THE EFFECT OF BADMINTON TRAINING ON SPORTS PERFORMANCE, BODY FAT, AND SELF-CONFIDENCE IN OBESE STUDENTS

CHEN HAO

Graduate School Srinakharinwirot University

2024

ผลของการฝึกแบดมินตันที่มีต่อสมรรถนะทางกีฬา ไขมันในร่างกาย และความมั่นใจในตนเอง ในกลุ่มนักเรียนอ้วน

CHEN HAO

ปริญญานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
วิทยาศาสตรมหาบัณฑิต สาขาวิชาวิทยาศาสตร์การกีฬาและการออกกำลังกาย
คณะพลศึกษา มหาวิทยาลัยศรีนครินทรวิโรฒ
ปีการศึกษา 2567

THE EFFECT OF BADMINTON TRAINING ON SPORTS PERFORMANCE, BODY FAT, AND SELF-CONFIDENCE IN OBESE STUDENTS

CHEN HAO

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of MASTER OF SCIENCE

(Sport and Exercise Science)

Faculty of Physical Education, Srinakharinwirot University

2024

THE THESIS TITLED

THE EFFECT OF BADMINTON TRAINING ON SPORTS PERFORMANCE, BODY FAT, AND SELF-CONFIDENCE IN OBESE STUDENTS

BY

CHEN HAO

HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE
IN SPORT AND EXERCISE SCIENCE AT SRINAKHARINWIROT UNIVERSITY

.....

(Assoc. Prof. Dr. Chatchai Ekpanyaskul, MD.)
Dean of Graduate School

.....

ORAL DEFENSE COMMITTEE

..... Major-advisor
(Asst. Prof. Dr.Witid Mitranun)

..... Chair
(Assoc. Prof. Dr.Chaiyawat Namboonlue)

..... Committee
(Asst. Prof. Dr.Achariya Anek)

Title	THE EFFECT OF BADMINTON TRAINING ON SPORTS PERFORMANCE, BODY FAT, AND SELF-CONFIDENCE IN OBESE STUDENTS
Author	CHEN HAO
Degree	MASTER OF SCIENCE
Academic Year	2024
Thesis Advisor	Assistant Professor Dr. Witid Mitranun

This study aimed to explore the impact of badminton instruction and training on the agility and self-confidence of obese students. Using a combination of literature review, experimental methods, questionnaire surveys, and statistical analysis, 30 obese junior high school students from Rong County Middle School in Guangxi Province, China, who had no prior systematic sports experience or badminton training, were selected as participants. These students were randomly divided into an experimental group and a control group. The experimental group underwent a 12-week badminton training program in addition to regular physical education classes, while the control group only participated in the regular physical education curriculum. The results indicated significant improvements in the experimental group's strength-related physical tests, height, weight, and body composition ($P < 0.05$), while no significant changes were observed in the control group ($P > 0.05$). Moreover, the experimental group showed notable improvements in agility, as measured by the quadrant jump and T-test ($P < 0.05$), with post-intervention scores significantly higher than those of the control group. In addition, the experimental group exhibited a significant increase in self-confidence, with their scores on the self-confidence scale showing substantial improvement compared to the control group ($P < 0.05$). These findings suggest that badminton training significantly enhances both physical and psychological aspects in obese students, improving their agility and self-confidence. As a result, integrating badminton into physical education curricula may serve as an effective strategy to enhance overall physical fitness and combat obesity-related challenges in adolescents.

Keyword : Badminton Training, Obese Students, Agility, Self-confidence

ACKNOWLEDGEMENTS

Time flies, and my graduate journey is about to come to an end. As I type the final words of this thesis, my heart is filled with both reluctance and immense gratitude. The completion of this paper would not have been possible without the support and assistance of countless individuals, and I would like to express my deepest thanks here.

First and foremost, I would like to express my heartfelt gratitude to my supervisor, Assistant Professor Witid Mitranun. From the selection of the topic, to the conceptualization of the framework, and the meticulous revisions, you have invested tremendous effort in guiding me. Your rigorous academic attitude and profound expertise helped me find clarity during moments of confusion. Your patient guidance and selfless support have not only shaped this thesis into its present form but also taught me how to approach both academics and life with a sense of rigor and dedication.

I am also deeply grateful to all the teachers at the university. The knowledge imparted in the classroom has broadened my academic horizons, and the valuable feedback during the thesis review process has consistently challenged me to refine my thinking. My sincere thanks also go to the students who engaged in academic discussions with me. The collaborative work in the laboratory and the exchange of ideas during discussions have been a source of warmth and inspiration on my academic journey.

I would like to extend special thanks to my family and friends. During times of anxiety about my thesis, your understanding and encouragement gave me the strength to continue. When I felt weary and lost my motivation, your unwavering support helped me regain my focus and drive. Your companionship has been my most steadfast support throughout this process.

Finally, I would like to express my deepest appreciation to all those who have supported and helped me along the way. Your care and assistance mean the world to me!

CHEN HAO

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

Background

Obesity has become a major health problem globally, and the diseases of physical inactivity and ill health associated with it show a continuous upward trend (Liu Xueqin.2013). The results of physical health surveys in China show that the physical health status of adolescents is declining year by year, with obesity being one of the main causes of this phenomenon. Student obesity is a global epidemic and has far-reaching negative effects on the healthy development of adolescent (Li, 2024). Adolescent obesity is closely associated with many chronic diseases of adulthood (e.g., hypertension, diabetes), leading to a sharp increase in the morbidity and mortality rates of these diseases (Li, 2022).

Badminton, as a popular sport among secondary school students, plays an important role in enhancing physical fitness and promoting health (Dai Chuanqin.2018). Badminton is a comprehensive sport and occupies an important position in school physical education. However, at present, the overall physical health status of junior high school students in China is worrying, and effective physical education interventions have become the main way to improve this situation. The accuracy and reasonableness of the physical fitness assessment of junior high school students is crucial to the promotion of

students' health, and physical education interventions are especially important in addressing the problem of obesity and promoting the further development of school physical education (Huang, 2023).

However, due to external factors, the intensity and duration of physical education classes in Chinese schools are no longer sufficient to meet students' sporting needs (Jin, 2022). Many Chinese parents therefore choose to have their children participate in extracurricular sports camps after school, which not only helps them learn new sports skills, but also makes up for the lack of exercise in school sports activities. Junior high school students are at a critical stage of rapid physical growth, and their physical development is mainly influenced by their parents' genetics as well as environmental and educational factors (Cabello-Manrique et al., 2022). Physical exercise plays an important role in promoting the development of bones, muscle strengthening and cardiorespiratory function of junior high school students in the rapid growth period, which is conducive to their growth and development (Liu, 2017). At the same time, physical exercise can also improve physiological and psychological state, help students relax, cultivate sentiment, and maintain a healthy state of mind (Ouyang, 2021). In particular, group programmes help to cultivate the spirit of unity and cooperation, and in the process quickly master basic skills such as speed, reaction ability, strength, endurance, agility and flexibility. Moreover, there are relatively few studies on obesity related to badminton in China (Pei, 2020).

Based on the above background, this study aims to investigate the effects of badminton on agility and self-confidence of obese junior high school students from the perspectives of athletic training science and health, so as to provide a scientific basis for solving the problem of adolescent obesity.

Purpose of the study

To investigate the improvement and promotion effects of badminton training on the physical fitness, strength, agility, and psychological confidence of obese students.

Comparative investigate on the differences in physical fitness, strength, agility, and confidence improvement between obese students who participated in badminton training and those who did not participate in systematic badminton training.

The focus is on exploring the impact of badminton training on improving the agility and confidence of obese middle school students, and studying the chain effect path of "improving athletic ability, enhancing physical self-esteem, and increasing behavioral participation enthusiasm". Provide a basis for the coordinated intervention of physical and mental health in obese middle school students through badminton operation.

Significance of the study

Theoretical significance: This study aims to promote the theoretical development of the research on the effectiveness of badminton training on adolescent health. Through the analysis and summary of the existing badminton training related research, combined with the current quality education, health concepts and the current situation of social education in China, to explore more suitable for adolescents to enhance the physical and mental health of the effective methods, enrich the theoretical knowledge of badminton training on the health of adolescents, and then promote the further development of badminton training on the adolescent physical and mental health research.

Practical significance: This study addresses the effects of badminton training on the physical and mental health of adolescents, and explores the intrinsic connection between badminton sports and physical and mental health, starting from the relationship between the two. The results of the study provide effective data support for the promotion of badminton activities in society in the future, and at the same time provide guidance and reference for the research standards, training methods and paths of youth physical fitness and mental health, and other practical aspects.

