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Article

# A study on multimodal assessment and intervention strategies of the impact of college volleyball teaching on students' physical and mental health

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**Abstract:** The purpose of this study is to explore the influence of volleyball teaching in colleges and universities on students' physical and mental health, and to systematically analyze it by multi-modal evaluation method. 300 college students were randomly divided into experimental group and control group. The experimental group received personalized intervention based on multimodal evaluation system during 16 weeks of volleyball teaching, covering multi-dimensional monitoring and feedback of physiological, psychological and technical performance. Through heart rate, body fat rate, heart rate variability (HRV), GHQ-12 scale, technical score and self-efficacy, the students' physical quality, mental health, technical proficiency and self-efficacy were comprehensively evaluated. The results show that the multimodal intervention strategy is effective in improving physical health and mental health, and the experimental group is superior to the control group in heart rate, body fat rate, vital capacity, HRV, GHQ-12 score, technical proficiency and self-efficacy. The real-time monitoring and feedback of multimodal assessment in teaching optimizes the intervention effect and provides a scientific basis for the optimization of physical education courses in colleges and universities.

**Keywords:** multimodal assessment; volleyball teaching; physical and mental health; college physical education; intervention strategy

## 1. Introduction

With the promotion of health literacy education and the reform of college physical education courses, students' physical and mental health has become a core focus in higher education. Volleyball, as a team sport, not only enhances physical fitness but also promotes mental well-being through teamwork. However, traditional volleyball teaching has limitations in meeting individualized needs and providing effective feedback, making it difficult to fully improve students' physical and mental health. The multimodal assessment method, which integrates physiological, psychological, and technical data, offers comprehensive feedback for personalized teaching and dynamic intervention, and thus has gained wide attention in the fields of education and health. Based on a multimodal assessment system, this study designed and implemented a 16-week personalized volleyball teaching intervention, thoroughly analyzing its impact on students' physical fitness, mental health, technical skills, and self-efficacy, providing scientific support for the optimization of college physical education courses and student health management.

## 2. Theoretical basis

### 2.1. The theory of the relationship between physical and mental health and physical exercise

Physical exercise plays an important role in maintaining and promoting individual physical and mental health. Studies have shown that regular physical activity significantly enhances physical fitness and improves mental health. Among college students, due to academic pressures and fast-paced lifestyles, physical and mental health issues are relatively common [1,2]. Moderate physical activity helps improve students' physiological state, alleviate psychological stress, and strengthen their ability to cope with challenges. Volleyball, as a team-based competitive sport, not only imposes high physical demands on students but also enhances various aspects of physical abilities, such as focus, coordination, and responsiveness.

In terms of specific physical fitness indicators, volleyball positively impacts cardiovascular health, respiratory function, muscle strength, and flexibility. The frequent jumping and movement in volleyball training strengthen lower body muscles and improve cardiovascular and pulmonary function, thereby enhancing overall fitness [3]. Physical exercise stimulates the release of neurotransmitters such as endorphins, providing a sense of pleasure and relaxation. Additionally, the intense team interactions and competitive scenarios in volleyball help engage emotions effectively, bringing about enjoyment and partially alleviating negative mental states like anxiety and depression.

### 2.2. Self-Determination theory in sports psychology

Self-Determination Theory (SDT) provides a scientific basis for understanding the mechanism of exercise on individual mental health. SDT emphasizes that individual mental health and motivation are closely related to three basic psychological needs: autonomy, competence and sense of belonging. The satisfaction of these needs directly affects the individual's intrinsic motivation and willingness to continue to participate in activities, and then affects his mental health. Autonomy refers to the individual's freedom in behavior choice, competence refers to the individual's cognition and sense of accomplishment of his own ability, and sense of belonging refers to the individual's perception of the closeness of his relationship with others and the acquisition of social support. In volleyball teaching, the satisfaction of these three needs is the key to improve students' intrinsic motivation and willingness to participate.

Autonomy in volleyball teaching can be promoted by providing students with a certain choice. If students can choose their own training content, training methods or the degree of participation in teaching, they can feel the satisfaction of independent control, which will enhance their inner interest in sports and the motivation for lasting participation. In teaching, teachers can provide technical exercises with different difficulties and types according to students' interest and ability level, allowing students to achieve higher autonomy in self-selection, thus promoting their intrinsic motivation [4].

Competency in volleyball teaching is mainly realized through skill training and technical feedback. Volleyball is a sport with high technical requirements. Students gradually master the skills by constantly practicing basic movements such as spike, block and pass, which can effectively meet their needs for competence. In order to enhance the sense of competence, teaching design should adopt hierarchical teaching strategies, so that students can achieve a sense of accomplishment in training tasks suitable for their own level, and encourage students to continue their efforts through timely positive feedback. In addition, teachers can make students feel that they are making progress by setting specific achievable goals, thus enhancing their positive experience of sports activities [5].

As a collective sport, volleyball emphasizes teamwork and collective responsibility. In this collaborative environment, students can gain a sense of belonging through interaction with teammates and feel that they are an indispensable part of the team. The acquisition of this sense of belonging not only helps to improve students' social skills, but also enhances their psychological security in sports, thus promoting the further development of mental health. In the teaching process, teachers can design tasks based on team cooperation, such as team competition and group training, so that students can experience collective support and interaction in actual cooperation, thus meeting their needs of belonging.

