International Journal for Housing Science and Its Applications
Publish August 4, 2025. Volume 46, Issue 3 Pages 1769-1778

https://doi.org/10.70517/ijhsa463139

Modeling Research on Table Tennis Teaching and Students' Physical Fitness and Health Improvement Paths Based on Complex Network Computational Analysis

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Abstract Focusing on the modeling and optimization of students' physical fitness improvement pathway, this study innovatively integrates complex network theory and multiple regression analysis to construct a dynamic influence model of table tennis teaching and students' physical fitness. Topological parameters such as node degree value, median and importance were quantified by constructing a complex network. Combined with the composite Euclidean distance method, a student user model was established to investigate the influence mechanism of table tennis teaching activities on students' physical health indicators. The experiment used stratified sampling method to compare the physical fitness changes between the experimental group and the control group, and used Spearman correlation analysis and multiple linear regression to reveal the nonlinear association between table tennis teaching activities and physical fitness. The results showed that the total score of table tennis teaching was moderately correlated with 1000 meters running (r=0.249, p=0.002) in the boys' group, and the index of sitting forward bending was lowly correlated with the total score of table tennis teaching (r=0.166, p=0.029) and the classroom activities (r=0.157, p=0.011) in the girls' group. Explosive strength improvement was significant in the lower grades and endurance improvement was prominent in the upper grades. The total score of table tennis teaching (β=0.322) had the greatest influence on physical fitness, followed by classroom activities (β=0.261) and activity frequency (β=0.214), which together constituted the core drivers. In teaching practice, the design of table tennis teaching program should be optimized by focusing on classroom activities and activity frequency, and differentiated intervention programs should be designed for different genders and school segments in order to effectively improve students' physical fitness and health.

Index Terms complex network, multiple regression, correlation analysis, table tennis teaching, physical health

I. Introduction

In recent years, the physical fitness of Chinese college students has continued to decline, and poor physical health of college students has become a common problem faced by colleges and universities [1], [2]. As the national ball of China, table tennis has always been a popular sport for public fitness [3]. With the deepening of sports reform in colleges and universities, it has also been better developed in colleges and universities with a wider mass base and the characteristics of the sport that integrates fitness, fun and entertainment, and it is one of the popular electives in college and university physical education courses [4]-[6]. With the increase in the number of participants, the promotion of table tennis teaching for human health has also received more and more attention [7].

As a kind of whole-body sport, table tennis teaching has many benefits for the physical health of college students [8], [9]. Table tennis can effectively promote the cardiorespiratory function of college students [10]. Through prolonged practice and competition, students' cardiorespiratory function can be exercised and improved, cardiorespiratory adaptability and endurance can be improved, and it helps to improve the physical fitness level and anti-fatigue ability [11]-[13]. Table tennis can enhance the muscle strength and flexibility of college students [14]. In the process of playing the ball, it is necessary to frequently perform rapid movement, bending, stretching and other actions, which can effectively exercise to the muscle groups of the whole body, improve muscle strength and flexibility, and help to maintain the health and strength of the body [15]-[17]. Table tennis can also improve the hand-eye coordination and reaction ability of college students [18]. In table tennis, it requires a high degree of concentration and sensitive reaction to improve hand-eye coordination and reaction speed, which has a positive effect on improving students' learning efficiency and coping with various challenges [19]-[21]. It can be seen that table tennis teaching has obvious feasibility to improve the physical health of college students, and effectively promote the improvement of students' physical health [22], [23].