CHAPTER2

LITERATURE REVIEW

This chapter draws upon a multitude of domestic and international research literatures concerning the impacts of badminton training on physical health and mental well-being. Studies have demonstrated that badminton training not only improves students' physical appearance, bodily functions, and various physical fitness indicators but also significantly enhances cardiopulmonary function, strength, flexibility, and other aspects. Moreover, badminton training can boost participants' self-confidence, aiding them in better confronting life's challenges and improving their mental health status. Despite extensive evidence affirming the positive effects of badminton on general student populations, there remains a dearth of in-depth analyses specifically targeting overweight or obese students. Focusing on this underrepresented group, namely overweight junior high school students, the present study designs a systematic badminton training program aimed at addressing this gap within existing research. Previous studies have provided substantial theoretical support for this investigation, laying a solid foundation for further exploration into the specific benefits of badminton training for this demographic. This research endeavors to contribute uniquely by highlighting the innovative and practical implications of badminton training for

enhancing both physical agility and self-confidence among overweight adolescents. The topic in this chapters as follows:

1. Drawing on domestic and foreign literature, this study analyzes the current situation of adolescent obesity and its negative impact on physical health and psychological status, emphasizing the necessity of exercise intervention;

2. Summarize the significant effects of badminton training on improving the physical and mental health of obese students through domestic and foreign research data, and explore its physiological and psychological mechanisms;

3. Analyze the current research status in China and abroad, explore research gaps and innovative directions, and draw on existing research theories to provide theoretical support for specialized research on obese adolescents.

1 Definition of Concept

1.1Definition and evaluation criteria of obesity and overweight

In daily life, public understanding of obesity and overweight primarily relies on observable indicators, such as whether body fat percentage exceeds the normal threshold. The Obesity Society (TOS) of the United States defines obesity as follows: Obesity is a chronic metabolic disorder, largely associated with environmental, psychological, genetic, and physical activity factors. Effectively addressing obesity is pivotal to mitigating its threat to human health. according to the World Health

Organization (WHO), obesity is characterized by an imbalance between energy intake and expenditure, resulting from excessive fat accumulation or abnormal distribution in the body. This condition typically arises from genetic predispositions and external environmental influences. Without timely intervention, obesity may severely compromise health and even endanger life (Ma, 2020).

The evaluation criteria for obesity and overweight: 1. Body Mass Index (BMI). It is a commonly used international indicator for assessing the degree of obesity, calculated as BMI=weight (kg)/height 2 (cm2). This formula is published by the World Health Organization and has been accurately calculated by domestic experts. According to Chinese standards, the MBI index ranges from 24-27.9 kg/m ^ 2 for overweight, ≥ 28 kg/m ^ 2 for obesity, and BMI<18.5 kg/m ^ 2 for emaciation. Professor Zhou Beifan of the Chinese Academy of Medical Sciences also gave the same standard in Popular Medicine. Based on the former's summary of China's population physique in the 1990s, he gave the most suitable weight scale for countrymen: 24kg/m2 or more is overweight, 28kg/m2 or more is obesity. The selection of experimental subjects in this article is based on this standard. 2. Waist to Hip Ratio (WHR), waist circumference: When the subject stands, their feet are naturally open 25-30 centimeters, and the midpoint of the line connecting the anterior superior spine and the lower edge of the twelfth rib is measured. The normal waist circumference is usually less than 85 centimeters for males and less than 80 centimeters for females; Waist to hip ratio: hip

circumference measures the circumference of the most prominent point of the pelvis around the hips. Compared to the hips, the waist is usually less than 0.9 for males and less than 0.85 for females (Tian, 2021).

1.2 Agility

Agility refers to the ability of athletes to adjust the position and direction of their body in space when conditions suddenly change. In competitive sports, agility occupies a central position and is closely linked to all athletic abilities. Therefore, from one perspective, the quality of agility constitutes the foundation of all professional skills. With the continuous progress of science and technology, people's attention to the issue of human sensitivity is also increasing, especially in the field of competitive sports. Agility represents a comprehensive ability that encompasses qualities such as speed, flexibility, and strength (Lu, 2022).

1.3 Self-confidence

Self-confidence is a complex and multidimensional psychological characteristic manifested by a person's evaluation of their own abilities and values through self-awareness. When scholars define the concept of self-confidence, they mainly define it from two dimensions: subjective feelings and personal self-worth. Self-confidence is a basic element that expresses a person's mental state and psychological qualities, a positive attitude expressed through self-evaluation, and recognition and understanding of one's own value. It is a subjective assessment of an individual's own

abilities, skills, and ability to cope with various environments in a reasonable manner. This kind of evaluation usually combines the level of self-ability and the quality of social evaluation. Some scholars believe that self-confidence is an indispensable part of self-esteem, showing an individual's positive or negative psychological state towards themselves, and demonstrating confidence in five dimensions of personal talent, identity, achievement, and value (Wu, 2022)

2 Current status of research in China

2.1Study on the effects of badminton training on physical fitness and health

In "A Study of the Effects of Badminton Training on the Physical Fitness of Secondary School Students," Chinese scholar Fu Qiang conducted a study on the first-year students of Beijing Dayu High School, selecting 60 physically fit students with no prolonged history of exercise and no badminton fundamentals to undergo badminton training for a period of 16 weeks. The results showed that badminton training had different degrees of positive effects on the students' physical form, physical function, as well as on a number of indicators such as strength, speed, endurance, sensitivity, flexibility, etc., and contributed to the students' overall physical fitness (Fu, 2015).

Yang Xiaodong mentioned in the Experimental Study on the Effect of Badminton Specialised Training on Physical Quality that badminton specialised quality training is an exercise method selected according to the characteristics of the sport and

combined with the technical movements of badminton, aiming to promote specialised physical qualities closely related to the level of badminton, so as to enable the participants to make better use of the techniques and tactics in the sport. Specialised exercises improve the playing condition by establishing, consolidating and perfecting the movement techniques, enhance the organism's ability, and develop all aspects of the body's qualities in a comprehensive and coordinated manner. Therefore, the mutual combined development of general physical qualities and specialised qualities can only lead to the improvement of athletes' technical level (Yang, 2008).

Zou Xiuzhu mentioned in "Research on the influence of specialised physical training and related qualities in badminton technical learning" that good strength qualities are indispensable for any sport, but the strength qualities required for badminton are not the greater the better. Strength exercises for badminton should focus on training the quality of strength as fast as possible in order to improve the relative strength of the players and increase the explosive power of the legs and arms. During training, static exercises should be used less or not at all, and power exercises should be used mainly, while taking into account the coordinated development of large and small muscle groups, so as to make the stirrups and straddle movements of the athletes in the competition more rapid. Badminton sports on the speed quality requirements and 100 metres track events similar to the project, whether it is on the athletes' reaction speed, action speed or displacement speed requirements are very high. Each time a

badminton player completes a move and starts the next move in a game, there is no regularity in the direction and interval time, and the combination of foot movement and hand striking action is also random. Every ball received by the player is a test of speed quality. The agility of badminton players is reflected in their ability to quickly orientate themselves in time and space, and their ability to coordinate their bodies to move quickly and precisely to complete their movements. Therefore, strength, speed and sensitivity are important for the learning of techniques in badminton teaching and training (Zou, 2014).

Li Yifan, in the article "The effect of badminton on the agility of high school students", conducted a 12-week badminton exercise by taking 80 students in the second year of the high school attached to the College of Fine Arts of Hebei Normal University as the research subjects, using the method of controlled experiment, to study the effect of the sport on the agility test indexes of high school students, and verified the validity and feasibility of the benign effect of the 12-week badminton exercise on the agility of the high school students. and feasibility, providing theoretical reference and guidance for high school students to participate in badminton exercise and improve physical fitness in the future (Y. F. Li, 2015).

In the article "The effect of badminton exercise on college students' body form and agility", Haixia Sha took students of the class of 2006 from Jilin University who were in good physical condition and had no history of prolonged exercise as the

research subjects, and uniformly tested the quality of the subjects before and after the exercise, which included cardiorespiratory function test, muscular strength test, flexibility test, and body composition test. The subjects participated in weekly badminton training sessions and twice weekly extracurricular activities for a period of 12 months. By comparing the data before and after the experiment, it was found that after 12 months of training, the subjects' muscular strength and endurance were significantly improved, and although there was little change in body morphology, there was a significant decrease in adiposity, and the lean body mass showed a significant upward trend. The conclusion shows that after 12 months of badminton training for college students has no significant effect on body morphology-related indexes, but it has a certain effect on the improvement of body composition and physical fitness, and the effect is different for different genders .

2.2 A study of the effects of badminton training on mental health

The research of Qu Xiaopei and Li Yixia shows that after participating in badminton training, in addition to enhancing physical fitness, it also improves college students' physical self-esteem ability. It enables college students to handle the pressure from life with ease, and also improves their positive psychological quality and self-confidence (Xue, 2016).