## 2.3. The concept and application of multimodal assessment

Multimodal assessment refers to a comprehensive evaluation of an individual's physical and mental state by integrating multiple data sources across various dimensions. Unlike single-dimension assessment methods, multimodal assessment uses a combination of physiological, psychological, and behavioral data to more accurately and objectively reflect an individual's health status. In recent years, multimodal assessment has been widely applied in fields such as mental health and sports rehabilitation. In this study, a multimodal data collection system is employed to integrate physiological indicators (such as heart rate and body fat percentage), psychological health scales (such as the GHQ-12), and volleyball technical performance observations, to comprehensively evaluate the physical and mental states of college students during volleyball instruction [6].

In this study, heart rate sensors are used to monitor students' physiological responses in real-time during volleyball instruction, the GHQ-12 scale is applied to assess changes in psychological state, and video recording and analysis are used to track technical skills. Multimodal data capture dynamically records students' physiological and psychological performance during instruction, and after data integration, it allows analysis of the specific impact of different training segments on students' physical and mental health. This assessment method not only improves data accuracy but also provides real-time feedback on students' states, aiding instructors in optimizing teaching strategies.

## 2.4. Design principles of volleyball instruction intervention strategies

The intervention strategy of volleyball teaching designed in this study aims to enhance students' experience in volleyball teaching in a scientific and personalized

way. The core of intervention strategy is to meet the needs of students' autonomy, competence and sense of belonging by accurately adjusting teaching content and methods, so as to promote students' mental health and technical upgrading. In the process of implementation, this study proposes to introduce autonomous support strategies into teaching, including providing different intensity exercises and promoting self-reflection to stimulate students' autonomy [7].

In terms of autonomous support, students can choose the appropriate training intensity according to their own abilities, which can enhance their sense of control over activities. Teachers encourage students to reflect on themselves, fill in personal training logs after class, and record classroom feelings, technical mastery and physical and mental state, so as to promote students' independent evaluation and self-adjustment. By grouping students according to their technical level, hierarchical teaching allows each student to train at a level suitable for their own abilities, thus enhancing their sense of competence. Teachers give timely and constructive feedback according to students' progress to help students gain a sense of accomplishment in the gradual mastery of technology [8,9].

Based on the multimodal evaluation system, this study collects students' real-time data feedback (such as physiological indicators and psychological state) in the classroom, and adjusts teaching strategies accordingly. The system can monitor students' heart rate, physical exertion and emotional fluctuation in real time, and teachers can adjust the training intensity, content and methods according to these feedbacks to ensure that every student can participate in the training in the best condition [10].

Considering the popularity of volleyball in the world, this study also discusses the applicability of intervention strategies in different cultural backgrounds. In different cultures, students' psychological needs, educational models and exercise habits may be different, so intervention strategies should be flexibly adjusted according to the characteristics of local culture. For example, some cultures may pay more attention to group activities and teamwork, while others may emphasize the improvement of personal skills. Teachers need to adjust teaching methods according to different cultural backgrounds to ensure that intervention strategies can fully meet students' needs and promote their psychological and technical development [11].

## 2.5. The impact of training interventions on athletes' physical and mental health

Based on self-determination theory and multi-modal evaluation data feedback, this study designed a series of personalized intervention strategies, aiming at enhancing students' autonomy, competence and sense of belonging, and enhancing their enthusiasm and involvement in volleyball. Specific intervention strategies are as follows:

Autonomy enhancement strategy: In order to enhance students' autonomy, students in the experimental group will be provided with different intensity and direction-oriented training options. Each student can choose the training content according to his own physical condition and interest, which can stimulate students' initiative and intrinsic motivation. In the process of implementation, teachers will

monitor students' physiological states (such as heart rate and fatigue) in real time through multimodal evaluation system, so as to ensure that students will not exceed the range of physical endurance when choosing training content, thus avoiding overtraining and maintaining an efficient learning state [12–14].

Hierarchical technical training: Based on the real-time data feedback of multi-modal evaluation system, students are divided into three training levels: primary, intermediate and advanced. The training content of each level is customized according to the students' physiological condition and technical level. For example, students in the primary group will be trained in basic technical movements, while the intermediate group will pay attention to the diversity and complexity of skills, while the advanced group will challenge higher-intensity technical training and competition simulation. Through this hierarchical training, it is ensured that each student can accept the challenge at a level suitable for his own ability and improve his sense of competence and skill proficiency [15].

Teamwork training: In order to enhance students' sense of belonging and teamwork ability, several teamwork links have been added in the experimental design, such as paired cooperative passing and multi-person cooperation blocking [16,17]. The team cooperation project will monitor students' physiological indexes (such as heart rate and exercise intensity) and psychological state (such as emotional fluctuation) in real time through the multi-modal evaluation system, and dynamically adjust the training intensity and task difficulty according to real-time feedback.

Feedback and adjustment: The real-time feedback function provided by the multimodal assessment system enables teachers to continuously monitor students' physiological and psychological states. The system can detect students' high heart rate, excessive fatigue or abnormal psychological state, and give an alarm to teachers in time, and teachers can adjust the training content and intensity according to these feedbacks. If the system detects that a student's heart rate is too high, the teacher can reduce the training intensity or arrange more rest time. If students' emotional state is low or anxious, teachers can also take corresponding psychological counseling measures, such as providing encouragement and adjusting teaching methods, to help students maintain a positive learning attitude and emotional state.