Literature [24] examined the effect of table tennis training on muscular strength and cardiorespiratory endurance of adolescent students, based on comparative experiments pointing out that the effect of current training methods is not obvious enough, and the effect of table tennis training is more effective in promoting students' physical health. Literature [25] aimed to investigate the effects of a six-month table tennis (TT) training on bone health, muscle mass and physical performance in older men and revealed that TT was effective in mitigating changes in bone health and physical performance associated with aging and sedentary lifestyle. Literature [26] aimed to review the scientific evidence regarding the effects of table tennis practice on children and adolescents, based on a literature review showing that table tennis positively affects various domains such as executive function, motor skills, large muscle motor skills, and coordination. Literature [27] examined the effects of table tennis on the physical and functional health of older adults, and the study affirmed the importance of the table tennis program in positively affecting agility and balance in older adults. Literature [28] aimed to identify and analyze the effects of table tennis on students' health, independence, and character, and through the techniques of observation, interviews, and document collection of data, it revealed that table tennis had a positive effect on both the physical and mental health of the students. Literature [29] analyzes amateur table tennis, its practitioners and their activity patterns and describes table tennis as a sport, pointing out that its use as part of physical education classes can bring benefits such as health, pleasure, and personal and social development.

In this paper, we first detail the parameters of complex network characteristics and construct a learner network by integrating the complex Euclidean distance of learners' achievement and personality traits. The measurement method of students' physical fitness is proposed, and the core influencing factors of students' physical fitness and health are identified through the topological parameters of nodes. Stratified sampling method was used to select research subjects and design the table tennis teaching intervention experiment. Combining correlation analysis and multiple regression analysis, the critical path and differentiated intervention strategies of table tennis teaching to improve physical fitness and health are revealed.

II. Determination of students' physical health indicators and modeling of complex networks

Physical fitness refers to the functions of the human body such as strength, speed, endurance, sensitivity, flexibility and so on, which are manifested in activities. A reasonable way of physical exercise can promote growth and development, improve athletic ability, and thus enhance students' health. Table tennis has always been a necessary part of the physical education curriculum in colleges and universities. With the improvement of the physical education curriculum in colleges and universities and the continuous improvement of infrastructure, many schools have added modern teaching facilities, so that table tennis is also continuously improved and developed in colleges and universities. However, there are few studies on the effects of table tennis teaching on students' physical fitness. Existing studies have mostly focused on the linear effects of single teaching variables on physical fitness indicators, and lacked comprehensive consideration of the topological characteristics of teaching networks and learner heterogeneity. With the rise of complex network theory, its powerful ability to mine nonlinear relationships provides a new perspective to analyze the dynamic coupling mechanism between table tennis teaching activities and physical fitness.

II. A. Description of complex network characteristic parameters

The network of knowledge points is composed of individual knowledge points, and the knowledge structure of the textbook or a certain chapter can be regarded as a complex network, with each knowledge point abstracted as a node of this network, and their interconnections abstracted as connecting lines or edges between nodes. According to the theory of complex network, this paper selects three topological parameters to characterize the nodes, including node degree value, node median and importance degree.

(1) Node Degree

Node degree is the number of other nodes directly connected to a node, and the size of the node degree represents the influence of the node. The larger the degree value of a node, the more nodes directly connected to it, the greater the direct impact will be, occupying a more important position in the network. From the perspective of knowledge point analysis, nodes with higher degree values are usually more important basic knowledge points in the knowledge system, providing the basis for the learning of subsequent knowledge points.

(2) Node median

Node mediator represents the indirect influence of the node, and the definition adopted in this paper is as follows:

$$B_i = \sum_{\substack{a,b\in v \\ a\neq b\neq i}} \left[m_{ab}(i) / M_{ab} \right] \tag{1}$$

where $m_{ab}(i)$ denotes the number of paths passing through node i among all shortest paths from node a to node b in this network, and M_{ab} denotes the number of all shortest paths from node a to node b in this network.

A point with a larger median value means that more paths pass through the node, implying that more concepts have to be expressed with the help of the knowledge point, i.e., the node has more influence on other nodes. From the perspective of knowledge point analysis, the node with a larger value of the node median is actually a bridge between the related knowledge.

