International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18 (2026) pp. 1-8

https://doi.org/10.70917/ijcisim-2026-0034
Article

Exploring the Quantitative Relationship of Physical Activity on Group Health Benefits Based on Regression Analysis Models

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Abstract: This study takes 1,000 college students in a university as the research object, and explores the quantitative relationship of physical exercise on group health benefits based on multiple linear regression model and Spearman correlation analysis. By setting health literacy as the dependent variable, exercise space, behavior, equipment and individual willingness as independent variables, and combining descriptive statistics and demographic difference analysis, the study systematically analyzed the mechanism of the influence of different exercise dimensions on health benefits. Regular exercise behavior had the strongest correlation with health literacy ($r = 0.419$, $P = 0.000$), followed by individual willingness ($r = 0.396$, $p = 0.000$), while exercise space ($r = 0.178$, $p = 0.009$) and equipment ($r = 0.233$, $p = 0.002$) were supporting factors. Multiple regression analysis showed that restricted exercise space, irregular exercise and no exercise equipment significantly reduced the probability of high health literacy, while the probability of high health literacy was much higher in the voluntary exercise group than in the unwilling group ($p < 0.001$).

Keywords: physical activity; multiple linear regression; Spearman correlation analysis; influence mechanism

1. Introduction

With the rapid development of the economy, people's material life has become increasingly rich, and the pace of life and habits have undergone fundamental changes. However, fierce competition and complex social relationships often make people feel irritable, anxious, fearful, frustrated and exhausted, caught in a paradox of pursuing a higher quality of life but having difficulty in getting rid of unhealthy lifestyles [1-3]. A large number of clinical practices and medical studies have proved that individual health literacy plays an important role in disease occurrence, development, prevention, treatment and recovery [4-5]. At the same time, some studies have also shown that physical activity and health literacy are not only of equal importance to individual health, but also that the two are influenced by each other and closely linked together [6-7].

Health is one of the core contents of personal physical activity and health literacy ability to live, which is a sign of personal literacy and social progress [8]. And physical exercise behavior is a social phenomenon, reflecting the way people participate in physical activity and sports life, and directly reflecting the individual's physical culture literacy [9]. For a long time, people in the field of physical exercise on the health of the research is also mostly focused on how exercise to promote the development of physiological and psychological qualities, as well as the efficacy of the promotion of health and prevention of disease, and less talk about the benefits of physical exercise and health-related literacy brought about by the interaction of the impact of the benefits [10-13]. Positive health knowledge concepts and good health-related literacy can not only give full play to the significance and function of physical exercise, but also achieve the ideal health enhancement benefits [14-16].

In this paper, we first sorted out the influence of physical exercise on college students' physical health, and selected 1,245 college students from a university as the survey object. The dependent variable system was constructed based on health literacy, and the independent variables were set by combining demographic characteristics with exercise-related variables. The questionnaire survey was used to obtain 1000 valid data, and data standardization was used to eliminate the influence of the scale. Descriptive statistics were used to analyze the current status of health literacy and demographic differences, and Spearman correlation analysis was used to screen key variables. Based on the multiple linear regression model, the influence path of each exercise dimension on health benefits was quantified.

2. Study Design of the Impact of Physical Activity on College Students' Physical Health Based on Regression Analysis

2.1. Influence of Physical Exercise on the Physical Health of College Students

In the field of higher education, the majority of young students are between the ages of 18 and 22 years old, which is the key point of the human body's growth and development towards maturity and stability, and the physiological functions and physical structure have reached a relatively perfect situation. During this crucial growth period, long-term, systematic and scientific physical exercise can greatly promote the efficient operation of the metabolic mechanism of college students, accelerate the exchange of substances and energy transformation process, thus realizing the overall optimization and significant enhancement of the body's functions, and promoting the athletic performance to reach a new peak. Through precise stimulation of cardiomyocytes, physical exercise activates the biochemical process of protein synthesis, which in turn enhances the contraction force of the heart muscle. At the same time, it positively affects the walls of blood vessels, increasing their elasticity and accelerating the rate of blood circulation, thus effectively preventing cardiovascular disease. Especially crucial is that the active participation of the respiratory system is an indispensable part of the process of physical exercise, through continuous exercise, the lung capacity has been significantly expanded, and the lung ventilation also increases, not only can comprehensively improve the overall function of the respiratory system, but also can provide the body with a more adequate supply of oxygen, and thus provide a solid guarantee for the normal conduct of various physiological activities.