## 3. Research methods

### 3.1. Study participants and experimental design

The participants in this study were university students, with 300 individuals randomly selected and divided into an experimental group and a control group, with 150 students in each group. The experimental group participated in a 16-week volleyball program supported by a multimodal assessment system and intervention strategies, while the control group received standard volleyball instruction. The experiment consisted of two 90-minute classes per week, totaling 32 sessions. This experimental design aims to systematically observe the long-term effects of volleyball instruction on students' physical and mental health and to verify the effectiveness of the multimodal assessment system in this process [9].

The experiment included three assessment phases: the initial phase (week 1), the mid-term assessment phase (week 8), and the final assessment phase (week 16).

In each phase, all participants underwent comprehensive evaluations of their physiological, psychological, and technical performance to assess the dynamic impact of volleyball instruction on their physical and mental health. This design not only examines the short-term effects of the instruction but also further validates the sustained effects of long-term interventions on psychological well-being and physical fitness, providing feedback to adjust and refine the intervention strategies.

### 3.2. Data collection methods

To ensure comprehensive assessment, data collection in this study covered three main dimensions: physiological, psychological, and technical.

**Table 1.** Data collection indicators and methods for physiological, psychological, and technical performance.

| Data Type | Collection Indicator | Equipment/Scale | Collection Frequency |
|---|---|---|---|
| Physiological Data | Heart Rate (HR) | Heart rate monitor | Recorded every 5 seconds |
| | Heart Rate Variability (HRV) | Heart rate monitor, calculated based on HR variation | Dynamic monitoring |
| | Body Fat Percentage (BFP) | Body fat monitor | Periodic measurement |
| Psychological Data | GHQ-12 Score | GHQ-12 mental health scale | Assessed at each phase (initial, mid-term, final) |
| | POMS Score | POMS mood states scale | Assessed at each phase (initial, mid-term, final) |
| Technical Performance Data | Skill Proficiency Score | Motion analysis software | After each training session |
| | Average Skill Score | System-generated average score | After each training session |

As shown in **Table 1**, all data were transmitted and consolidated in real-time to a central database through the multimodal assessment system, facilitating subsequent analysis and adjustments to intervention strategies.

### 3.3. Construction of the multimodal assessment system

The multimodal assessment system is the core tool of this study, integrating physiological sensors, psychological assessment scales, and technical performance scoring modules. Based on a multidimensional data fusion model, the system combines heart rate, body fat, psychological scores, and technical scores to provide a quantified assessment of physical and mental health.

The system's core model is a weighted multidimensional assessment model, expressed by the following Equation (1):

$$S_{total} = \omega_1 \cdot S_{physical} + \omega_2 \cdot S_{psychological} + \omega_3 \cdot S_{technical} \quad (1)$$

Where $S_{total}$ represents the overall health score; $S_{physical}$ denotes the physical health score; $S_{psychological}$ is the psychological health score; and $S_{technical}$ represents the technical performance score. The weights $\omega_1, \omega_2, \omega_3$ for each dimension, based on expert opinion and preliminary experimental data, are set as follows: $\omega_1 = 0.4$, $\omega_2 = 0.3$ and $\omega_3 = 0.3$.

### 3.4. Scoring and calculation methods

(1) Physical Health Scoring: The physical health score $S_{physical}$ is calculated based on heart rate, HRV, and body fat percentage. The heart rate score $S_{HR}$ and HRV score $S_{HRV}$ are calculated using the following Equations (2) and (3):

$$S_{HR} = \frac{HR_{min}}{HR_{actual}} \tag{2}$$

$$S_{HRV} = \frac{HRV_{actual}}{HRV_{max}} \tag{3}$$

Where $HR_{min}$ and $HRV_{max}$ represent the ideal values for standard heart rate and HRV, respectively. The comprehensive formula for the physical health score is as (4):

$$S_{physical} = \alpha \cdot S_{HR} + \beta \cdot S_{HRV} + \gamma \cdot S_{BFP} \tag{4}$$

Where $S_{BFP}$ represents the body fat percentage score, and $\alpha, \beta, \gamma$ denotes the weighting coefficients, set as $\alpha$ = 0.5, $\beta$ = 0.3 and $\gamma$ = 0.2.

(2) Psychological Health Scoring: The psychological health score $S_{psycho\,log\,ical}$ is calculated based on the GHQ-12 and POMS scales, with the specific formula as (5):

$$S_{psycho\,log\,ical} = \frac{Max\_Score - GHQ\_12}{Max\_Score} \times 100 + \frac{Max\_POMS - POMS}{Max\_POMS} \times 100 \tag{5}$$

Where $Max\_Score$ and $Max\_POMS$ represent the maximum scores of the GHQ-12 and POMS scales, respectively. By using reverse scoring, lower values correspond to a higher state of mental health.

(3) Technical Score: The technical performance score $S_{technical}$ is calculated by combining the scores for passing, spiking, and blocking, with the formula as (6):

$$S_{technical} = \frac{\sum_{i=1}^{n} T_i}{n} \tag{6}$$

Where $T_i$ represents the score for each type of technical skill, and$n$denotes the number of actions. This score provides an indication of changes in students' technical proficiency at different stages.

### 3.5. Intervention strategy design

The intervention strategies are based on Self-Determination Theory and feedback from multimodal assessment data, with a series of personalized interventions aimed at enhancing students' autonomy, competence, and sense of belonging, thereby increasing their enthusiasm and engagement in volleyball. The specific intervention strategies are as follows.

Autonomy Enhancement Strategy: Students in the experimental group are provided with training options of varying intensities and focuses, allowing them to choose exercises based on their physical condition. This enhances their sense of autonomy and intrinsic motivation.