(3) Node importance

The importance of the node reflects the comprehensive influence of the node, the static parameters of the knowledge point network model given above describe the direct or indirect influence of the knowledge node in the network model from a single point of view, and lack of evaluation of the comprehensive influence of the network node. For a network model, its importance does not depend entirely on these characteristics of the nodes, and these factors need to be considered simultaneously to make a more accurate assessment of the importance of the nodes and the network. The introduction of the node importance parameter can be from the node degree value and median of these two aspects, the integrated consideration of the node's direct and indirect influence, as well as the node itself and its first-order neighboring nodes on the importance of the node's contribution to the node, in order to evaluate the size of the influence of a node.

The basic expression of node importance is

$$I_k = D_k E_k B_k \tag{2}$$

Among them:

$$D_k = \left[\frac{1}{\phi_k} \sum_{j \in \pi^{(1)}(k)} \frac{1}{\phi_j} \right] \tag{3}$$

is the node k degree contribution matrix, where ϕ_k denotes the degree ranking value of node k, and $\sum_{j \in \pi^{(1)}(k)} \frac{1}{\phi_j}$ denotes the inverse sum of the degree ranking values of the nodes that are 1st order neighbors of node k.

$$B_k = \left[\frac{\frac{1}{\varphi_k}}{\sum_{j \in \pi^{(1)}(k)} \frac{1}{\varphi_j}} \right] \tag{4}$$

is the mediator contribution matrix of node k, φ_k denotes the node mediator ranking value of node k, and $\sum_{j \in \pi^{(1)}(k)} \frac{1}{\varphi_j}$ denotes the inverse sum of the mediator ranking values of the nodes that are the 1st order neighbors of node k. .

$$E_k = \begin{bmatrix} \delta_{k,1}^{(0)} & \delta_{k,2}^{(0)} \\ \delta_{k,1}^{(1)} & \delta_{k,2}^{(1)} \end{bmatrix} = \begin{bmatrix} \delta_{k,1} & \delta_{k,2} \\ \sum_{j \in \pi^{(1)}(k)} \delta_{j,1} & \sum_{j \in \pi^{(1)}(k)} \delta_{j,2} \end{bmatrix} \tag{5}$$

is the matrix of assessment indicators E_k.

$$\delta_{k,n}^{(m)} = \sum_{j \in \pi^{(m)}(k)} \delta_{j,n} \tag{6}$$

$\delta_{k,n}^{(m)}$ is the total contribution of the set of m-order neighboring nodes of node k to the importance of node k under the constraint of the nth metric, and $\delta_{j,n}\left(j \in \pi^{(m)}(k)\right)$ is the nth metric value of node j in the set of m-ordering neighboring nodes of node k.

Equation (6) presents a second-order matrix because only two metrics, degree and median, are used and only the node itself and its 1st-order neighbor nodes are considered. Considering that the range of values of different indicators may vary greatly, the evaluation indicator matrix E_k needs to be normalized. The final formula for the importance of node k is obtained as

$$I_k = D_k E_k' B_k \tag{7}$$

II. B.Learning knowledge network construction incorporating learners' personality traits

After obtaining the data reflecting the learner's personality traits, this paper incorporates the learner's personality traits into the user model by constructing the composite Euclidean distance, i.e., realizing the personality-learning model mapping. The composite Euclidean distance includes: one is the Euclidean distance d_1 of the learner's academic performance; one is the Euclidean distance d_2 of the learner's personality, where the Euclidean distance is the distance between two nodes in the N-dimensional space, and the smaller the value is, the greater the correlation between the two nodes. The principle of dividing the study group in this study is that the group members are similar in terms of achievement dissimilarity personality, and the composite Euclidean distance D between two learners is calculated by the following formula: $D = \alpha \frac{1}{d_1} + \beta d_2$. α and β are the weights of the two types of Euclidean distances, $\alpha + \beta = 1$, respectively.

