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Impact of Badminton Training on Adolescents' Social and Emotional Regulation Ability

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Abstract: *Given the challenges of long cycles, inconsistent results, and a lack of sustainability in school-based psychological interventions and emotion regulation methods, which make them ineffective in alleviating anxiety and depression experienced by adolescents during social interactions, this study introduces physical exercise, specifically badminton training, as an intervention for emotion regulation and social adaptation, exploring the role of exercise intervention in improving adolescent mental health. Data are collected from a sample of adolescents using a questionnaire-based and experimental design. Structural equation modeling (SEM) is used to examine the impact of physical exercise on adolescents' emotion regulation efficacy, social interaction skills, and subjective well-being, focusing on the mediating effects of self-efficacy and emotion regulation strategies. The experimental intervention involves a moderate-intensity exercise program, primarily based on badminton, designed to maintain a heart rate between 120 and 150 beats per minute. Physical examinations, heart rate monitoring, warm-up and stretching, and social and psychological assessments are also implemented to ensure safety and scientific research. Reliability and validity tests and model fit analysis are conducted using AMOS 24.0 software to assess the rationality of the research instrument and structural model. Through "emotion controlling efficacy → emotion suppression mechanisms → mental health" (β = 0.15, 95% CI = [0.09, 0.21]), the experimental results demonstrate that physical exercise also has a noticeable chain mediation effect. This implies that the association between physical exercise and mental health was mediated by psychological regulation techniques as well as the effectiveness of emotion regulation.*

Keywords: *Adolescent Mental Health; Physical Exercise; Badminton Training; Emotion Regulation; Self-Efficacy*

1. Introduction

Adolescent mental health issues are receiving increasing attention from all sectors of society. In particular, under the multiple influences of academic pressure, social environment, and family expectations, adolescents are prone to anxiety, depression, and difficulty regulating emotions. Emotional regulation, as a core psychological mechanism for individuals to cope with stress and social situations, not only affects adolescents' mental health but also has a profound impact on their social skills, academic performance, and overall well-being. According to earlier research, adaptive emotion regulation is strongly associated with academic engagement, social-emotional abilities, and mental health. It also has a good correlation with cognitive empathy, affective empathy, and sympathy. Furthermore, physical exercise, as an effective behavioral intervention, not only improves physical fitness and enhances cardiopulmonary function but may also indirectly improve mental health by enhancing emotional regulation efficacy and strategies. The processes via which physical exercise influences teenage emotion control and mental health, however, have not been thoroughly examined in the literature, which has primarily concentrated on single groups or particular circumstances.

Based on this, this study aims to explore the impact of physical exercise on adolescents' emotion regulation ability, collaborative communication ability and mental health, and analyze the mediating role of emotion regulation efficacy and strategy through structural equation modeling, so as to provide theoretical basis and empirical support for adolescent mental health intervention and school sports practice.

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2. Related Work

Over the past ten years, a growing amount of study has focused on the critical role that emotion regulation plays in an individual's emotional and social development, cognitive performance, and emotional well-being. From many angles, pertinent empirical research has demonstrated the connection between emotion control and social adaption, academic achievement, and mental health.