Tiered Technical Training: Based on real-time feedback from the multimodal assessment system, students are divided into beginner, intermediate, and advanced training levels. Each level has tailored training content to ensure that students at different skill levels receive appropriate technical and physical challenges, thus increasing their sense of competence.

Team Collaboration Training: Team interaction elements are incorporated into the experimental design, such as paired passing and group blocking, to enhance students' sense of belonging and teamwork abilities. The system continuously monitors physiological indicators and psychological states during team projects, dynamically adjusting interaction intensity to ensure positive emotional experiences during group activities.

Feedback and Adjustment: The real-time feedback function of the multimodal assessment system enables instructors to monitor student status at any time and make adjustments based on physiological and psychological data. For example, if a high heart rate or unusual psychological state is detected, the system alerts the instructor, who can then adjust the training intensity or provide psychological support to the student.

## 4. Experimental results and analysis

### 4.1. Analysis of physical fitness indicators

**Table 2** shows the physiological health scores of the experimental and control groups at different assessment stages.

**Table 2.** Physiological health scores of the experimental and control groups at different assessment stages.

| Stage | Experimental Group HR Score $S_{HR}$ | Experimental Group BFP Score $S_{BFP}$ | Experimental Group VC Score $S_{VC}$ | Experimental Group Physical Health Score $S_{physical}$ | Control Group Physical Health Score |
|---|---|---|---|---|---|
| Initial Assessment | 62 | 64.5 | 58.3 | 61.2 | 60.8 |
| Mid-term Assessment | 68.7 | 71.4 | 65.5 | 68.2 | 63.5 |
| Final Assessment | 75.8 | 78.2 | 73 | 75.4 | 65.4 |

Through multimodal intervention strategies, this study significantly improved the physical fitness of students in the experimental group, particularly in physiological indicators such as heart rate, body fat percentage, and lung capacity. Experimental data show that the physiological health score of students in the experimental group increased from an initial 61.2 to 75.4 after 16 weeks of instruction, whereas the control group only rose from 60.8 to 65.4. This indicates that the multimodal intervention strategy is considerably more effective than conventional teaching in enhancing physical fitness. The improvements in heart rate and body fat percentage, in particular, suggest an effective enhancement in students' cardiovascular health and metabolic levels.

The improvement in heart rate and body fat percentage in the experimental group may be closely related to the personalized tiered training and real-time

feedback mechanisms. These measures ensure that students exercise at an intensity suited to them, thereby improving cardiopulmonary function and optimizing exercise outcomes through continuous feedback. The enhancement of physical fitness may also be linked to psychological guidance and teamwork within the multimodal intervention, which increases students' enthusiasm for participation. The smaller improvement in the control group's physical fitness indicates that conventional teaching has a relatively limited impact on students' physical health. As shown in **Figure 1**, Physiological Health Scores of the Experimental and Control Groups at Different Assessment Stages.

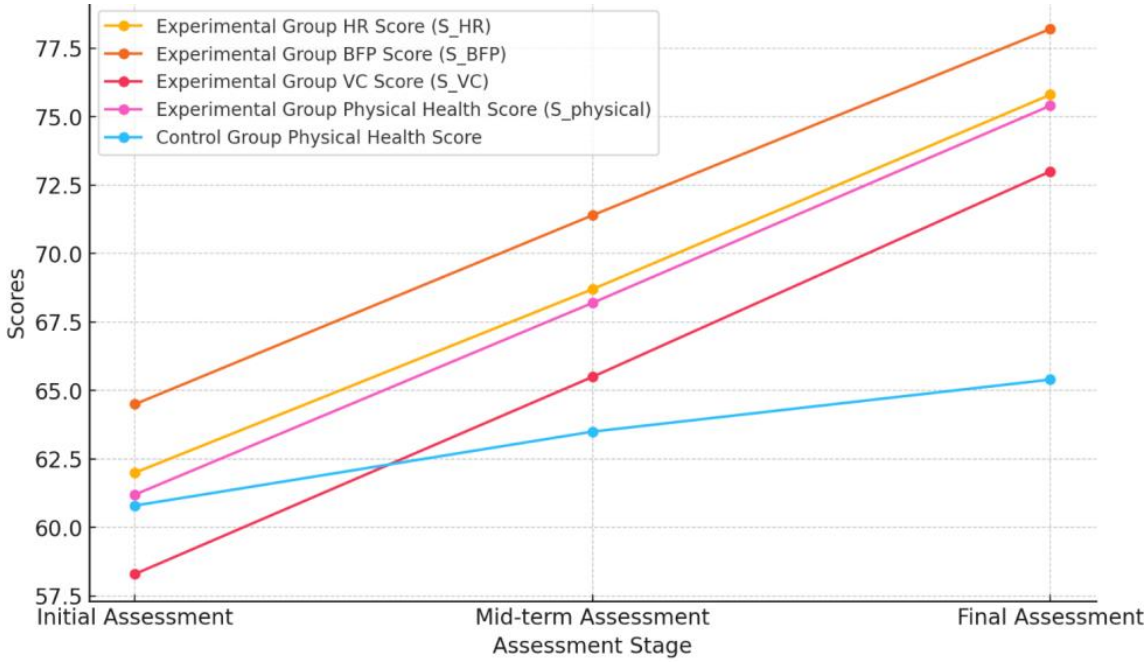


**Figure 1.** Physiological health scores of the experimental and control groups at different assessment stages.

## 4.2. Analysis of heart rate variability (HRV) data

**Table 3** shows the HRV scores of the experimental and control groups at different assessment stages.

**Table 3.** HRV scores of the experimental and control groups at different stages.

| Stage | Experimental Group HRV Score $S_{HRV}$ | Control Group HRV Score |
|---|---|---|
| Initial Assessment | 54 | 53.6 |
| Mid-term Assessment | 61.5 | 55.3 |
| Final Assessment | 68.4 | 56.7 |