2.2. Information and Methodology

In this study, 1,245 college students from a university were selected as survey subjects. The inclusion criteria were (1) freshmen and sophomores; (2) able to participate in sports normally without contraindications to sports or serious physical health problems; and (3) provided complete and accurate responses to the questionnaire, and the data were not missing or obviously abnormal. Among them, 1002 met the criteria, 526 males and 476 females, aged 20-35 years, with a mean of (19.1±0.97) years.

The study was conducted by distributing questionnaires in 2 ways: online and offline. 1002 questionnaires were distributed and 1000 valid questionnaires were finally selected by excluding invalid questionnaires.

2.3. Research Process

2.3.1. Variable Settings

The health literacy level of college students was set as the dependent variable, consisting of the dimensions of athletic agility, physical flexibility, athletic endurance, bouncing power and upper body strength, corresponding to the quantitative indicators: 50-meter running performance, 1-minute sit-up performance, men's 1000-meter/women's 800-meter running performance, standing long jump performance, and men's pull-up/women's 60-degree inclined push-ups performance, which were recorded as $y_j, j = 1, 2, \cdots, 5$, respectively. Based on the percentile of the final score of health literacy was divided into 3 levels (low, medium and high) of <P30, P30~P80 and >P80. The questionnaire, which focused on the respondents' basic demographic characteristics (e.g., gender, grade level), exercise space, whether they exercised regularly, whether they owned fitness equipment, and whether they voluntarily exercised, was set as the independent variable.

2.3.2. Data Pre-Processing

First, abnormal data, mainly including data related to students with physical disabilities and incomplete participation in the physical test, were screened and excluded, and finally 1,000 sets of data were retained as the sample for analysis. Second, some of the non-quantitative raw indicator data were quantified.

Usually in a multi-indicator evaluation system, the data have different scales and orders of magnitude because of the different nature of each evaluation indicator. When there is a large difference in the level between the indicators, if the raw data are used directly for statistical analysis, the indicators with higher numerical levels will amplify their role in the comprehensive analysis, thus weakening the role of the indicators with relatively lower numerical levels.

Therefore, in order to ensure the reliability of the results of data analysis, the raw indicator data need to be standardized before data analysis. The indicator values a_{ij} of the independent variables are sequentially transformed into standardized indicator values $\tilde{a}_{ij}$.

$$\tilde{a}_{ij} = \frac{a_{ij} - \mu_j^{(1)}}{s_j^{(1)}}, i = 1, 2, \cdots, 1000, j = 1, 2, \cdots, 8 \tag{1}$$

where $\mu_j^{(1)} = \frac{1}{1000}\sum_{i=1}^{1000} a_{ij}; s_j^{(1)} = \sqrt{\frac{1}{1000-1}\sum_{i=1}^{1000}(a_{ij} - \mu_j^{(1)})^2}, j = 1, 2, \cdots, 8$.

Call $\tilde{x}_j = \frac{x_j - \mu_j^{(1)}}{s_j^{(1)}}, j = 1, 2, \cdots, 8$ the standardized indicator variable.

Similarly, the indicator values b_{ij} of the dependent variable are transformed into standardized indicator values $\tilde{b}_{ij}$.

$$\tilde{b}_{ij} = \frac{b_{ij} - \mu_j^{(2)}}{s_j^{(2)}}, i = 1, 2, \cdots, 1000, j = 1, 2, \cdots, 5 \tag{2}$$

where $\mu_j^{(2)} = \frac{1}{1000}\sum_{i=1}^{1200} b_{ij}; s_j^{(2)} = \sqrt{\frac{1}{1200-1}\sum_{i=1}^{1200}(b_{ij} - \mu_j^{(2)})^2}, j = 1, 2, \cdots, 5$.

Correspondingly, call $\tilde{z}_j = \frac{z_j - \mu_j^{(1)}}{s_j^{(1)}}, j = 1, 2, \cdots, 5$ the corresponding standardized variable.

2.3.3. Analytical Methods

In statistics, a linear regression model is a method of modeling the relationship between a scalar variable y and one or more explanatory variables X through an establishment. If there is only one explanatory variable X, we call it simple linear regression. If there is more than one explanatory variable, we call it multiple linear regression.