In computing the Euclidean distance, the N-dimensional Euclidean space is a set of points, and each of its points X or vectors X can be denoted as $\left(x^{[1]}, x^{[2]}, \cdots, x[N]\right)$, where $x[i]\left(i = 1, 2, \cdots, N\right)$ are real number called the i th coordinate of X. In N-dimensional space, suppose two nodes $A = \left(a^{[1]}, a^{[2]}, \cdots, a[N]\right)$ and $B = \left(b^{[1]}, b^{[2]}, \cdots, b[N]\right)$, then the A and B The Euclidean distance $\rho(A, B)$ between A and B is calculated using equation (8):

$$\rho(A, B) = \sqrt{\left[\sum\left(a[i] - b[i]\right)^2\right]}\left(i = 1, 2, \cdots, N\right) \tag{8}$$

In order to eliminate the effect of magnitude between the indicators to achieve comparability between the indicators, this study normalizes the data using min-max normalization, so that the value of the composite Euclidean distance is mapped to $[0-1]$.

After obtaining the user model of the learners, each learner is viewed as a node and the composite Euclidean distance is used as a distance metric to determine whether there is an edge connection between two nodes. The smaller D between two learners indicates the higher correlation between their points. The composite Euclidean distance between nodes is lower than the threshold value, then the nodes are considered to be connected by an edge. In this case, a times the average of all composite Euclidean distances between nodes in the network is used as the threshold value for determining whether there is a connection between nodes, i.e., $thresh\_hold = a * mean\_value$, $0.3 \le a \le 1.5$. When $D \le thresh\_hold$, there is a connection between two nodes; $D > thresh\_hold$, there is no connection between two nodes.

II. C.Measurement of students' physical fitness

(1) Test Indicators

According to the test methods and test indexes stipulated in the Standard for Students' Physical Fitness and Health and the Measurement and Evaluation of Physical Education, as well as drawing on the relevant studies on the measurement indexes and evaluation of table tennis-specific physical fitness, 50-meter run was chosen as the evaluation index of speed quality; 1000-meter run for men and 800-meter run for women were chosen as the evaluation indexes of endurance quality; seated forward bending was chosen as the evaluation index of flexibility quality; standing long jump was chosen as the evaluation index of lower limb strength quality; and standing jump was chosen as the evaluation index of lower limb strength quality. The standing long jump was chosen as the evaluation index of lower limb strength quality.

(2) Testing time

The experimental cycle is 3 months, 12 weeks in total, 2 classes per week, a total of 90 minutes, the content of the students' class consists of three parts, respectively, special warm-up, table tennis learning, special physical quality exercises.

(3) Standing Long Jump

The test is conducted by two testers, one keeping score and one reading. Testing method: Before the test, students are led to warm up physically so that they can reach a higher state of physical functioning. Test twice and take the highest value. Measuring tool: tape measure.

(4) Seated Forward Bend

Two testers, test method: appropriate stretching exercises before the test to prevent injuries, when the test legs together straight, hands as far as possible forward to push the vernier until it can not be stretched forward, test twice, take the average score. Testing tool: seated forward bend tester.

(5) 50 meters

Two testers, test method: lead students to warm up before the test in case of discomfort. Explain to the students that it is a school physical fitness monitoring and let them try their best to run. Testing tool: stopwatch.

(6) 800 (female)/1000 (male) meters

Two testers, test method: Warm up before the test in case of discomfort. Explain to the students that it is a school physical fitness monitor and ask them to run as hard as they can. Testing tool: stopwatch.

III. Analyzing the effect of table tennis teaching on students' physical health based on complex networks

In this paper, a stratified sampling method was used to select 300 students as experimental subjects from the 23rd grade non-physical education majors undergraduate students of three universities in Province A. There were 150 students in the experimental group (78 male and 72 female) and 150 students in the control group (76 male and 74 female), with an average age of 19.13±0.534 years old, and the experimental group was additionally taught table tennis in physical education classes for 12 weeks, twice a week, for a total of 90 minutes of table tennis exercise intervention, and the control group was taught routinely. All subjects completed an informed notification form.