Heart rate variability (HRV) is an important physiological indicator reflecting emotional regulation and stress response capacity. In this study, the HRV of the experimental group significantly increased, indicating that the multimodal intervention strategy positively impacted students' emotional stability and psychological resilience. The data show that the HRV score of the experimental group increased from an initial 54.0 to 68.4 during the experiment, while the HRV score of the control group only rose from 53.6 to 56.7. This suggests that the

multimodal intervention strategy in volleyball instruction is effective in helping students improve HRV and is superior to conventional teaching methods.

The effectiveness of the multimodal intervention strategy may stem from its systematic emotional support and stress relief design. Specifically, students in the experimental group experienced interventions such as emotional support, autonomy in choice, and team collaboration, which helped them establish stronger psychological support and emotional management mechanisms during exercise. The significant improvement in HRV may also be related to tiered training and personalized feedback, ensuring that students train at appropriate intensity levels, thereby avoiding HRV fluctuations caused by excessive fatigue or increased psychological load. As shown in **Figure 2**, HRV Scores of the Experimental and Control Groups at Different Stages.

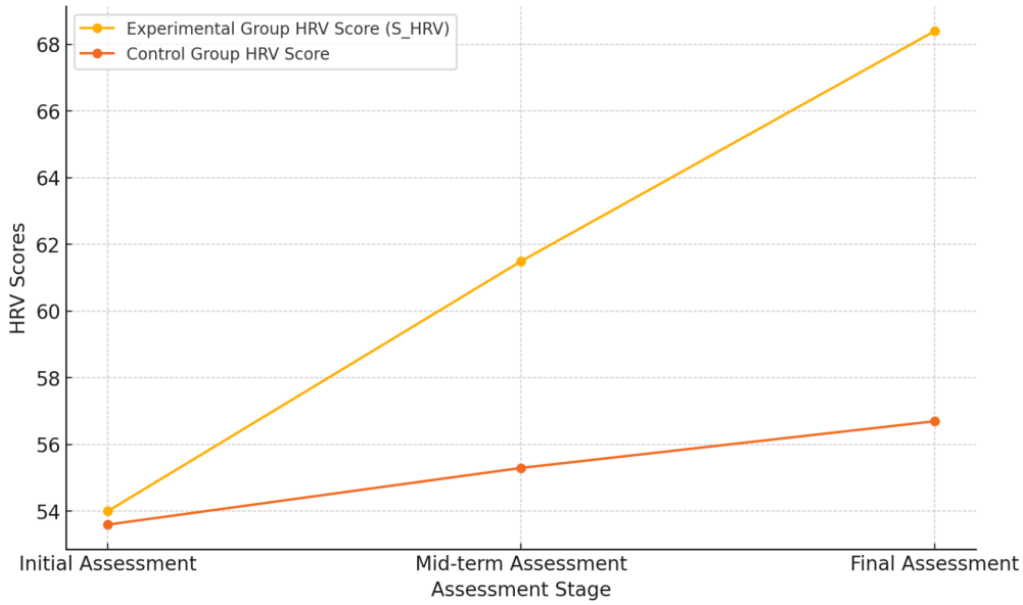


**Figure 2.** HRV scores of the experimental and control groups at different stages.

### 4.3. Analysis of psychological health index (GHQ-12 Scale)

The experimental results show that the multimodal intervention strategy significantly improved students' psychological health. According to GHQ-12 scale data, the psychological health score of students in the experimental group increased from an initial 60.0 to 73.3 by the end of the study, while the control group's score only increased from 58.3 to 65.0. The improvement in negative emotions, such as anxiety and depression, was significantly greater in the experimental group, indicating that the multimodal intervention strategy had a substantial effect on enhancing psychological health.

The improvement in psychological health can likely be attributed to the use of autonomy support, team interaction, and personalized feedback within the multimodal intervention. Specifically, students in the experimental group were able to choose their training content autonomously and received timely feedback from instructors, which enhanced their intrinsic motivation and engagement. The teamwork and interaction inherent in volleyball training strengthened students' sense of belonging, further alleviating feelings of anxiety and depression. The limited

improvement in the control group's psychological health score suggests that conventional teaching methods are less effective in managing emotions and providing psychological support compared to the multimodal intervention. The results demonstrate that the multimodal intervention strategy meets students' basic psychological needs during activities, helping to establish a healthier psychological state in physical education. **Table 4** shows the psychological health scores of the experimental and control groups at different assessment stages.

**Table 4.** Psychological health scores of the experimental and control groups at different stages.

| Stage | Experimental Group GHQ-12 Score | Experimental Group Psychological Health Scores psychological | Control Group GHQ-12 Score | Control Group Psychological Health Score |
|---|---|---|---|---|
| Initial Assessment | 31 | 60 | 32 | 58.3 |
| Mid-term Assessment | 27 | 66.7 | 30 | 61.7 |
| Final Assessment | 24 | 73.3 | 28 | 65 |

Reliability analysis: the stability of retest reliability assessment scale at different time points. Pearson correlation coefficient will be used to calculate the correlation between the scores of the experimental group and the control group at different stages, as shown in Equation (7).