Li's research also shows that: badminton can not only bring strong body to the experimental subjects, through the victory of the game, but also improve self-

confidence, through the training and game communication, to obtain harmonious interpersonal relationships at the same time, but also to relieve psychological pressure, to create an optimistic psychological environment for students. Through long time badminton exercise, it can release the pressure on the body caused by work, relieve the physical and mental fatigue brought by daily life, and give relaxation to the brain in the state of long-term tension work. In addition, playing badminton for a long time can also improve the psychological quality, ease interpersonal relationships and improve communication with others (Y. X. Li, 2015).

Tao Shuai's study mentioned that the long-term badminton exercise for junior high school students has a very significant effect on shaping junior high school students' will quality and independent personality (Tao, 2016).

Wang Jiliang's study concluded that badminton can effectively regulate the mood of young people, is conducive to sharpening the willpower to enhance self-confidence, but also to improve the interpersonal skills of young people (J. L. Wang, 2017).

2.3 Research on the Impact of Obesity and Overweight on Middle School Students

Research has shown that weight gain in middle school students first affects systolic blood pressure. Compared to students with normal weight, overweight students have higher systolic blood pressure, while obese students have higher systolic and

diastolic blood pressure. This indicates that if middle school students continue to gain weight, the worsening effects of increased systolic and diastolic blood pressure may damage vascular elasticity and cause irreversible harm. In the study of blood biochemical indicators of obese middle school students. Gao (2024) a Chinese scholar, concluded that the levels of blood pressure, blood sugar and triglycerides of overweight and obese middle school students are generally higher than those of normal weight students, and the levels of high-density lipoprotein are generally low. Moreover, these changes caused by overweight and obesity will greatly increase the risk probability of chronic diseases such as cardiovascular disease and diabetes in adulthood. At the same time, obesity is also prone to human suffering from cerebral thrombosis, coronary heart disease, diabetes, endocrine and metabolic abnormalities and other diseases, and the incidence rate is significantly higher than that of normal people. For example, the incidence rate of cerebral thrombosis is twice as high as that of normal weight people, the incidence rate of hypertension is two to six times more than that of normal people, diabetes patients are about four times higher than that of normal people, and more importantly, the life span of obese people will be shorter than that of normal people.

The study by (Huang, 2015) shows that 34.3% of obese students are unwilling to participate in physical education classes. The reason for this is that obese students have a serious sense of inferiority, and the current sports content in physical

education courses is difficult to stimulate the participation enthusiasm of obese students. The reason may be due to their erroneous self-awareness, negative self suggestion, and persistent frustration and sense of failure. If left uncontrolled, it can lead to physical and mental illnesses as well as physiological dysfunction, which will inevitably affect learning ability and social interaction skills. In addition, there will be more profound and lasting effects in adulthood.

2.4 Research on Weight Loss Methods for Obese Students

Niu Lili believes that the widely used weight loss methods currently are low-intensity aerobic exercise and high-intensity interval exercise (Niu, 2020). In the future, research should be conducted from different physical constitutions, ages, and health conditions to make the intensity and duration of aerobic exercise suitable for most people. Teng Jinli proposed that scientifically effective aerobic exercise can better enhance plasma lipid metabolism levels. And it was found that the combined resistance exercise group had better changes in blood indicators (Teng, 2019). Remind us that in the future, the training methods for students with simple obesity should not be too single.

Functional training, as an innovative comprehensive training method based on individual differences and gradually promoted, brings benefits not only limited to reducing BMI and body fat percentage, but also demonstrates high practicality in daily life. In addition, functional training is relatively more effective than traditional training in protecting more muscles while burning fat.

2.5 Research on Badminton Training Methods

Y. Zhu (2023) pointed out that high school students' badminton skills can be significantly improved by using two training programs. However, compared to single ball training programs, multi ball training has a more significant improvement and maintains a more stable dynamic pattern. In terms of mastering various techniques, multi ball training is also more evenly distributed. Badminton training has a significant and comprehensive impact on the physical fitness of high school students, mainly reflected in their speed, strength, flexibility, and endurance. Liu (2020) proposed that compared with traditional physical training methods, the multi ball training method focuses more on practical simulation and athlete reaction training, enabling athletes to better adapt to the pace of the game and improve their performance during training. At the same time, due to the combination of game elements in the multi ball training method, the training process is more interesting, which stimulates athletes' training enthusiasm and improves their concentration.

Liu (2023) studied on the specialized movement ability of 9-11-year-old badminton players using the soft ladder training method found that the soft ladder training method is flexible and varied, with diverse training content, which is easy to cultivate interest and improve motivation for students in the childhood stage. It can not only improve concentration and neuromuscular control, but also effectively reduce the boredom and monotony during training. Conclusion: Soft ladder training method is

significantly higher than traditional training method in terms of improving specialized mobility.

Li (2023) conducted in-depth research on the application of high-intensity interval training in badminton elective courses for college students in 2023. His experimental research shows that high-intensity interval training is more effective in improving the physical health of badminton elective students compared to conventional training. Specifically, students' physical form and function have significantly improved, especially in terms of weight and lung capacity indicators; At the same time, students' physical fitness has also been significantly enhanced, with significant improvements in their performance in the 50meter sprint, standing long jump, and women's sit up.

2.6 Research on Psychological Health of Middle School Students

Long (2023)found in his study "The Impact of Basketball on the Mental Health of Middle School Students" that when using an experimental control method to measure two basketball classes at Guilin No.17 Middle School, the factor scores of various symptoms in the experimental group were generally lower after participating in basketball activities than befor. Basketball has obvious rules of confrontation, collectivism, and unity. Regular participation in basketball can improve the physical and mental strength of middle school students, cultivate their good psychological resilience, exercise their character in competitions, and express their emotions and attitudes in victory and defeat.

Hou (2021) conducted an experimental study on the impact of orienteering on the mental health of middle school students. Through experimental results, it can be found that students who participate in orienteering learning have significantly improved their symptoms of depression, obsessive-compulsive disorder, anxiety, paranoia, interpersonal sensitivity, hostility, learning anxiety, interpersonal anxiety, loneliness tendency, and self-blame tendency through orienteering exercise.

Chen (2016) also stated in their article that moderate intensity badminton activity has the effect of improving health status, regulating mental state, and also improving mood and regulating emotions. In addition, Tao (2016) have proven through research that badminton can effectively regulate the anxiety level of college students, with high-intensity intervention training having the most significant effect.

3.Status of research in other countries

3.1Study on the effects of badminton training on physical fitness and health

In a foreign study, Hao (2019) conducted a badminton education experiment on 64 third-grade secondary school students using the teaching experiment method. The results of the study showed that before the experiment, the physical fitness level of the students in the experimental class was at the same level as that of the students in the control class. After 16 weeks of training, the physical fitness level of both experimental and control class students developed with natural growth. However, the

physical fitness level of the students in the experimental class was higher than that of the control class. This difference suggests that badminton education has a positive impact on improving the physical fitness level of students.

Cabello Manrique's research has found that regular participation in physical activity has multiple benefits for the general health of individuals of all ages and life stages. After analysing the results, it was concluded that badminton may bring about improvements in various aspects, with the greatest change being in physical health, mainly in terms of improved cardiorespiratory fitness and basic physical fitness (Cabello-Manrique et al., 2022).

Wen (2022) in analysing the effects of badminton training on cardiorespiratory fitness and blood lactate indexes in male badminton players found that badminton training had a significant difference in VO_2max between the two training groups, and the results of blood fatigue were also significantly different between groups.

(Wong et al., 2019) compared amateur badminton players with other sportspersons in terms of balance, agility, eye-hand co-ordination and sports performance. Static single-leg standing balance (eyes closed) was measured using a force platform, dynamic balance was measured using a Y-balance test, agility was measured by a hexagonal agility test, eye-hand co-ordination was measured by a computerised finger pointing task, and the number of times a badminton ball landed in a designated area after a badminton serve quantified athletic performance. The results of

the study showed that badminton improves balance, agility and eye-hand coordination in athletes.

3.2 A study of the effects of badminton training on mental health

In his study, Chang explored how badminton training improved participants' physical fitness and emotional recognition through data analysis using smart sensors. The study found that badminton training significantly improved participants' physical fitness, including cardiorespiratory fitness, strength and flexibility. At the same time, the participants also showed significant improvement in their emotion recognition ability, and were able to better recognise and manage their emotions. Ultimately, the study concluded that badminton not only helps to improve physical fitness, but also improves mental health and emotion recognition, suggesting that badminton should be promoted in education and health promotion activities (Wong et al., 2019).