In a linear regression model, we use a linear function to model the data and estimate the unknown parameters in the model. This kind of model used we call as linear model. In general, linear regression is a model in which we find the conditional mean of y given a value of X. It is a projective function of X. In particular, a linear regression model expresses the median, or some other quantile, of the conditional distribution of y for a given X as a linear function of X. Like other forms of regression analysis, linear regression focuses on the conditional distribution of y given X, rather than examining the joint distribution of X and y. Linear regression was the first well-studied and widely applied method of regression analysis. Most of the data is a little easier to fit with linear than with non-linear methods, and can intuitively provide some basis and methodology for further analysis of the model.

Due to the relatively large number of parameters in the model, we use multiple linear regression model for simulation. The central idea is to use the method of least squares to find the best estimates of the parameters. The specific methods are as follows:

If the sample size is given as data n, $\{y_i, x_{1i}, ..., x_{pi}\}_{i=1}^{n}$ (we define X in the model as such later on) The linear regression model assumes that the dependent variable y_i is linearly related to the independent variable x_i (in p-dimensions), such that we attempt to build the following linear model

$$y = X\beta + \varepsilon, \quad \varepsilon \sim NID(0, \sigma^2 I) \tag{3}$$

Here:

$$y=\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}, X=\begin{pmatrix} x_{11} & \cdots & x_{1p} \\ x_{21} & \cdots & x_{2p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix}, \beta=\begin{pmatrix} \beta_1 \\ \vdots \\ \beta_p \end{pmatrix}, \varepsilon=\begin{pmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_n \end{pmatrix} \quad (4)$$

From the method of least squares we get: $\hat{\beta}=(X^{'}X)^{-1}X^{'}y$.

3. Study of the Quantitative Relationship of Physical Activity to Group Health Benefits

3.1. Descriptive Statistics

The results of the survey on the status of health literacy of the study population are shown in Table 1. It can be found that the availability rate of high level of health literacy in the study population is 17.80%, and the reporting rate of high level of health literacy is 16.81% for freshmen and 19.30% for sophomores. The reporting rate of medium level of health literacy of the study subjects was 58.80%, and the reporting rate of medium level of health literacy of freshmen and sophomores was 57.74% and 60.40%, respectively, and the difference was statistically significant ($p < 0.01$). The reporting rate of low level of health literacy in the study population was 23.40%, and the reporting rate of low level of health literacy in freshman and sophomore students was 25.46% and 20.30% respectively, and the difference was statistically significant ($p < 0.05$). This indicates that as the health literacy level of college students rises, the reporting rate of infrequent physical activity behaviors are on a decreasing trend.

Table 1. Survey Results of the Current Situation of health Literacy[n(%)].

Demographic characteristics	Option	n	>P80	P30~P80	<P30
Gender	Male	524	95(18.13)	302(57.63)	127(24.24)
	Female	476	83(17.44)	286(60.08)	107(22.48)
	χ^2		0.55	0.89	1.97
	P		0.61	0.42	0.21
Grade	Freshman Year	601	101(16.81)	347(57.74)	153(25.46)
	Sophomore year	399	77(19.30)	241(60.40)	81(20.30)
	χ^2		4.01	10.77	6.83
	P		0.08	<0.01	0.02
Total		1000	178(17.80)	588(58.80)	234(23.40)

3.2. Analysis of Demographic Differences

The results of one-way ANOVA on physical activity behavior for different health literacy levels and different demographic characteristics are shown in Table 2. In the gender dimension, males and females showed statistically significant differences ($p < 0.05$) in the behaviors of exercise space ($p = 0.04$), exercise behavior ($p = 0.02$), exercise equipment ($p = 0.03$), and individual willingness ($p = 0.04$). Statistically significant differences were also demonstrated in the grade level dimension. Weak correlations between academic performance and monthly income and physical activity behavior indicated that economic conditions or academic stress did not have a significant effect on college students' exercise behavior.

Table 2. Results of one-way ANOVA of physical exercise behavior[n(%)].