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}} \tag{7}$$

Among them, $X_i$ and $Y_i$ are the scores of the experimental group and the control group in different evaluation stages. $\bar{X}$ and $\bar{Y}$are the average of each group's scores.

Pearson correlation coefficient between GHQ-12 score and mental health score in experimental group is −0.997, which indicates that there is a very strong negative correlation between GHQ-12 score and mental health score in experimental group. In other words, with the decrease of GHQ-12 score, the mental health score increased significantly. From the perspective of retest reliability, there is a strong negative correlation between GHQ-12 score and mental health score, which indicates that the scale can effectively measure mental health status.

Pearson correlation coefficient between GHQ-12 score and mental health score in the control group is −0.999, which also indicates a very strong negative correlation, almost completely negative correlation. This negative correlation shows that the higher the GHQ-12 score in these two groups (indicating the more serious psychological distress), the lower the mental health score. Conversely, the lower the GHQ-12 score, the higher the mental health score.

Validity analysis:

Content validity: GHQ-12 scale covers many aspects of mental health (anxiety, depression, insomnia, etc.), so it has good content validity.

Structural validity: There is a significant negative correlation between GHQ-12 score and mental health score, which shows that the scale has good structural validity in distinguishing mental distress from mental health status.

As shown in **Figure 3**, Psychological Health Scores of the Experimental and Control Groups at Different Stages.

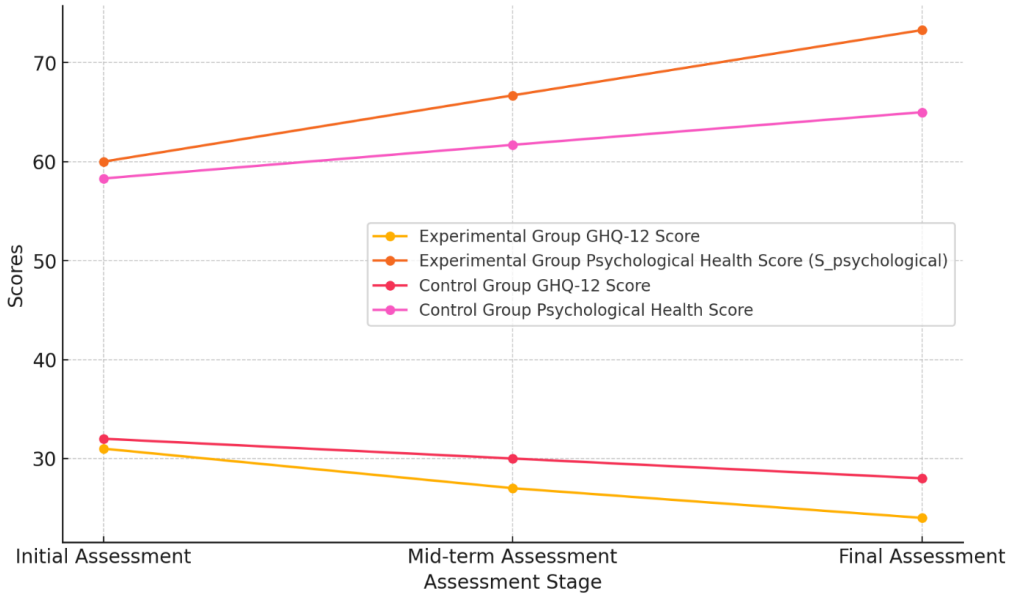


**Figure 3.** Psychological health scores of the experimental and control groups at different stages.

### 4.4. Evaluation of volleyball skill proficiency

**Table 5** shows the skill proficiency scores of the experimental and control groups.

**Table 5.** Skill proficiency scores of the experimental and control groups.

| Stage | Experimental Group Technical Score $S_{technical}$ | Control Group Technical Score |
|---|---|---|
| Initial Assessment | 48.7 | 47.5 |
| Mid-term Assessment | 61.3 | 53 |
| Final Assessment | 72.8 | 56.4 |

The experimental results show that the multi-modal intervention strategy has significantly improved students' proficiency in volleyball skills, especially in basic skills such as passing, spiking and blocking, and the progress of the experimental group is significantly higher than that of the control group. The technical score of the experimental group reached 72.8 in the final evaluation, while that of the control group was only 56.4. This gap shows that volleyball teaching under the multi-modal intervention strategy can effectively promote the improvement of students' skill level.

The improvement of technical proficiency is mainly attributed to hierarchical teaching and personalized feedback mechanism. Hierarchical teaching enables students to steadily improve their skills under the training intensity that conforms to their own ability level, and avoids the common problems of high intensity or low challenge in skill training. Real-time feedback mechanism plays a key role in the process of technical upgrading, helping students adjust and optimize technical actions in time, thus significantly improving technical proficiency. Although the control group has made some progress under the conventional teaching, the speed

and degree of progress are far less than that of the experimental group, which shows the importance of personalized teaching design.

When evaluating the technical performance of volleyball, the main concerns at present are passing, spiking and blocking. However, in order to assess students' volleyball technical ability more comprehensively, it is suggested to consider adding other technical dimensions such as serving and receiving. Through all-round technical examination, students' comprehensive technical level in volleyball can be evaluated more accurately. As shown in **Figure 4**, Skill Proficiency Scores of the Experimental and Control Groups.