Sun (2019) conducted a related study on how to promote students' health and overall development, as well as how to help young students develop a lifelong awareness of exercise and improve their mental health. The study applied the SCL-90 psychological scale to badminton case teaching and analysed the mental health level of students, and came to the following conclusions: (1) the mental health level of students in the experimental group was higher than that of the control group; (2) the badminton case teaching method can promote the development of students' mental health.

Meng et al. (2019) in a study of cognitive functioning in athletes showed that athletes excelled on tasks of attention and sensorimotor ability and athletes generally outperformed healthy controls in the area of selective cognition. This proves that badminton is beneficial to the cognitive performance of athletes

Sun (2023) compared and analyzed the elderly population who participated in badminton, other sports, and did not participate in any sports activities, and finally concluded that elderly people who participated in badminton had higher mental health and life satisfaction.

Scholars are studying whether after-school physical activities affect the mental health and school adaptation of vocational training school students. The final results show that the experimental group has lower levels of tension, depression, and anger, higher vitality, and higher school adaptation scores than the control group. However, there was no difference in fatigue and confusion between the experimental group and the control group (Lassandro et al., 2021).

In summary, previous studies have involved different age groups, sports, teaching contents, teaching cycles, regions and different experimental and control groups for comparative analyses. A large number of teaching experimental studies have shown that badminton teaching training can produce changes in students' physical fitness. At the same time, the research also shows that there are some differences in the degree of influence of different sports or badminton teaching training on students of

different ages and genders, and the changes in their physical quality are closely related to the characteristics of the programme. The previous research provides a lot of theoretical basis for the research of this paper, which lays a solid foundation for better selection of teaching content, design of experimental methods and completion of experimental research.

In summary, by integrating the current research status in China and international perspectives, studies both domestically and internationally have demonstrated that badminton training has positive effects on the physical form, function, and various physical fitness indicators of middle school students. A substantial amount of research data confirms that badminton exercise positively impacts participants' overall health levels, cardiorespiratory function, and basic physical fitness. Additionally, studies show that different sports or badminton teaching and training programs have varying degrees of impact on students of different age groups and genders, with changes in physical fitness closely related to the characteristics of the sport.

However, most existing research focuses on general student populations, with fewer studies specifically targeting obese students for in-depth analysis. In contrast, this study focuses on obese junior high school students, designing a systematic badminton training program to examine its effects on agility and self-confidence. This approach fills a significant gap in the existing literature. Previous studies provide a wealth of theoretical foundations for the direction of this research,

laying a solid groundwork for selecting teaching content, designing experimental methods, and completing the experimental research. this study employs a variety of research methods, including literature review, experimentation, questionnaire surveys, and statistical analysis, ensuring the reliability and scientific validity of the results. The research direction not only aims to verify the positive impact of badminton training on physical fitness but also places special emphasis on its role in enhancing the self-confidence of obese students. This focus is relatively rare in both domestic and international research, making the study highly innovative and valuable in practical applications.

3.3 Research status on obesity among students

Dubois et al. (2012) found in their research on twins that genetic factors play a crucial role in children as they age. In the past few years, extremely obese children have experienced an increase in food intake due to personal or familial genetic mutations that affect the biological regulation of appetite. Some excessively obese children may also be caused by chromosomal mutations.

Oudejans et al. (2012) conducted a 55 years follow-up study at Harvard University in the United States, which showed that childhood obesity is extremely harmful. Regardless of whether this obesity persists into adulthood, these individuals have a higher incidence of disease and premature death in adulthood.

Cugusi et al. (2019) Conducted Zumba dance intervention on obese women and women with cardiovascular diseases. The research shows that Zumba dance improves the obesity status and body composition of healthy women, which fully shows that Zumba dance can improve the physical fitness of healthy women to a certain exten.

In Yokum research, he proposed the idea that there is a two-way correlation between obesity and inhibitory function, which opened up the breadth of research on the correlation between obesity and inhibitory function, and put forward the view that there is a selective negative correlation between childhood obesity and prefrontal inhibitory control, which further expanded the depth of research on the correlation between obesity and inhibitory function (Yokum,2022) .Kamijo and Masaki (2016) weakened the problem of nerve stimulation signal, and did not realize the importance of experimental intervention on the improvement of inhibitory function. He believed that the experimental intervention could not improve the inhibition function level for a long time, and he did not come up with a direct basis for whether the long-term experimental intervention could improve the executive function.

Researchers such as (Must et al., 1992) have found that overweight individuals in adolescence are significantly more likely to suffer from cardiovascular diseases and other chronic non communicable diseases and have a higher risk of death in adulthood. Even if these individuals control their weight in adulthood, this health risk still exists.

Racette s B said that overweight and obesity will increase the risk of various diseases in adolescents. Overweight and obesity can lead to glucose and lipid metabolism disorders and target organ damage. The detection rate of type 2 diabetes in obese children was 3.8 times higher than that in non-overweight obese children. The risk of hypertension in overweight adolescents was 71% higher than that in normal weight adolescents, and the risk of hypertension in obese adolescents was 3.4 times higher than that in non-overweight obese adolescents (Racette et al., 2006).

Dandona et al. (2005) said that overweight and obesity will also increase the risk of metabolic and immune diseases in children. Obesity will not only affect the current health status of children, but also increase the risk of various diseases in adulthood. Obesity in children and adolescents is an independent risk factor for cancer and premature death in adulthood. Obesity in adolescents is closely related to obesity in adulthoo.

CHAPTER 3

METHODOLOGY

This chapter aims to investigate the impact of badminton training on the physical agility and self-confidence of overweight junior high school students. Thirty overweight students from Rongxian Middle School in Guangxi, who have no long-term systematic sports participation, were selected as the research subjects and randomly divided into an experimental group and a control group, each consisting of 15 students. The experimental group underwent a structured badminton training program that lasted for 12 weeks, with sessions held three times per week, each lasting 90 minutes, while the control group participated in regular on-campus physical activities. Multiple research methods including literature review, experimental method, questionnaire survey, and mathematical statistics were employed. Tools such as the Rosenberg Self-Esteem Scale (RSS) were used to assess changes in students' self-confidence, alongside experimental tests measuring various indicators including height, weight, and BMI.

1.Research Objectives

To investigate the improvement and promotion effects of badminton training on the physical fitness, strength, agility, and psychological confidence of obese students.

Comparative investigate on the differences in physical fitness, strength, agility, and confidence improvement between obese students who participated in badminton training and those who did not participate in systematic badminton training.

The focus is on exploring the impact of badminton training on improving the agility and confidence of obese middle school students, and studying the chain effect path of "improving athletic ability, enhancing physical self-esteem, and increasing behavioral participation enthusiasm". Provide a basis for the coordinated intervention of physical and mental health in obese middle school students through badminton operation.

2.Research methodology

2.1 Literature method

By reviewing the literature related to this study, research results in the fields of badminton training, agility and self-confidence of obese students were collected and analysed to provide theoretical support. Literature mainly comes from academic journals, research reports and authoritative databases (e.g., China Knowledge, PubMed, EBSCO, etc.), and combined with relevant books and monographs to systematically sort out the key theoretical and practical results of existing research. Through screening and analysing the literature, the theoretical basis of the research, the current status of the research and the shortcomings of the existing research are

identified to provide a basis for the experimental design and methodology of this paper and to ensure that the research is scientific and prospective.

2.2 Experimental method

A teaching experiment on badminton training was designed and implemented to analyse the changes in agility and self-confidence of obese students before and after training according to the research needs. Thirty obese junior high school students were randomly selected and divided into experimental and control groups. The experimental group participated in specially designed badminton training courses, while the control group participated in regular physical education classes. The experimental period was 12 weeks, and the specific process included: identifying the experimental subjects, experimental time and place, pre-test, intervention training, adjustment and post-test. Finally, the results of the experimental and control groups were compared and analysed.

2.3 Questionnaire method

In order to assess the changes in self-confidence of obese students before and after badminton training, the Rosenberg Self-Esteem Scale (RSS) will be used as the questionnaire in this study. The scale has good reliability and validity and is widely used to measure individual's sense of self-worth and self-confidence level. The questionnaires were administered to the students in the experimental and control groups before and after the experiment to assess the effect of badminton training on their self-

confidence. The effectiveness of the intervention was explored by comparing and analysing the changes in the questionnaire scores of the two groups of students before and after the experiment. The questionnaire data provided an objective quantitative basis for the study and helped to better understand the positive effects of badminton training on students' mental health.