III. A. Identification of Impact Factors

Firstly, the factors of teaching activities in table tennis courses were extracted, then the factors were used as network nodes, and the connecting edges were constructed according to the knowledge relationship to form a network of students' physical fitness and health, and to identify the factors of the influence of table tennis teaching on students' physical fitness and health.

Six indicators were identified as medium-high intensity table tennis activity, classroom table tennis activity, after-school table tennis activity, table tennis activity summary, table tennis activity frequency, and total score of table tennis teaching, and the nodes with larger degrees of connectivity are shown in Table 1, where a larger degree means more nodes are directly connected to it, and the greater the likelihood of possessing a core status. The nodes with the largest degree of connectivity were "total table tennis teaching score", followed by "medium and high-intensity table tennis activities", "classroom table tennis activities" and "table tennis activity frequency", indicating that the edges directly connected to these nodes were the most, indicating that they had an important position in the students' physical health network.

Table 1: Student physical health network node identification

Node name	Connectivity
Total score of Table Tennis Teaching	34
Moderate to high-intensity table tennis activities	32
Classroom table tennis activity	28
Table tennis activity frequency	24
After-school table tennis activities	20
Summary of Table Tennis Activities	17

The distribution of node proximity centrality and meso centrality in the students' table tennis knowledge learning network is shown in Figure 1. It is found that the number of nodes with proximity centrality in the range of 0~0.4 is in the majority, and a small portion of nodes have proximity centrality in the range of 0.8~1.2, which indicates that they are in a more central position. However, there is also a part of nodes whose proximity centrality is in the range of 0~0.2, which are in a more marginal position in the network or do not have edges that can reach other nodes. It can be seen that the students' physical health network presents a layout in which a small portion of the nodes are located in the core position and most of the nodes surround the nodes in the core position. The centrality of the mediator number of most nodes is between 0 and 0.005, and the centrality of the mediator number of a small number of nodes is more than 0.025, indicating that some nodes play the role of a bridge. The nodes represented by the nodes with large median centrality in the students' physical health network are likely to be the bridges connecting different influencing factors, and the problems in this node may destroy the whole teaching link and affect the students' physical health.