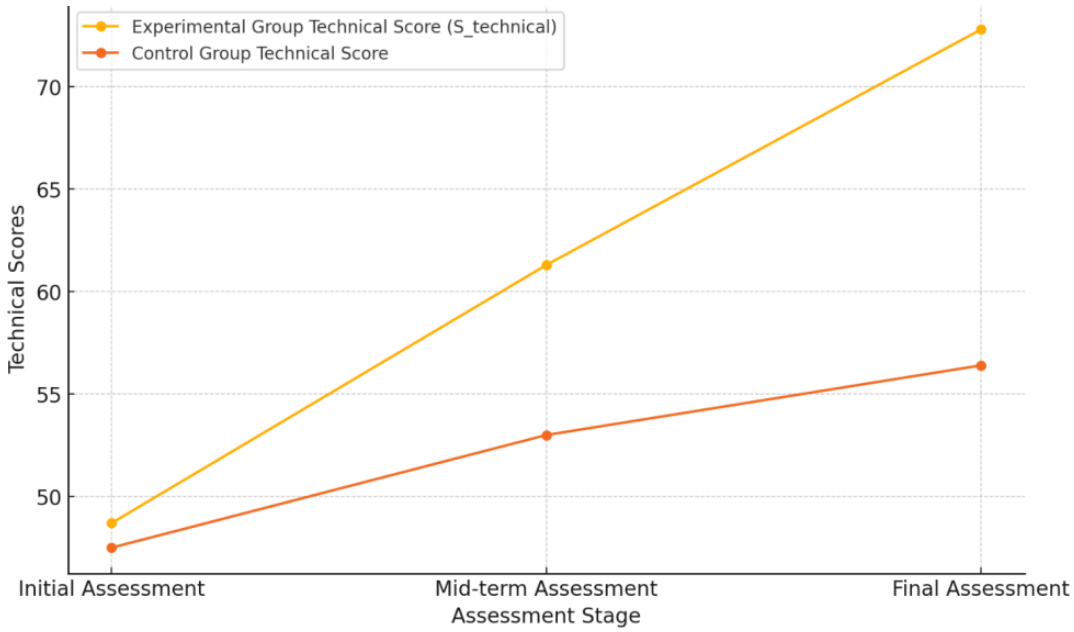


**Figure 4.** Skill proficiency scores of the experimental and control groups.

### 4.5. Analysis of self-efficacy indicators

**Table 6** shows the self-efficacy scores of the experimental and control groups at each assessment stage.

**Table 6.** Self-efficacy scores of the experimental and control groups at each stage.

| Stage | Experimental Group Self-Efficacy Score | Control Group Self-Efficacy Score |
|---|---|---|
| Initial Assessment | 49.2 | 48.7 |
| Mid-term Assessment | 63.5 | 52.1 |
| Final Assessment | 74.6 | 55.8 |

Self-efficacy is a key indicator of students' confidence and initiative in volleyball instruction. The experimental results show that the self-efficacy score of the experimental group significantly increased from an initial 49.2 to 74.6 by the end, which was much higher than the control group's final score of 55.8. This indicates that the multimodal intervention strategy has a significant positive impact on students' confidence and self-efficacy.

The increase in self-efficacy is attributed to the self-reflection and personalized feedback mechanisms within the multimodal intervention strategy. Students in the

experimental group engaged in self-reflection at the end of each session, which helped them internalize their achievements in learning volleyball and gradually build confidence. This self-reflection and feedback mechanism allowed students to develop a positive perception of their abilities, enhancing their ability to face challenges. During the intervention, students in the experimental group also experienced team collaboration, personalized tiered instruction, and autonomy support, further enhancing their sense of accomplishment and belonging. The smaller improvement in the control group's self-efficacy score suggests that conventional teaching is less effective in fostering confidence compared to the multimodal intervention. As shown in **Figure 5**, Self-Efficacy Scores of the Experimental and Control Groups at Each Stage.


**Figure 5.** Self-efficacy scores of the experimental and control groups at each stage.

## 5. Discussion and analysis

### 5.1. Impact of college volleyball teaching on students' physical health

The results of this study show that college volleyball teaching based on multimodal evaluation has a significant role in promoting students' health. Through the 16-week multi-modal intervention strategy, the physical quality indexes of the students in the experimental group, including core physiological parameters such as heart rate, body fat rate and vital capacity, have been significantly improved, which shows that volleyball teaching can effectively improve the cardiovascular function, body fat control and respiratory system ability of college students. At the end of the experiment, the students' physical health scores in the experimental group were significantly higher than those in the control group, which showed the practical effect of multimodal intervention strategy. With the support of stratified teaching and real-time feedback, the experimental group can control the intensity appropriately according to individual ability and physical condition, so as to maximize the exercise

effect and avoid the problems of excessive fatigue or physical injury that may occur in conventional teaching.

Compared with the control group, the improvement of key health indicators such as heart rate, body fat rate and vital capacity in the experimental group is more significant, which further verifies the scientific nature of the multi-modal intervention strategy. Multi-modal intervention strategy not only provides personalized training intensity selection, but also helps students adjust their sports state in time through dynamic data feedback, which improves students' sports efficiency and effect. The improvement of physical fitness in the control group is relatively limited, indicating that the effect of conventional teaching in improving physical health is relatively limited. This discovery supports the advantages of volleyball teaching supported by multimodal evaluation in students' physical health, and shows that multimodal teaching method can be a powerful supplement to traditional physical education, thus promoting students' physical quality more effectively, and providing scientific basis for the design and implementation of volleyball teaching in colleges and universities. This study also has some limitations. The effects of exercise intensity and training time during the experiment on students' health may also be different due to individual differences.