2.4 Mathematical and Statistical Methods

In this study, the raw data obtained from the questionnaire and experiment were firstly collated and summarized using Excel, and the raw data in the recovered questionnaires were analysed using SPSS22.0 software, with the paired-sample T-test within the group and the independent-sample T-test between the groups. The test indicators before and after the experiment were expressed as mean (x)±standard deviation (sd) and statistically analysed, and the statistical results of $p\text{-value}<0.01$ for highly significant difference, $p\text{-value}<0.05$ for significant difference, and $p\text{-value}>0.05$ for non-significant difference were expressed to find out whether there is a significant difference between pre- and post-experimentation badminton training on improving the agility and self-confidence of the obese students, and then to find out whether there is a significant difference between pre- and post-experimentation badminton training on increasing agility and self-confidence of obese students. In order to find out whether there is a significant difference between before and after the experiment on improving the agility and self-confidence of obese students, and then summarise the specific

impact of badminton training on improving the agility and self-confidence of obese students.

3.Experimental design

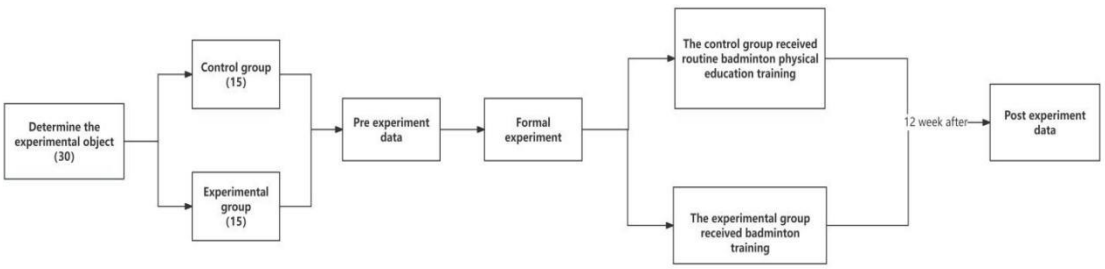
3.1 Experimental Objects

In this study, 30 obese junior high school students with homogeneity without long-term experience of systematic participation in sports and without the foundation of badminton training were randomly selected as experimental subjects in Rongxian Middle School, and the principle of voluntary participation was completely followed. The experimental subjects were evenly divided into two groups of 15 each, with 12 weeks of badminton training in the experimental group and 12 weeks of regular badminton physical education classes in the control group.

3.2 Determine the time and place of the experiment

The experimental group's training period was set to 12 weeks, with a frequency of 3 sessions per week, and each session lasting 90 minutes. The training location was the Badminton Training Base at Rong County Middle School.

3.3 Experimental process



3.4 Experimental control

The purpose of this experiment was to test the changes in the relevant indicators of physical agility and self-confidence of the subjects before and after the badminton training, using longitudinal comparative analysis in order to visualise the specific effects of badminton training on obese students. The experimental group consisted of 15 students who underwent 12 weeks of badminton training, with a training frequency of 3 times per week, each lasting 90 minutes. During the training, the subjects were asked to keep their heart rate at about 70% of their maximum heart rate, which was about 120 beats per minute. The 15 students in the control group only participated in regular badminton physical education classes without any training intervention, and data collection was conducted before and after the experiment.

In order to ensure the reliability of the experimental data, the students in the experimental group avoided participating in other high-intensity sports activities during the experimental period except for badminton training. At the same time, a sign-in system was implemented, and subjects with more than three unexcused absences would be excluded from the experimental data. The tests of physical agility and self-confidence and other related indexes were carried out three days before the beginning and after the end of the experiment to ensure the consistency of the test conditions.

3.5 Purpose and process of the experiment

The purpose of this experiment was to test the subjects' physical agility and self-confidence and other related indicators based on the Student Physical Fitness Standard, and to verify the positive effects of badminton training on obese students in these two areas. experimental procedure: before the experiment began, the subjects were first pre-tested on physical agility and self-confidence and other related indicators, and the data were collated and summarised. Subsequently, students in the experimental group underwent a 12-week badminton training. Immediately after the training, the subjects were post-tested to re-assess the relevant indicators of physical agility and self-confidence. Longitudinal comparisons were made by collating and analysing the data from the pre and post-tests in order to derive the specific effects of badminton training on physical agility and self-confidence of obese students and to summarise the findings of the study.

3.6 Training programmes

The experimental group consisted of 15 students who underwent badminton training for 12 weeks with a frequency of 3 times per week lasting 90 minutes, totalling 36 training sessions. The 15 students in the control group participated in free physical activity within the school for 12 weeks.

This study is based on the Badminton Training Outline for Young Students and WS/T101-1998 Sportswear and Hygiene Standards for Physical Exercise in Middle

and Secondary Schools, combining the theoretical foundations of the disciplines of exercise physiology, athletic training and sports psychology, and following the general laws of students' physical and mental development to develop a training programme. The programme takes full account of the special situation of obese secondary school students, ensuring the reasonableness of the exercise load, the scientific nature of the training content and the diversity of cognitive participation.

Specific training arrangements are as follows: learn new content in the first week, review and consolidate the previous week's learning in the second week; learn new content again in the third week, continue to review and consolidate in the fourth week, and so on, to ensure that students can effectively master the skills they have learnt at each stage

Table 1 Training programme for the experimental group

Weekly	Training content and methods
First week	(1) preparatory activities, warm-up exercises (10min); (2) basic knowledge of badminton, basic stance, forehand and backhand grip, training methods: in situ and marching forehand and backhand turnover exercises (15min); (3) learning to throw the ball overhand, overhand swing in place,

	frontcourt footwork, training methods: overhand throwing, in situ multi-group overhand swing in place, multi groups of frontcourt two-point running, front and backcourt folding run (35min); (4) straight line in and out running, throwing solid ball with both hands in place (20min); (5) stretching, relaxing and summarising this training (10min);
Second week	Review and consolidation of what was learnt in First week (1) Preparatory activities, warm-up exercises (10min); (2) review the serve and racket swinging action, learn badminton forehand serve long ball, training methods: serve and racket swinging exercises, in situ and marching between the forehand and backhand turnover exercises, forward and backward racket change, multi-ball backcourt long ball exercises (15min)
Third week	(3) Learning backcourt footwork, training methods: listening to the command backcourt two-point running position, backcourt multi-group two-point running position, front and backcourt folding run (35min); (4) listening to the command variable speed running, both hands in situ to throw a solid ball (20min); (5) stretching, relaxing and summing up this training (10min);
Fourth week	Review and consolidation of what was learnt in Third week

	(1) Preparatory activities, warm-up exercises (10min);
	(2) review serve and overhand swinging action, review badminton forehand catching high ball technology, training methods: overhand swinging practice, multi-ball practice overhand swinging catching straight high ball (15min);
Fifth week	(3) learning net netting action, training methods: in situ netting practice (no ball, multi-ball) (35min);
	(4) forecourt, killing Net step (combined with overhand swinging practice), court left and right touch side of the folding run, listening to the command to accelerate the run, jump rope single swing 30 times * 3 groups (20min);
	(5) stretching, relaxation and summary of the training (10min);
Sixth week	Review and consolidation of what was learnt in Fifth week
	(1) Preparatory activities, warm-up exercises (10min);
	(2) review badminton forehand catching and hitting skills, net release techniques, training methods: multi-ball practice catching and hitting a
Seventh week	straight line high ball (fixed point), net release exercises (15min);
	(3) learning the foreground picking, foreground footwork, kill the net footwork, learning to catch and kill (35min);
	(4) front and back of the field folding run, straight line in and out of the

	run, Throwing the ball in place, jumping rope double swing 10 times * 3 groups (20min); (5) Stretching, relaxing and summing up the training (10min);
Eighth week	Review and consolidation of what was learnt in Seventh week
Ninth week	(1) Preparatory activities, warm-up exercises (10min); (2) review net release techniques, review the front court picking, kill the net footwork, catch and kill method, combined with footwork to practice multi-ball catch and hit the high ball techniques and net release techniques (15min); (3) learn the basic technical movements of the hanging ball, high ball, training method: combined with the footwork for the multi-ball hanging ball technical movement practice (20min); (4) Teaching competition, in practice to further consolidate the receiving and hitting techniques and footwork, front and back field folding run, jumping rope single swing 30 times * 3 groups (35min) (5) stretching, relaxation and summary of this training (10min);
Tenth week	Review and consolidation of what was learnt in Ninth week
Eleventh week	(1) Preparatory activities, warm-up exercises (10min); (2) review the serve and overhand swinging action, review badminton

	forehand catching and hitting high ball technology, picking, hanging, high ball technical action (15min); (3) combined with the footwork of the multi-ball practice high ball, picking, hanging, net and other technical actions, training methods: multi-ball practice high ball, picking, hanging, net and other techniques, exercise half-court mobile handling Ball technique (20min); (4) Teaching competition, straight line in and out running, running at variable speed on command, throwing a solid ball in place, jumping rope double swing 10 times * 3 groups (35min); (5) Stretching, relaxing and summing up this training (10min);
Twelfth week	Review and consolidation of what was learnt in Eleventh week