Salazar Kaempf et al. investigated the connection between social emotion, emotion control, and cognition. They discovered a favorable correlation between adaptive emotion management and empathy for thinking, affective empathy, and sympathy based on the study of 58 datasets and 549 effect sizes [1]. Eriksen and Bru explored the relationship between social-emotional abilities (emotion regulation, interpersonal skills and learning planning) and emotional health and academic participation (behavior and emotion). The findings demonstrated a strong link between emotional wellness and emotion management [2]. Hansen Sandseter et al. looked into the three socioeconomic aspects of children's risky games: mental health and emotion regulation, social function and challenging routines, and physical well-being and development. The stimulating emotions stimulated by risky games help children grow in a psychosocial environment and prepare for the challenges of future adult life [3]. Li et al. investigated how difficulties and social regulation differed between collaborative debate teams that performed well and those who did not. The study found that the low-performing group encountered more challenges, especially social-emotional challenges, and when solving challenges, the low-performing group relied more on cognitive and social-emotional regulation, but lacked effective motivational regulation strategies [4]. Mousoulidou et al. explored the impact of news headlines on individual emotions and well-being. The study found that regardless of the emotional tendency of the headlines, participants had strong negative emotions when reading the headlines. Emotional regulation failed to significantly affect emotional state, but resilience played an important role [5]. Restrepo et al. investigated whether perceived social support and cognitive emotion management techniques mediated the effects of stress on college life adaptation. According to the study, stress was reduced by using constructive cognitive emotion management techniques like reappraisal and attention [6]. After adjusting for age, gender, and race, Giordano et al. investigated how emotion regulation can predict the degree of social media addiction and online gaming disorder. According to the study, both behavioral addictions were strongly predicted by gender and emotion regulation, with minor to moderate impacts [7]. Boyes et al. investigated if social support moderates the associations between family functioning and nonsuicidal self-injury (NSSI) and if emotion management issues mediate these correlations. The findings demonstrated a strong correlation between NSSI history and poor family functioning, as well as a positive correlation between NSSI history and the frequency of NSSI during the previous 12 months and emotion control issues [8]. Sethi and Jain thoroughly examined AI technologies such as bots for conversation, augmented realities, gamification, sentiment detection tools, and wearable technology to see how well they can enhance social and emotional education. The study found that AI technology can provide personalized support, increase participation, promote empathy development, and improve well-being [9]. Almeida et al. investigated the connection between negative mental state management (e.g., worry and rumination), pre-sleep thinking and arousal, social media use at bedtime, the state of sleep, and Fear of Missing Out (FoMO).According to the study, worry and FOMO can impact sleep quality by raising cognitive arousal and encouraging the use of social media at night, which could be a coping mechanism for negative cognitive states [10]. Fombouchet et al. pointed out that emotional, cognitive, and social changes during adolescence play a central role in the development of emotion regulation [11]. Although a large number of studies have explored the relationship between emotion regulation and social emotion, cognition, and mental health, most existing studies focus on specific groups or single situations, lacking a systematic and mechanistic analysis of the effects of behavioral interventions such as physical exercise on adolescent emotion regulation and mental health.

3. Method

3.1 The Relationship between Social Anxiety and Subjective Well-Being in Adolescents

Adolescents' social anxiety and subjective well-being have a significant mediating effect. This may be because, under social tension or stress, adolescents often develop irrational beliefs, believing they lack the ability to cope with current negative emotional events. This leads to increased negative emotions and decreased positive emotions, which in turn reduces their positive emotional self-efficacy.People who struggle with controlling themselves feel less happy and more negative emotions, which impacts their internal state of happiness. One important mediating factor between

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college students' subjective state of mind and anxiety regarding social situations is their low sense of emotional self-worth. This may be because adolescents with higher negative emotional self-efficacy tend to have better emotional control, cope with stress, and face challenges with courage. Conversely, when they are able to effectively cope with negative emotions, they experience fewer negative emotions and more positive emotions, thus experiencing greater joy in life, which improves their subjective well-being.

3.2 The Role of Badminton in the Psychological and Physical Health of Adolescents

Badminton is a form of exercise that benefits both physical and mental health. Playing badminton can enhance young people's cardiopulmonary function and comprehensively develop their cardiac endurance. As the intensity of badminton increases, cardiopulmonary endurance and stamina improve to accommodate the rapid physical exertion, thereby enhancing a young person's physical fitness. Furthermore, the constant attention paid to the ball's direction, landing point, and speed can reduce eye fatigue and prevent vision loss. Regular badminton play can also enhance young people's interpersonal relationships. Furthermore, badminton competitions can strengthen young people's psychological resilience and improve their ability to cope with stress, significantly benefiting their mental health. Finally, consistent badminton play can significantly improve a young person's physical development. The constant running, jumping, and stretching involved in playing badminton significantly enhances a young person's physical form.