## 5.2. Impact of college volleyball teaching on students' mental health

The experimental data show that volleyball teaching based on multimodal intervention has a significant positive effect on college students' mental health, especially in relieving anxiety and improving depression. The data of GHQ-12 scale shows that the students in the experimental group have significantly improved their mental health scores, from the initial 60.0 to 73.3, which is obviously better than that in the control group. This remarkable improvement is attributed to the design factors such as emotional support, autonomy promotion and teamwork in multimodal intervention strategies. Students in the experimental group have gained some autonomy in the teaching process, for example, they can adjust the intensity and rhythm of training according to their personal needs and emotional state. Teamwork in volleyball enhances students' sense of belonging and social support, relieves personal psychological pressure, reduces loneliness and promotes positive emotional transformation to some extent.

In contrast, the improvement of the mental health score of the control group is limited, which indicates that the conventional teaching lacks systematic psychological support and it is difficult to effectively cope with the psychological fluctuation and emotional pressure of students in sports. It is found that multimodal intervention strategy not only helps students find psychological satisfaction and emotional support in sports, but also further reduces their psychological pressure through personalized feedback mechanism.

The limitation of this study is that the study only focuses on the 16-week dry expectation and fails to explore the long-term effect. Future research can further observe the lasting influence of multimodal intervention strategies on students' mental health, and consider interdisciplinary methods, combining the knowledge of

psychology and sports science, and deeply study the interactive relationship between personalized feedback and mental health.

### 5.3. Effectiveness analysis of the multimodal assessment method

The multi-modal evaluation method in this study shows remarkable effect in detecting and analyzing students' physical fitness, mental health and sports skills, and provides scientific basis for precise intervention and personalized teaching. By integrating multi-dimensional data such as heart rate, body fat rate, HRV and GHQ-12, the multi-modal evaluation system can comprehensively track students' physical and mental state, and provide a basis for real-time adjustment of teaching intensity and personalized feedback. The experimental data show that the experimental group with multimodal evaluation is significantly higher than the control group in all indicators, especially in emotional management, technical proficiency and self-efficacy.

In volleyball teaching, it is very important to control the intensity of exercise. Monitoring students' physiological state in real time through multimodal assessment can prevent fatigue or potential injury caused by excessive exercise and ensure the safety of teaching process. The experimental results show that the multi-modal evaluation teaching mode is obviously superior to the traditional teaching method in students' participation and sports performance, which further verifies its practical application value in college physical education teaching.

Although the multi-modal assessment method shows remarkable effect in this study, students' sports habits, psychological state and educational needs may be different under different cultural backgrounds. In collectivism culture, the design of teamwork task may be more conducive to students' mental health and technical learning, while in culture that emphasizes personalized learning, it may be more effective to add personalized feedback and independent choice. Besides volleyball, this method can also be extended to basketball, football and other team sports. By adjusting the multi-modal evaluation strategy according to the characteristics of different events and the needs of students, students' physical health, psychological quality and technical ability can be improved, so as to better promote the overall effect of physical education.

### 5.4. Practical effectiveness of the intervention strategy

Multi-modal intervention strategy has achieved remarkable results in improving students' physical fitness, mental health, technical proficiency and self-efficacy, which provides empirical support for the effectiveness of volleyball teaching in colleges and universities. The experimental data show that the experimental group is significantly better than the control group in all indicators, especially in physical health and mental health. After 16 weeks, the physical health score of the experimental group increased by 22.3%, and the mental health score increased by 21.5%, which was much higher than that of the control group. Hierarchical teaching enables students to receive training at an intensity suitable for their physical level, which avoids the risk of fatigue and injury caused by improper intensity and ensures the safety and participation of students.

Factors such as teamwork and independent choice in intervention strategies play a key role in improving students' psychological resilience and self-efficacy. Through team interaction, students gain a higher sense of belonging and support in the classroom, and gradually build up confidence in facing challenges. In contrast, the self-efficacy of the control group was improved slightly, indicating that the traditional teaching methods have some limitations in confidence training. With the support of intervention strategies, the students in the experimental group not only significantly improved their sports skills, but also substantially improved their emotional management, stress resistance and self-confidence.

In view of the popularity of volleyball in the world, the results of this study show the potential of intervention strategies in improving students' physical and mental health. Students from different cultural backgrounds may have different educational needs and psychological characteristics. It is suggested that when this intervention strategy is applied to other cultural backgrounds, it should be adjusted according to the local cultural characteristics. In some cultures, students may pay more attention to collectivism and teamwork, while in other cultures, students may be more inclined to personal achievement and self-challenge. According to these cultural differences, we can adjust the proportion of teamwork or the degree of independent choice to ensure that the intervention strategy can be widely applied in the world and maximize its effect.

## 6. Conclusions

This study empirically validates the positive impact of volleyball teaching, supported by multimodal assessment, on the physical and mental health of college students. The results indicate that the multimodal intervention strategy significantly enhances students' physical fitness, mental health, technical proficiency, and self-efficacy. Health indicators such as heart rate, body fat percentage, and lung capacity in the experimental group showed notable improvement, outperforming the control group. Additionally, significant improvements in GHQ-12 mental health scores and HRV in the experimental group suggest that volleyball teaching positively influences emotional regulation and stress management. Real-time feedback and personalized intervention strategies helped the experimental group achieve substantial progress in skill mastery and confidence. The study demonstrates that multimodal intervention strategies not only improve students' physical and mental health but also optimize the effectiveness of physical education courses, providing scientific support for college physical education reform and contributing to the comprehensive development and health literacy of students.

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