Table 2 Control group training programme

Weekly	Training content and methods
First week	Badminton theoretical knowledge teaching, badminton competition rules; badminton forehand and backhand grip, upside down practice; badminton high long ball decomposition and coherent technology;

Second week	Review badminton lofting techniques; review lofting sequences; learn lofting stroke;
Third week	Review high ball technique; learn to step back from high balls and use pace to catch the ball;
Fourth week	Review the technical movements of the overhead shot; review hitting the overhead shot at a backward pace; learn to serve the overhead shot with the forehand;
Fifth week	Review and consolidate the overhead and forehand serve; learn forehand and backhand picking techniques;
Sixth week	Review overheads, picks and serves; learn the pace of movement left and right in front of the net; learn the pace of movement back and forth;
Seventh week	Review overhead and pick and roll drills; review badminton forehand and backhand net release techniques and pacing; attempt serve and overhead pairs;
Eighth week	Midterm test to test overhead technique, forehand serve overhead technique, and to test forehand and backhand picking technique;
Ninth week	Review badminton serve and loft technique sparring techniques; attempt to pull lofts against each other; learn net release and pace

	techniques;
Tenth week	Play high balls against each other; review net release and picking drills; practice singles match.
Eleventh week	Practical exercises will be carried out using the techniques of long balls, picks, and net releases;
Twelfth week	Review the practice of lofting, serving and picking techniques; and try to apply them in a comprehensive manner in real life situations

3.7 Experimental test indexes and methods

3.7.1 Height Test Method

The subject stood barefoot and upright on the test apparatus, with feet together, upper limbs naturally drooping, heels, sacrum and both scapular regions in contact with the uprights, torso naturally straight, head straight, and the upper edge of the ear screen level with the lower edge of the eye sockets. The tester gently slid the horizontal pressure plate down and lightly pressed it on the top of the subject's head. The eyes were flush with the horizontal plane of the pressure plate during the reading, and the recorder reviewed and recorded the data in centimetres, retaining one decimal place.

Test Equipment: Horizontal Platen

3.7.2 Methods of weight testing

The subject removes his/her jacket barefoot and stands on the scale, maintaining a standing position with both eyes looking straight ahead. The recorder makes a record, in kilograms, with one decimal place.

Testing Instrument: Weight Scale

3.7.3 Body Mass Index (BMI) Test Methods

BMI was calculated based on the weight (kg) and height (m) of the subjects using the formula: weight (kg) / height (m), with the result retained to one decimal place, and was used to assess the fatness and thinness of the students.

3.7.4 Body fat percentage test method

The subject stands barefoot on the measuring panel with both feet corresponding to the electrode plates of the measuring instrument, keeping the body upright. After the tester enters the age, height and gender data, the display will show the subject's weight. When the weight is stable, the subject bends down, touches the electrode on the handle with the palm of the hand, straightens both arms and raises them upwards, and the test ends when the numbers on the panel are stable. The tester is responsible for registering and recording the data.

Testing Instrument: Body Composition analyser

3.7.5 Waist-to-hip ratio test method

Measure your waist and hip circumference first and calculate the ratio of waist to hip circumference.

3.7.6 T-Running Test

As shown in the figure, after the command sounded, the person under test A position to start at the same time to start timing, and then accelerate to the 10-meter B position and one-handed touch the top of the sign cylinder, in the B position after an emergency stop and accelerate right to the 5-meter C position and one-handed touch the top of the sign cylinder, and then reverse the acceleration of the run to the 10-meter D position and one-handed touch the top of the sign cylinder, After an emergency stop, reverse the acceleration of the run to the 5 meter B position and touch the top of the sign cylinder with one hand, and finally turn right 90° from point B to accelerate back to the starting point A position at a distance of 10 meters and touch the top of the sign cylinder with one hand, at this point the test is over and the time is stopped. Each person is tested twice and the best result is recorded.

Test Equipment: Ruler, Marking Cylinder, Stopwatch

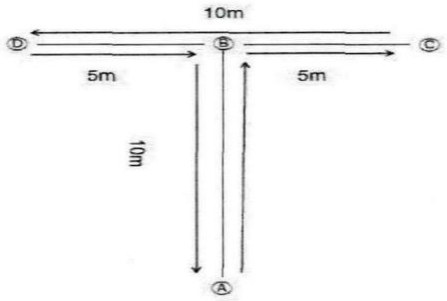


FIGURE 1 T-Running Test

Source: (Lin, 2023)

3.7.7 Cross-quadrant jump test

Two vertical 1-metre straight lines are drawn on a flat surface, dividing the test site into four quadrants, which are marked with sequential numbers. The participant stands on quadrant "1" with feet together and knees slightly bent, jumps in the order of 1-2-3-4 on command and records the time taken to complete 10 cycles.

Test equipment: stopwatch, ruler, whistle

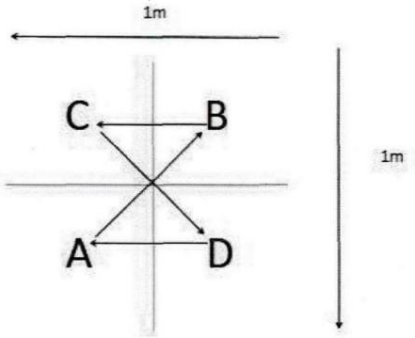


FIGURE 2 Cross-quadrant jump test

Source: (Lin, 2023)

3.7.8 Badminton Toss Test

The subject stands behind the marking line, stands with both feet in front and behind, holds the ball in one hand and throws it from above the shoulder. After the ball leaves the hand, it must not be stepped on or over the marking line, the observer records the landing point and marks it with a pen, and after the subject has thrown the ball again, the best score of the two times is taken, measured in centimetres.

Test equipment: badminton ball, straightedge

3.7.9 Standing Long Jump Test

Subjects used the bottom line of the badminton court as the jumping line, and the tape measure was placed vertically on the jumping line for measurement. The subjects stood naturally at the starting line, swung their arms and jumped forward, landing on both feet at the same time. After the jump stops, wait for the teacher to measure the results before moving the position, each subject jumps 3 times, take the best performance record, keep 2 digits after the decimal point as the test results.

Testing Instrument: Straight Rule

3.7.10 Experimental data analysis software-SPSS

SPSS software is a professional statistical analysis software widely used for data processing and analysis in fields such as social sciences, medicine, business, and education. The experimental data of this study were calculated and analyzed using

SPSS software, and T-test related experimental results were obtained to provide data analysis support for the experimental conclusions.

3.7.11 Paired sample t-test

Paired sample t-test refers to the data comparison of the same group of subjects under two different conditions (such as before/after the intervention) to determine whether there is a significant change in the mean value of paired data difference. The calculation steps are as follows:

Calculate the difference: di=xi1−xi2;

Calculate the mean and standard deviation:

$$\bar{d} = \frac{\sum d_i}{n}$$

FIGURE 3 (Mean value of difference)

$$s_d = \sqrt{\frac{\sum (d_i - \bar{d})^2}{n-1}}$$

FIGURE 4 (Standard deviation of difference)

1、Calculate **Paired sample T value**: (**n is the paired sample size**)

$$t = \frac{\bar{d}}{s_d/\sqrt{n}}$$

FIGURE 5 (Paired sample T value)

Subjects used the bottom line of the badminton court as the jumping line, and the tape measure was placed vertically on the jumping line for measurement. The subjects stood naturally at the starting line, swung their arms and jumped forward, landing on both feet at the same time. After the jump stops, wait for the teacher to measure the results before moving the position, each subject jumps 3 times, take the best performance record, keep 2 digits after the decimal point as the test results.

Testing Instrument: Straight Rule

3.7.12 Independent sample t-test

Independent sample t-test, also known as two sample t-test, is a statistical method used to compare whether there is a significant difference between the mean values of two groups of independent samples. This test is applicable when there is no pairing relationship between two samples.. The calculation steps are as follows:

Calculate the average of the two groups: $\bar{X}1$、 $\bar{X}2$;

Calculate the variance between the two groups: $S1^2$、 $S2^2$;

If the variance is homogeneous, the T value is as follows

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

FIGURE 6 (Independent sample T value)

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

FIGURE 7 (Combined variance)

1、 **If the variance is not homogeneous ,** the T value is as follows

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

FIGURE 8 (Independent sample T value)

3.7.13 P Value

P value is the probability of observing the current sample result or more extreme result under the premise that the original hypothesis (H $_0$) is true, which is used to measure the statistical significance. The calculation logic is divided into four steps:

1. Set h$_0$ (such as "no difference") and alternative hypothesis h$_1$;

2. Calculate statistics (such as t value) according to test type (such as t test);

3. Determine the theoretical distribution of Statistics (such as t distribution) based on H_0;

Calculate the probability of more extreme results through distribution: the one-sided test directly calculates the one-sided probability, and the two-sided test multiplies by 2. If the p value is less than the significance level (e.g. 0.05), reject h_0. For example, when t=2.3 (DF=20), bilateral P-VALUE=0.032, indicating that the results are significant. The p value only reflects the statistical significance, not the actual difference size, and depends on the data distribution assumption (such as normality).