3.3 Current Status and Research Project Design of Badminton Training

Badminton is a comprehensive sport that enhances physical fitness, prevents and treats illnesses, and regulates both the mind and body. Currently, there is limited research, both domestically and internationally, on the effects of moderate-intensity badminton training on heart rate and mood in adolescents. Therefore, building on previous research, this project aims to explore the effects of moderate physical exercise on heart rate and mental state in youth, both theoretically and experimentally, and to identify patterns within these exercises, thereby laying a solid foundation for the future development of badminton. Moderate exercise is defined as stimulating the body and maintaining a heart rate between 120 and 150 beats per minute. Heart rate (HR) refers to the number of heartbeats per unit time; mood refers to a person's emotional state over an extended period, which can be monitored and regulated along with other mental activities and behaviors.

3.4 Considerations for School Sports in Alleviating Anxiety and Depression in Adolescents

First, a complete physical examination should be performed before participating in physical activity. Cardiovascular stress testing should be performed on individuals with a genetic predisposition or cardiovascular impairment, using maximum heart rate and maximum oxygen consumption as indicators for regulation. Furthermore, participants can be taught self-monitoring methods, such as heart rate monitoring and abnormality detection, so that they can stop immediately if they feel unwell, ensuring the safety of their exercise.

Second, it must exercise at a level of difficulty that ranges from 50% to 80% of your maximal heart rate. From the perspective of physical fatigue, increasing the frequency of physical exercise is effective in preventing and treating anxiety, depression, and other emotions. At the same time, it's important to plan your exercise schedule appropriately to prevent boredom caused by a single exercise method. Individuals should ensure a thorough warm-up and stretching routine during exercise, while also incorporating verbal guidance to create a platform for both body and mind to vent.

Third, it conducts psychosocial assessments. Researchers use questions from the relevant dimensions of the self-rating depression scale and peer-rating depression scales, adjusting exercise patterns appropriately based on students' physical activity and emotional well-being.

Fourth, it emphasizes value-added assessments; uses students' growth and changes as evaluation criteria, creates a relaxed and self-disciplined exercise environment, and encourages students to actively and consistently exercise.

Finally, it emphasizes the organic integration of group and individual development, prioritizing the integrated growth of mental and physical health.

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3.5 Emotional Regulation Self-Efficacy and the Promoting Role of School Physical Education

Self-efficacy in regulating emotions is a level of confidence in effectively regulating one's own emotional state. It includes the ability to recognize one's own emotions, the ability to understand one's feelings towards others, and the ability to control positive and negative emotions.

Physical exercise in school can improve students' psychological qualities, develop their emotions, cultivate their personalities, and enhance their self-confidence. School sports activities help college students rationally regulate their emotions, improve their emotional self-control, cultivate social emotions, and avoid emotional outbursts caused by excessive mood swings. School sports can help students channel their negative emotions through appropriate means, adjust their mindsets, and achieve a harmonious state of mind while maintaining a positive and optimistic outlook, thereby reducing physical and mental stress and preventing and alleviating certain psychological problems. Modern medical, psychological, and physiological research has shown that emotions have a direct impact on a person's physical and mental health and development, playing a significant role in their studies, work, and daily lives. They are a crucial factor in measuring a person's mental health.

4. Results and Discussion

4.1 Questionnaire Survey Method

A total of 100 questionnaires are randomly distributed, serving as preliminary data for the revision of this study's measurement tools. Reliability and validity tests are conducted on these preliminary data. Subsequently, formal measurements are conducted on a random sample of adolescents using the Physical Activity Level Scale, School Belonging Scale, Self-Efficacy Scale, and Emotion Regulation and Collaboration and Interpersonal Skills Scale. The data collected include information on the adolescents' physical activity levels, school belonging, self-efficacy, and current levels of emotional regulation, collaboration, and interpersonal skills. This provides raw data for modeling and analysis to explore the impact of perceived school belonging and self-efficacy on emotional regulation, collaboration, and interpersonal skills during adolescent physical activity.