Demographic characteristics	Option	n	Exercise space>40m^2	Exercise regularly	Have exercise equipment	Volunteer to exercise
Gender	Male	524	306(58.40)	323(61.64)	268(51.15)	320(61.07)
	Female	476	309(64.92)	318(66.81)	299(62.82)	308(64.71)
	χ^2		14.84	21.06	12.33	7.64
	P		0.04	0.02	0.03	0.04
Grade	Freshman Year	601	311(51.75)	322(53.58)	274(45.59)	302(50.25)
	Sophomore year	399	304(76.20)	319(79.95)	293(73.43)	326(81.70)
	χ^2		30.78	18.53	29.07	22.14
	P		0.01	0.03	0.02	0.04
Academic performance	Excellent	208	130(62.50)	128(61.54)	128(61.54)	119(57.21)
	General	611	372(60.88)	394(64.48)	334(54.66)	397(64.98)
	Poor	181	113(62.43)	119(65.75)	105(58.01)	112(61.88)
	χ^2		2.36	1.98	3.09	2.44
	P		0.62	0.78	1.25	0.92
Monthly income	<1000yuan	157	108(68.79)	103(65.61)	100(63.69)	101(64.33)
	1000~3000yuan	683	406(59.44)	426(62.37)	365(53.44)	417(61.05)
	>3000yuan	160	101(63.13)	112(70.00)	102(63.75)	110(68.75)
	χ^2		1.53	2.42	1.63	2.11
	P		0.88	1.02	0.73	0.54
Health literacy level	High	178	122(68.54)	133(74.72)	115(64.61)	127(71.35)
	General	588	368(62.59)	401(68.20)	359(61.05)	386(65.65)
	Low	234	125(53.42)	107(45.73)	93(39.74)	115(49.15)
	χ^2		30.19	42.58	21.57	29.38
	P		<0.01	<0.01	0.02	<0.01
Total			615(61.50)	641(64.10)	567(56.70)	628(62.80)

3.3. Correlation Analysis

The results of Spearman's correlation analysis are shown in Table 3, which shows that there is a significant correlation between the health literacy level of college students and the main health-related behavioral indicators covered by the questionnaire. Among them, exercise behavior (r = 0.419, p = 0.000) had the strongest correlation with health literacy, suggesting that regular physical activity is a core driver for improving health literacy. Exercise equipment (r = 0.233, p = 0.002) and exercise space (r = 0.178, p = 0.009) had weaker correlations, suggesting that external exercise conditions are supportive of health literacy. The correlation of individual willingness (r = 0.396, p = 0.000) was slightly lower than that of exercise behavior, but still showed a significant positive correlation, reflecting the sustained influence of intrinsic motivation on exercise behavior. In contrast, gender (r = 0.113, p = 0.042) and grade level (r = 0.216, p = 0.031) were weakly correlated with health literacy, whereas academic performance (r = 0.008, p = 0.562) and monthly income (r = −0.016, p = 0.789) were not significantly associated with health literacy (p > 0.05). This result suggests that the behavioral dimensions of exercise participation and subjective willingness are more critical to health literacy than demographic characteristics.

Table 3. Results of Spearman correlation analysis.

Indicator	r	*p*
Gender	0.113	0.042
Grade	0.216	0.031
Academic performance	0.008	0.562
Monthly income	-0.016	0.789
Exercise space	0.178	0.009
Exercise behavior	0.419	0.000
Exercise equipment	0.233	0.002
Individual will	0.396	0.000

3.4. Multiple Regression Analysis

3.4.1. Exercise Space

The results of regression coefficient estimation for exercise space are shown in Table 4. The regression coefficient for "exercise space ≤ 40 m^2" was −0.428, indicating that restricted space reduces the probability of high health literacy levels compared to adequate exercise space. The estimated values of health literacy level were 5.264 (high), 3.275 (medium), and −2.386 (low), and all of them were statistically significant ($p < 0.05$), indicating that the high health literacy group utilizes the exercise space more efficiently and needs it, and the spatial condition promotes their health benefits more obviously.

Table 4. Estimation of Regression Coefficients in Exercise Space.

		Estimate	SE	Wald	df	Sig.
Threshold	Health literacy level = High	5.264	0.308	301.486	2	0.000
	Health literacy level = General	3.275	0.337	128.397	2	0.000
	Health literacy level = Low	-2.386	0.384	80.114	2	0.000
Location	Exercise space≤40m^2	-0.428	0.166	6.023	2	0.022
	Exercise space>40m^2	Oa			0	

3.4.2. Exercise Behavior

The results of regression coefficient estimation for exercise behavior are shown in Table 5. The regression coefficient for "irregular exercise" was -0.937, indicating that irregular exercise significantly reduces the probability of high health literacy level ($p < 0.001$). The estimates of health literacy levels were 5.927 (high), 1.238 (medium), and −4.028 (low), a result that highlights the critical role of regularity of exercise behavior on health literacy.