CHAPTER 4

Experimental results and analysis

Building on the experimental methods outlined in the previous chapter, the specific experiments were conducted. The results showed that after 12 weeks of badminton training, the experimental group demonstrated significant improvements in physical fitness, body composition (such as BMI and body fat percentage), agility test scores, and self-confidence. The BMI of students in the experimental group decreased from 27.62±1.36 to 21.92±1.25, and their body fat percentage dropped from 24.34±1.87% to 19.42±1.65%. These changes were significantly different compared to the control group (P-VALUE<0.01). Additionally, the self-confidence of students in the experimental group was markedly enhanced. This indicates that badminton training not only effectively improves the physical fitness of overweight students but also positively impacts their mental health, providing crucial theoretical support and practical guidance for promoting the healthy development of this group. The study fills a gap in the in-depth analysis of overweight students and underscores the importance of scientifically designed badminton training programs. This chapter will analyze the experimental results from the following three aspects:

1. Analysis of the test results of relevant indicators between the experimental group and the control group students before the experiment.

2. Analysis of the test results of relevant indicators between the experimental group and the control group students after the experiment.

3. Analysis of Relevant Index Test Results Before and After the Experiment between the Experimental Group and the Control Group.

1.Analysis of the test results of the relevant indicators of students in the experimental group and the control group before the experiment (Independent sample T-test)

1.1 Comparative analysis of height and weight of students in the experimental group and control group before the experiment

In this study, the height, weight and body composition related data of obese students before and after participating in badminton training were selected for comparative analysis, aiming at exploring the specific effects of badminton training on the height, weight and body composition of obese students, so as to provide a theoretical basis for the healthy development of this type of students. The object of this experiment is obese junior high school students, in the critical period of growth and development, but also the fastest growth and development stage. This stage of growth and development is dominated by natural development, which is affected by multiple factors such as genetic factors, nutritional intake and exercise intervention. In this study, based on the measurement of height and weight, BMI (body mass index), body fat percentage and waist-to-hip ratio (WHR) were selected to reflect body composition.

Among them, height and weight are important indicators of physical health test; BMI can reflect the degree of obesity in human body; body fat percentage is the proportion of fat weight to body weight, which can accurately reflect the body fat content; waist-hip ratio is the ratio of waist circumference to hip circumference, which is an important indicator to reflect centripetal obesity. By collating and summarising the data before and after the experiment, the SPSS software was used to carry out paired-sample T-test and independent-sample T-test, and the specific data are shown in the table below.

Table 3 Comparison of height and weight test of students in the experimental group and control group before the experiment

Test metrics	control subjects at pre-test	experimental group at pre-test	T	p-value
Height (cm)	166.44±2.11	168.72±2.31	2.783	0.425
Weight (kg)	83.68±1.14	82.18±1.56	2.525	0.473

As can be seen from Table 3, there is No significant difference between the experimental group and the control group of students in the test results of two indicators of height and weight before the experiment, and the p-value is greater than 0.05, which does not reach the level of significant difference.

1.2 Comparative analysis of body composition of students in the experimental group and the control group before the experiment.

Table 4 Comparison table of body composition test between experimental and control groups before the experiment

Test metrics	control subjects at pre-test	experimental group at pre-test	T	p-value
BMI $\left(kg/m^2\right)$	28.63±1.65	27.62±1.36	3.276	1.042
Body fat percentage (%)	24.63±2.15	24.34±1.87	3.425	1.536
waist-to-hip ratio	0.95±0.013	0.93±0.018	2.525	0.413

As can be seen from Table 4, the test results of the three indexes of BMI, body fat percentage and waist-hip ratio of the students in the experimental group and the control group before the experiment were not significantly different from each other, and the P-value was greater than 0.05, which did not reach the level of significant difference.

1.3 Comparative analysis of sport performance of students in the experimental group and the control group before the experiment

Table 5 Sport performance test results of the experimental group and the control group before the experiment

Test metrics	control subjects at pre-test	experimental group at pre-test	T	p-value
Badminton throw (cm)	522.73±13.26	536.12±13.48	0.864	0.463
Standing long jump (cm)	130.1±4.595	130.3±3.591	0.938	0.426

Muscle fitness refers to the body's ability to rely on muscle contraction to overcome and counter resistance to maintain body movement, which is usually expressed in terms of muscle strength and muscle endurance. As we age, our body's muscle content decreases and fat content increases, resulting in a gradual decrease in basal metabolism, which seriously affects our health. Muscle strength, also known as maximal muscle strength, refers to the maximum contraction force generated when muscle fibres contract, and is an important criterion for evaluating the level of healthy fitness. In this study, badminton throwing distance and standing long jump were selected to reflect the muscle strength of obese students, and paired-sample t-tests

were conducted to measure the badminton throwing distance and standing long jump indexes of obese students before and after badminton training, and independent-sample t-tests were conducted on the experimental and control groups after the experiments, so as to analyse the specific effects of badminton training on the muscular fitness of obese students, and to provide a better opportunity for the scientific development of badminton training and promotion of healthy physical fitness for the children of this age stage. Badminton training for children of this age stage, to promote their health fitness positive development to provide a theoretical basis. This stage of students have gradually entered the important stage of sport performance growth, so in the process of this experiment muscle fitness is one of the main interventions, so in the test choose to overcome the self-weight method to evaluate the subject's local muscle strength.

Through reviewing the literature, it is learnt that badminton long throw is often used as an important index to reflect the strength of the upper limbs, which is commonly used to test the upper limb strength of badminton players and select materials. The badminton long throw puts high demands on the upper limb muscle strength and coordination of young students, and the characteristics of its force and trajectory are similar to those of badminton players who hit the high and long balls and kill the ball. Before the badminton teaching training, the badminton throwing performance of the experimental group and the control group students was tested, and

the results showed that the difference between the badminton throwing performance of the two groups of students before the experiment was not significant, and the P-value was greater than 0.05, which did not show a significant difference (see Table 5).

Vertical long jump is a long jump programme starting from a standing position without the aid of running, which is a regular item in the annual physical fitness test of secondary schools and universities, and can well reflect the lower limb strength. Before the badminton teaching training, the standing long jump performance of the experimental group and the control group students was tested, and the results showed that there was no significant difference between the standing long jump performance of the two groups of students before the experiment, and the P value was greater than 0.05.

1.4 Comparative analysis of agility between students in the experimental group and the control group before the experiment

Table 6 Agility test results of the experimental and control groups before the experiment

Test metrics	control subjects at pre-test	experimental group at pre-test	T	p-value
T-shaped run (s)	20.36±1.152	20.53±1.014	0.138	0.937
Cross-quadrant jump test (s)	20.83±1.479	21.11±1.102	1.378	0.254

Before the badminton teaching training, the agility indexes of the experimental group and the control group students - cross change of direction running and cross quadrant jumping were accurately tested according to the standard requirements. The test results showed that the difference between the cross change of direction running performance of the students in the experimental group and the control group before the experiment was not significant, and the P-value was greater than 0.05, which did not show a significant difference.

1.5 Comparative analysis of self-confidence between students in the experimental group and the control group before the experiment

Table 7 Self-confidence scale test results of the experimental and control groups before the experiment

Test metrics	control subjects at pre-test	experimental group at pre-test	T	p-value
Self-confidence scale score	29.22±2.517	29.22±2.517	0.691	0.567

There was no difference in the between-group means in terms of self-confidence scale scores between the pre-experimental and control students, which was not statistically significant (p-value > 0.05), suggesting a baseline equilibrium between the groups.

2.Test results of relevant indicators of students in the experimental group and control group after the experiment (Independent sample T-test)

2.1 Comparative analysis of height and weight test results of students in the experimental group and the control group after the experiment

Table 8 Post-experimental height and weight test results of the experimental and control groups

Test metrics	control group at post-test	experimental group at post-test	T	P
Height (cm)	167.13±1.54	169.68±2.29	5.602	0.003**
Weight (kg)	82.96±1.18	79.77±1.34	3.974	0.003**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

The height and weight of the two groups of students were tested again after the badminton training, and as shown in Table 8, the differences between the two groups of students in the two indicators of height and weight were very significant, with p-values less than 0.01.

2.2 Comparative analysis of the results of the body composition test between students in the experimental group and the control group after the experiment.