This study targets students from three regular middle schools in a certain city. A total of 350 questionnaires are distributed, of which 322 are valid, yielding a validity rate of 92%. The sample consists of 166 males (51.6%) and 156 females (48.4%). The age range is 12 to 20 years, with a mean age of 15 years (SD = 2.1).

To ensure the representativeness of the sample, the research subjects cover high school and junior high school students with different levels of exercise habits (regular participation, occasional participation, and basically no physical exercise) and different sports preferences (badminton, basketball, running, etc.).

4.2 Confirmatory Analysis of the Mechanisms of Physical Exercise in Improving Mental Health

4.2.1 Structural Model Construction

Based on the theoretical analysis of the mechanism by which physical exercise promotes mental health, a holistic structural model is established with "physical exercise" as the independent variable, "emotional regulation efficacy" and "emotional regulation strategies" as mediating variables, and "mental health" as the dependent variable. Among them, "emotional regulation efficacy" is an intermediate variable that affects the effectiveness of "emotional regulation strategies."

4.2.2 Quality Inspection and Analysis of Structural Models

Confirmatory factor analysis (CFA) is performed on a measurement framework prior to structural equation model (SEM) analysis in order to examine the connection between every potential variable and the variables that have been measured.

To evaluate the validity of the scales employed in this research, internal consistency analyses are conducted on each scale. According to the findings, the Physical Activity Level Scale's Cronbach's α is 0.81, the Cronbach’s α for the School Belonging Scale is 0.84, the Cronbach’s α for the Self-Efficacy Scale is 0.89, and the Cronbach’s α for the Emotion Regulation and Collaborative Communication Scale is 0.78. All scales had Cronbach's α values greater than 0.70, indicating that each scale had good internal consistency and could reliably reflect the subjects' performance in physical activity, school

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belonging, self-efficacy, emotional regulation, and collaborative communication skills, as shown in Figure 1. In summary, these scales provided a reliable data foundation for subsequent structural equation model analysis and mediation effect testing.

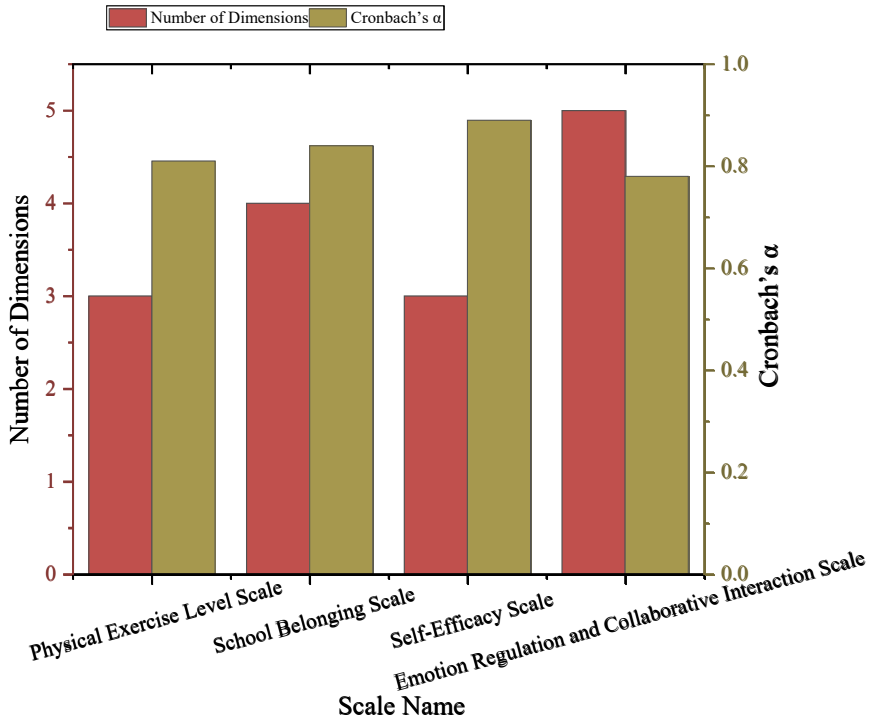

Figure 1 Internal consistency reliability test results of each scale (Sample Size (N) = 322)

