so as to enhance the enthusiasm of students' participation in sports activities, and thus better improve the mental health of students.

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