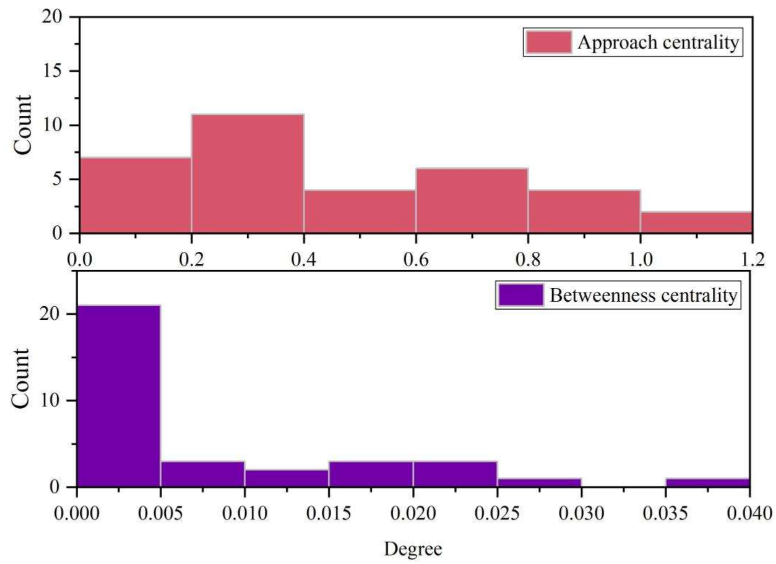

Figure 1: Distribution of proximity centrality and betweenness centrality

III. B. Correlation analysis

Prior to exploring the analysis of the quantitative and qualitative relationships between table tennis instruction and physical fitness indicators, the Kolmogorov-Smirmov test was used, which indicated that the table tennis instruction scores did not conform to a normal distribution. In view of this, Spearman correlation analysis was used in this study to assess the correlation between table tennis instruction and physical fitness test scores. The correlation results for boys and girls in the experimental group are shown in Tables 2 and 3, respectively, with "**" indicating a significant correlation at the 0.01 level (two-tailed) and "*" indicating a significant correlation at the 0.05 level (two-tailed). 0.2<|r|<0.4 is a low correlation, 0.4≤|r|<0.6 is moderate correlation while 0.6≤|r|<0.8 indicates high correlation. The correlation between different dimensions of table tennis instruction and physical fitness indicators under gender grouping was explored in order to seek a clear understanding of the relationship between students' different temporal and spatial dimensions of table tennis instruction and each physical fitness indicator.

Under the gender grouping, there were differences in the correlations between table tennis instruction and physical fitness indicators exhibited by male and female students. Specifically, in the male group, the total score of table tennis instruction showed moderate correlations with standing long jump (r=0.258,p=0.003) and 1000-meter run (r=0.249,p=0.002). The female group showed a different pattern of association, with the seated forward bend indicator showing a low correlation with the total table tennis teaching score (r=0.166,p=0.029) and classroom activity (r=0.157,p=0.011), while the 800-meter run showed a moderate strength of correlation with classroom activity (r=0.303,0=0.002). Gender heterogeneity may stem from different training responses due to differences in physiological characteristics, suggesting the need for targeted teaching strategies.

Table 2: Correlation between Male Table Tennis Teaching and physical Health

Index		Total score of Table Tennis Teaching	Moderate to high-intensity table tennis activities	Classroom table tennis activity	Table tennis activity frequency	After-school table tennis activities	Summary of Table Tennis Activities
50m run	r	0.183**	0.183*	0.185*	0.138*	0.146**	0.067
	p	0.002	0.024	0.009	0.035	0.003	0.483
Standing long jump	r	0.258**	0.078	0.286**	0.297**	0.314**	0.137**
	p	0.003	0.247	0.002	0.001	0.002	0.002
1000m run	r	0.249**	0.138*	0.267**	0.164**	0.247**	0.186
	p	0.002	0.022	0.001	0.003	0.001	0.077
Sit in a forward bend	r	0.135*	-0.067	0.198	0.178*	0.138	0.094
	p	0.022	0.664	0.074	0.015	0.076	0.186

Table 3: Correlation between Table Tennis Teaching for Girls and Physical Health

Index		Total score of Table Tennis Teaching	Moderate to high-intensity table tennis activities	Classroom table tennis activity	Table tennis activity frequency	After-school table tennis activities	Summary of Table Tennis Activities
50m run	r	0.146*	-0.022	0.187*	0.181*	0.138	
	p	0.028	0.476	0.015	0.023	0.089	0.174**
Standing long jump	r	0.119*	0.038*	0.193*	0.033	0.073	0.007
	p	0.037	0.032	0.002	0.832	0.396	0.186*
800m run	r	0.192*	0.086**	0.303**	0.194*	0.082	0.034
	p	0.014	0.003	0.002	0.018	0.385	0.436
Sit in a forward bend	r	0.166*	0.038	0.157*	0.089	0.092	0.099
	p	0.029	0.503	0.011	0.284	0.208	0.138

III. C. Analysis of control results

Horizontal comparison of the physical health level of the two groups before and after the experiment, the comparison of the physical health level of the two groups of students before and after the experiment is shown in Table 4, in which the test item is full of 100 points. Analyzed by independent samples t-test, there is no significant difference between the physical health level of the experimental group and the control group before the experiment (p>0.05), while a number of indicators of the experimental group are significantly better than the control group after the experiment. The experimental group was significantly better than the control group in 50m running (t=-1.694,p=0.035), standing long jump (t=1.585,p=0.022), 800/1000m running (t=-0.948,p=0.008), and seated forward bending (t=1.208,p=0.018), among which the intergroup differences in 800/1000m running reached high significance (p<0.01).