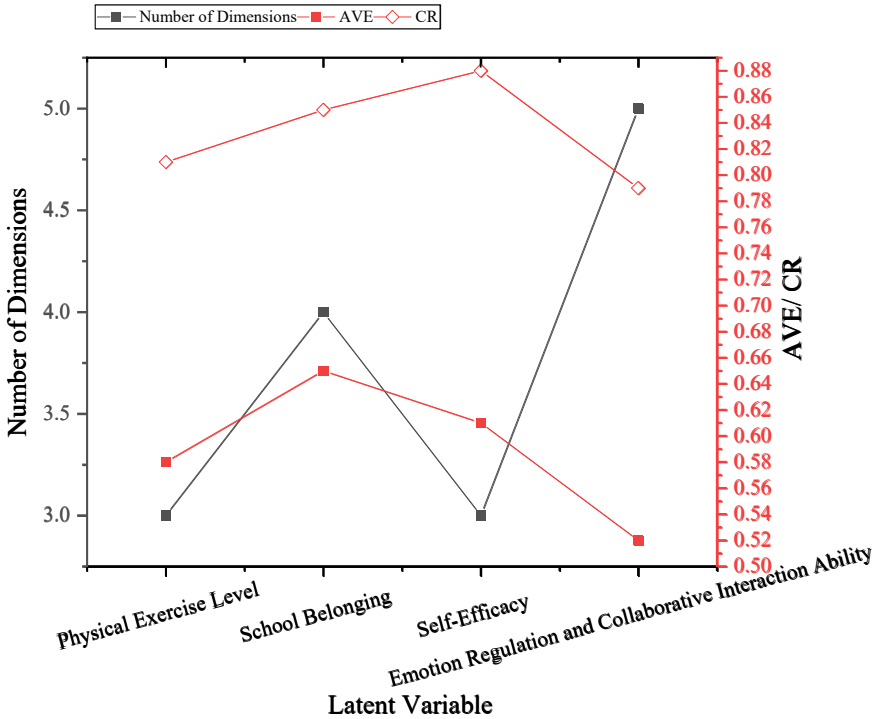

Figure 2 Results of convergent validity tests for each latent variable

To further verify the measurement validity of each latent variable, convergent validity tests are conducted. The results in Figure 2 show that the average variance extracted (AVE) for physical exercise level is 0.58, with a composite reliability (CR) of 0.81. Each latent variable being examined has high convergent validity and accuratelydepicts the underlying construct being assessed, as evidenced by the AVE andCR being greater than 0.50 and 0.70, respectively. This provides a solidquantitative basis for further structural equations modeling investigation.

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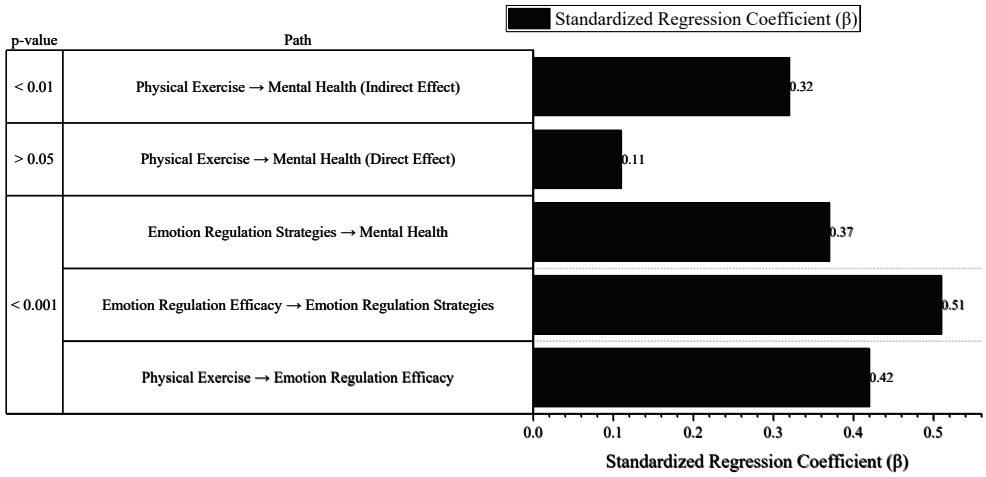