Table 5. Estimation Results of regression Coefficients for exercise behavior.

		Estimate	SE	Wald	df	Sig.
Threshold	Health literacy level = High	5.927	0.795	20.038	2	0.000
	Health literacy level = General	1.238	0.793	2.084	2	0.012
	Health literacy level = Low	-4.028	0.818	25.486	2	0.000
Location	Exercise irregularly	-0.937	0.208	29.486	2	0.000
	Exercise regularly	Oa			0	

3.4.3. Exercise Equipment

The results of the regression coefficient estimation for exercise equipment are shown in Table 6. The analysis shows that the ownership of exercise equipment is significantly associated with the level of health literacy. The regression coefficient for “not owning exercise equipment” was −0.679, with an OR of exp(−0.679) = 0.507, which means that the probability of high health literacy in the no-equipment group was 0.507 times higher than that in the equipment group (p < 0.001). The contribution of equipment ownership to high health literacy was equally significant at the threshold level; the availability of exercise equipment is an important material basis for maintaining regular exercise, and lack of equipment significantly diminishes the potential for health literacy improvement.

Table 6. Estimation Results of regression Coefficients for exercise equipment.

		Estimate	SE	Wald	df	Sig.
Threshold	Health literacy level = High	5.082	0.837	18.385	2	0.009
	Health literacy level = General	1.028	0.822	3.083	2	0.002
	Health literacy level = Low	−3.785	0.839	21.471	2	0.005
Location	Do not own exercise equipment	−0.679	0.197	23.486	2	0.000
	Have exercise equipment	Oa			0	

3.4.4. Individual Will

The results of the regression coefficients of individual willingness are shown in Table 7. The regression coefficient of “involuntary exercise” is -0.386, and the probability of high health literacy in the voluntary exercise group is much higher than that in the unwilling group (p < 0.001). This demonstrates that the health benefits of physical activity can be maximized only when individuals subjectively recognize the value of exercise and participate actively.

Table 7. Estimation Results of individual willingness regression coefficients.

		Estimate	SE	Wald	df	Sig.
Threshold	Health literacy level = High	5.275	0.201	221.536	2	0.000
	Health literacy level = General	2.697	0.206	195.287	2	0.009
	Health literacy level = Low	−2.586	0.229	302.275	2	0.000
Location	Involuntary exercise	−0.386	0.184	4.22	2	0.000
	Volunteer to exercise	Oa			0	

4. Conclusion

The present study revealed through quantitative analysis that physical exercise significantly contributes to the health benefits of the college student population, and that there are differences in the effects of different exercise dimensions.

Through Spearman correlation analysis, it was found that exercise behavior (r = 0.419, p = 0.000) had the strongest correlation with health literacy. Exercise equipment (r = 0.233, p = 0.002) and exercise space (r = 0.178, p = 0.009) had weaker correlations. Individual willingness (r = 0.396, p = 0.000) had a slightly lower correlation than exercise behavior, but still showed a significant positive correlation. In contrast, gender (r = 0.113, p = 0.042) and grade level (r = 0.216, p = 0.031) were weakly correlated with health literacy, while academic performance (r = 0.008, p = 0.562) and monthly income (r = −0.016, p = 0.789) were not significantly associated with health literacy (p > 0.05). This result suggests that the behavioral dimensions of exercise participation and subjective willingness are more critical to health literacy than demographic characteristics.

Multiple regression analysis showed that the regression coefficient of "exercise space ≤40m2" was -0.428, and the estimated values of health literacy level were 5.264 (high), 3.275 (medium) and −2.386 (low), respectively, and all of them were statistically significant (p < 0.05). The regression coefficient of "irregular exercise" was −0.937, indicating that irregular exercise significantly reduced the probability of high health literacy level (p < 0.001). The regression coefficient of "no exercise equipment" was −0.679, and its OR value was exp(−0.679) = 0.507, that is, the probability of high health literacy in the non-device group was 0.507 times that of the equipment group ($p < 0.001$). The regression coefficient of "involuntary exercise" was -0.386, and the probability of high health literacy in the voluntary exercise group was much higher than that in the unintentional group ($p < 0.001$).

Physical activity has a significant effect on the health benefits of the college population, in which regular exercise behavior is the most central driving factor, and exercise space, equipment, and individual willingness indirectly affect the health benefits through supportive or moderating effects.

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