Table 4: Comparison of physical health before and after the experiment

Index	Before the experiment		t	P	After the experiment		*t*	*P*
	Experimental group	Control group			Experimental group	Control group		
50m run	82.45±2.42	82.18±2.94	-1.593	0.297	89.38±1.04	84.06±2.58	-1.694	0.035*
Standing long jump	83.28±2.58	83.37±2.53	1.536	0.256	88.48±0.75	84.22±2.74	1.585	0.022*
800/1000m run	75.38±3.05	76.03±2.98	-0.497	0.302	82.58±1.75	77.49±2.85	-0.948	0.008**
Sit in a forward bend	80.03±2.84	80.19±2.85	0.974	0.198	84.03±1.05	80.58±2.06	1.208	0.018*

Longitudinal comparison of physical fitness level of the two groups before and after the experiment, the comparison of physical fitness level of the two groups of students before and after the experiment are shown in Table 5 and Table 6 respectively. After calculating the difference between the experimental and control groups before and after the experiment, the paired samples t-test was analyzed. The data showed that the experimental group showed significant improvement in both gender and grade dimensions. In the male group, the 50m run improved by 6.63±1.59 points (p<0.05) and the standing long jump improved by 5.03±1.53 points (p<0.01). The female group improved even more significantly, with 7.73±0.85 points (p<0.01) in the 800m run and 4.08±0.94 points (p<0.05) in the seated forward bend, suggesting that the female students were more sensitive to the intervention in terms of endurance and flexibility qualities. In the longitudinal comparison of the control group, the improvement of all indicators did not reach a significant level (p>0.05), confirming the effectiveness of the experimental intervention. The grade difference analysis showed that the lower grade students in the experimental group improved more significantly in the explosive strength index 50m run, while the higher grade students improved more prominently in the endurance index 1000m run, suggesting that the effect of the intervention may be characterized by the adaptive characteristics of school segments.

Table 5: Differences in physical health levels of the experimental group

Group	50m run	Standing long jump	800/1000m run	Sit in a forward bend
Male	6.63±1.59*	5.03±1.53**	6.49±0.96*	3.87±0.76*
Female	7.03±1.08**	4.02±0.59*	7.73±0.85**	4.08±0.94*
Freshman Year	8.08±1.64*	6.22±1.64**	7.33±0.48*	4.28±0.69**
Sophomore year	7.04±1.06	5.39±0.49*	7.12±0.39	3.97±0.88*
Junior	6.22±1.48*	4.22±0.58	7.93±0.95	3.68±0.92

Table 6: Differences in physical health levels of the control group

Group	50m run	Standing long jump	800/1000m run	Sit in a forward bend
Male	0.53±0.28	0.89±0.58	2.04±1.45	0.53±0.38
Female	0.22±0.11	0.94±0.48	1.94±0.97	0.56±0.95
Freshman Year	0.78±0.19	1.08±0.54	2.55±1.57	0.58±0.99
Sophomore year	0.61±0.22	0.96±0.85	2.01±0.98	0.47±0.92
Junior	0.17±0.35	0.84±0.79	1.95±0.77	0.33±0.58

III. D. Linear regression analysis

The dependent variable was set to be students' physical fitness and health level, and the independent variables were high-intensity table tennis activity, classroom table tennis activity, after-school table tennis activity, table tennis activity summary, frequency of table tennis activity, and total scores of table tennis teaching, which were used to analyze and explore how the table tennis teaching affects the physical fitness and health level of the students by using the multiple linear regression model. The results of the model regression coefficients are shown in Table 7. The VIF values of all independent variables ranged from 1.155 to 1.325, which were much lower than the critical value of 10, and the tolerance (TOL>0.7) indicated that there was no serious covariance among the variables, and the model interpretation was reliable. The standardized coefficients showed that the total table tennis teaching score (β=0.322) had the greatest effect on physical fitness, followed by classroom activity (β=0.261) and activity frequency (β=0.214), which together constituted the core drivers.