Figure 3 Path analysis results

The structural analysis structure's path analysis in Figure 3 shows that exercisesignificantly increases adolescence' efficacy in emotion control ($\beta = 0.42$, $p < 0.001$), suggesting that training might successfully improve adolescents' capacityfor emotion regulation. Emotion regulation efficacy significantly impacts emotion regulation strategies ($\beta = 0.51$, $p < 0.001$), indicating that adolescents with higher emotion regulation abilities are more likely to adopt effective emotion regulation strategies. Emotion regulation strategies also have a significant positive impact on mental health ($\beta = 0.37$, $p < 0.001$), indicating that appropriate emotion regulation strategies can significantly improve adolescents' mental health. Notably, while the direct effect of physical exercise on mental health is not significant ($\beta = 0.11$, $p > 0.05$), its indirect effect through the "emotion regulation efficacy → emotion regulation strategies" cascade is significant ($\beta = 0.32$, $p < 0.01$), indicating that the impact of physical exercise on mental health is primarily indirect, rather than direct, through mediating variables.

Table 1 Mediation effect test results (Bootstrap 5000 sampling)

Path	Indirect Effect (β)	95% Confidence Interval (CI)	Significance
Physical Exercise → Emotion Regulation Efficacy → Mental Health	0.21	[0.14, 0.29]	Significant Indirect Effect
Physical Exercise → Emotion Regulation Efficacy → Emotion Regulation Strategies → Mental Health	0.15	[0.09, 0.21]	Significant Chain Mediation Effect

The mediating role of exercise on mental health is investigated using bootstrap analysis (with 5000 replicates). The findings demonstrate that physical exercise has a significant indirect impact on mental health through emotion regulation efficacy ($\beta = 0.21$, 95% CI = [0.14, 0.29]), suggesting that emotion regulation efficacy is a key mediating factor in the association between mental health and physical exercise. The relationship between emotion regulation efficacy → emotion regulation strategies → mental health also shows a significant chain mediation effect of physical exercise ($\beta = 0.15$, 95% CI = [0.09, 0.21]), suggesting that both emotion regulation performance and emotion regulation strategies work together to mediate the effect of cardiovascular athletic activity on mental health. In summary, physical exercise effectively improves adolescents' mental health by enhancing their emotion regulation abilities and strategies, while its direct effect is not significant, further confirming the key role of the mediating mechanism (as shown in Table 1).

5. Conclusion

This study systematically explores the mechanisms by which physical exercise influences adolescents' emotion regulation, collaborative communication skills, and mental health through questionnaire surveys and structural equation modeling. The results show that physical exercise significantly improves adolescents' emotion regulation efficacy and indirectly promotes mental health through the effectiveness of emotion management techniques and its chain mediation. Furthermore, the direct effect of physical exercise on mental health is not significant, suggesting that its effects are primarily mediated through emotion regulation-related mechanisms. The scale's reliability, convergence validity, and discrimination validity were also confirmed by the experimental study, and the overall

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structure-function fit is good, offering empirical support for the idea that physical exercise and adolescent emotional health are related. However, this study has limitations: the sample is primarily concentrated in a single region, which may affect the generalizability of the results; and the cross-sectional design does not fully reveal causal relationships. Future research could consider expanding the sample size, adopting longitudinal designs, and further exploring the differential effects of different types of physical activity on improving adolescents' emotion regulation and mental health.

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