Table 7: Calculation results of the model regression coefficients

	Unstandardized coefficient		Standardized coefficient	*t*	Significance	Collinear statistics	
	B	SE	Beta			TOL	VIF
Total score of Table Tennis Teaching	0.281	0.041	0.322	6.823	0.002	0.875	1.155
Moderate to high-intensity table tennis activities	0.172	0.053	0.194	3.412	0.015	0.823	1.223
Classroom table tennis activity	0.241	0.032	0.261	4.252	0.004	0.798	1.276
Table tennis activity frequency	0.128	0.018	0.214	3.821	0.002	0.858	1.182
After-school table tennis activities	0.083	0.023	0.122	2.345	0.011	0.762	1.325
Summary of Table Tennis Activities	0.152	0.045	0.161	3.187	0.003	0.819	1.243
Constant	2.356	0.213	-	11.192	0.002	-	-

IV. Conclusion

Through complex network modeling and empirical analysis, this study systematically explained the nonlinear mechanism between table tennis teaching and students' physical health, and reached the following conclusions:

(1) The core drivers of the teaching network

The importance of nodes comprehensively reflects the influence of teaching content, and the node with the largest connection degree is the "total score of table tennis teaching", followed by "medium and high-intensity table tennis activities", "classroom table tennis activities" and "table tennis activity frequency", indicating that the edges directly connected to these nodes are the most, indicating that they have an important position in the students' physical health network.

(2) The effectiveness of table tennis teaching on the improvement of students' physical health

There was no significant difference between the physical health level of the experimental group and the control group before the experiment ($p>0.05$), while a number of indicators of the experimental group were significantly better than those of the control group after the experiment. The experimental group was significantly better than the control group in the indexes of 50-meter run ($t=-1.694, p=0.035$), standing long jump ($t=1.585, p=0.022$), 800/1000-meter run ($t=-0.948, p=0.008$), and seated forward bending ($t=1.208, p=0.018$), among which the intergroup difference of the 800/1000m run reached high significance ($p<0.01$). The experimental group showed significant improvement in both gender and grade dimensions ($p<0.05$), and in the longitudinal comparison of the control group, the improvement of all indicators did not reach the significant level ($p>0.05$).

(3) Heterogeneity by Gender and Academic Segment

In the boys' group, the total table tennis teaching score showed moderate correlation with standing long jump ($r=0.258, p=0.003$) and 1000m run ($r=0.249, p=0.002$). 50m run improved by 6.63±1.59 points ($p<0.05$) and standing long jump by 5.03±1.53 points ($p<0.01$). The seated forward bending indicator of the female group showed a low correlation with the total score of table tennis teaching ($r=0.166, p=0.029$) and classroom activities ($r=0.157, p=0.011$), whereas the 800-meter run correlated with the classroom activities ($r=0.303, 0=0.002$) with a moderate strength of correlation. The 800m run improved by 7.73±0.85 points ($p<0.01$) and seated forward bends by 4.08±0.94 points ($p<0.01$).

The analysis of grade difference showed that the lower grade students in the experimental group improved more significantly in the explosive strength index 50m running, while the higher grade students' improvement in the endurance index 1000m running was more prominent, suggesting that the intervention effect may have the characteristics of school section adaptation.

(4) Optimization path of teaching intervention

The multiple regression model revealed that the total score of table tennis teaching ($\beta=0.322$) had the greatest influence on physical fitness, followed by classroom activities ($\beta=0.261$) and activity frequency ($\beta=0.214$), which together constituted the core driving factors. The systematic design of table tennis instruction and the synergistic implementation of classroom activities and activity frequency are the core pathways for physical fitness improvement.

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