Table 9 Results of body composition tests of experimental and control groups after the experiment

Test metrics	control subjects at post-test	experimental group at post-test	T	p-value
BMI (kg/m^2)	26.33±1.81	24.92±1.25	-3.669	0.031*
Body fat percentage (%)	23.02±1.93	19.42±1.65	-0.245	0.001**
waist-to-hip ratio	0.93±0.01	0.90±0.011 t	3.920	0.032*

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

After the experiment, the test results of the three indexes of BMI index, body fat rate and waist-hip ratio of the experimental group and the control group students differed significantly. In the two indicators of BMI index and waist-hip ratio, the P-value is less than 0.05, and the difference is significant; in the body fat rate indicator, the P-value is 0.001, which is less than 0.01, and the difference is extremely significant. This shows that badminton training can significantly improve the body composition of obese students.

2.3 Comparative analysis of the results of the strength quality test between students in the experimental group and the control group after the experiment.

Table 10 Strength quality test results of experimental and control groups after the experiment

Test metrics	control subjects at post-test	experimental group at post-test	T	p-value
Badminton throw (cm)	536.12±13.48	560.13±22.22	3.525	0.001**
Standing long jump (cm)	135.92±4.605	140.66±3.502	2.636	0.002**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

After the badminton teaching training, the strength quality index of the experimental group and the control group was tested, and the test results are shown in Table 10: the average value of the badminton long throw of the control group after the experiment was 522.12cm, and that of the experimental group was 560.13cm, and the difference was very significant by the test of difference, with the P-value less than 0.01. The mean value of standing long jump of the control group after the experiment was 135.92cm, and that of the experimental group was 140.66cm, and the P-value was also

less than 0.01 through the test of difference, and the difference was very significant. It can be seen that there is a significant difference between the badminton long throw and standing long jump test scores of the experimental group and the control group after the experiment, indicating that badminton training can improve the strength quality of obese students to a certain extent.

2.4 Comparative analysis of the results of the agility test between students in the experimental group and the control group after the experiment

Table 11 Post-experimental agility test results for experimental and control groups

Test metrics	control subjects at post-test	experimental group at post-test	T	p-value
T-shaped run (s)	19.79±0.772	19.29±1.202	1.032	0.003**
Cross-quadrant jump (s)	20.12±1.067	19.87±1.352	1.421	0.003**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

Through reviewing the relevant literature, many scholars have used the cross change of direction run as a means of agility training or a common indicator for testing agility in their research on physical fitness or agility. The cross change of direction running consists of starting, braking, turning and sprinting, which can

effectively test the agility, coordination, resilience and leg muscle strength of the subjects, and it has high requirements for the test subjects' ability to start and brake quickly, and to change direction suddenly in the middle of the movement.

In badminton teaching and training, due to the characteristics of badminton and its teaching and training features, we can analyze the practice movements and technical characteristics of badminton participants in teaching or competition. It can be found that the badminton participants' sharp stops and starts, back and forth cross-steps, sliding steps on the court, and the swinging movements for badminton backcourt high balls and frontcourt balls all put requirements on the changes of the body's centre of gravity and the adjustments of the rhythm of the movements.

The practice of some footwork in badminton training, including acceleration, deceleration and change of movement, can help the muscles to form a memory for change of direction, rapid initiation and control, which can improve the performance of the cross change of direction run, and consequently, the participants' agility test index.

As a kind of agility test index, the movement of the cross quadrant jump not only requires the test subject's body coordination and lower limb muscle strength, but also challenges the test subject's ability to change and judge the direction of the movement, control the body, and the ability to accurately and quickly start the movement. The main purpose of the quadrant jump is to test the subject's body control ability and the ability to adjust the pace during acceleration and deceleration.

When performing a cross quadrant jump, the test subject is required to complete a precise number of jumps in a specified time by changing the direction of the jumps in all four quadrants. This requirement fully covers certain characteristics of agility. Therefore, combining the movement characteristics of badminton and the experimental results, we can conclude that the cross quadrant jump can effectively reflect the agility of secondary school students' physical fitness.

After the badminton teaching training, the agility index data of the experimental group and the control group were tested, and the test results are shown in Table 11: the mean value of the cross change running index after the experiment of the control group was 19.79 seconds, and the mean value of the cross change running index after the experiment of the experimental group was 19.29 seconds. Through the difference test, the P value is less than 0.01, and the difference is very significant. The average value of the cross quadrant jump index of the control group after the experiment is 20.12 seconds, and the average value of the cross quadrant jump index of the experimental group after the experiment is 19.87 seconds, and the difference test results show that the P value is also less than 0.01, and the difference is very significant. It can be seen that there is a significant difference between the cross change of direction running test scores and cross quadrant jump test scores of the experimental group and the control group students after the experiment, which indicates that badminton training can improve the agility of obese students to a certain extent.

2.5 Comparative analysis of the results of the self-confidence test between students in the experimental group and the control group after the experiment

Table 12 Test results of self-confidence scale scores of experimental and control groups after the experiment

Test metrics	control subjects at post-test	experimental group at post-test	T	p-value
Self-confidence scale score	29.40±1.528	30.72±0.891	34.052	0.000**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

As can be seen from Table 12, the mean value of self-confidence scale scores of the experimental group after the experiment is higher than that of the control group. After further testing, it was found that the p-value of the self-confidence scale scores of the control and experimental groups after the experiment was less than 0.01 and the difference was highly significant.

3.Test results of relevant indexes before and after the experiment for the experimental group and the control group (Paired Samples T-test)

3.1 Comparative analysis of height and weight test results before and after the experiment between the experimental group and the control group

Table 13 Results of height and weight tests before and after the experiment for the experimental group and the control group

	Height (cm)		Weight (kg)	
	control subjects	experimental group	control subjects	experimental group
pre-laboratory	166.44± 2.11	168.72± 2.31	83.68±1.14	82.18±1.56
post-experimental	167.13±1.54	169.68±2.29	82.96±1.18	79.77±1.34
T	1.032	2.413	1.231	3.825
p-value	0.046	0.001**	0.321	0.002**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

Height is an important measure of the vertical development of the human body. As can be seen from Table 13, after 12 weeks of badminton training, the heights of the students in the experimental and control groups underwent different degrees of

improvement compared to the pre-training period. Among them, the height change of the experimental group students was particularly significant, increasing from 168.72±2.31 before the experiment to 169.68±2.29 after the experiment, with a p-value of less than 0.01, indicating that the difference was highly significant. In contrast, the height of obese students in the control group changed, but the degree of change was not significant enough. The results of independent samples t-test showed that the p-value between the experimental and control groups also showed a very significant difference. This result indicates that badminton training has an important role in the development of height.

Body weight is an important indicator of the body's horizontal development and one of the most intuitive criteria for reflecting health status. Being underweight or overweight can have adverse effects on health. Studies have shown that the weight of healthy adults usually does not fluctuate greatly within a short period of time. However, the results of this experiment showed that the students in the experimental group had a significant weight loss in the weight indicator compared to the preexperimental test results, and the difference was highly significant (p-value < 0.01). In comparison, the weight fluctuations of the control group students were not significant enough.

This change is mainly attributed to the fact that systematic exercise interventions, under the premise of adjusting daily routines and reasonable diets, altered the physiological loads of the students and promoted a series of physiological

responses, which in turn accelerated their metabolism. In addition, exercise training increased students' nutrient demand and absorption, while promoting growth and development, resulting in significant changes in body weight. These results further emphasise the importance of badminton training in improving body weight and overall health of obese students.

Through the 12-week experimental intervention of badminton exercise, the experimental group's height mean was significantly higher than that of the control group. This result can be attributed to two main factors: firstly, with the improvement of people's living standards and parents' attention to children's nutrition, the growth and development of obese adolescents became more adequate and their metabolic capacity gradually increased, which led to a more favorable performance of natural growth in height; secondly, the experimental group increased badminton exercise after school, and compared with the control group, this extra exercise not only enhanced the obese The additional exercise not only enhanced the metabolic level of the obese adolescents, but also improved the nutritional status of the bones and enhanced their proliferative capacity.

By comparing the pre- and post-tests, the difference in height means of the experimental group was significantly better than that of the control group, which further verified that badminton training intervention can effectively enhance the height of obese adolescents. This result emphasizes the importance of appropriate physical exercise in

adolescent growth and development, which not only contributes to the healthy development of bones, but also positively promotes the improvement of overall physical fitness and health.

In terms of body weight, the experimental group also had a better difference between the pre- and post-tested mean values of body weight than the control group. Human muscle weight increases annually from birth to adulthood, and in childhood it accounts for about 20 per cent of body weight. This part of the increase stems from dietary intake on the one hand, and reflects the effectiveness of badminton exercise in controlling weight gain in obese adolescents on the other. Through badminton training, it not only helps to improve the physical fitness of students, but also promotes their healthy development.

3.2 Comparative analysis of body composition test results before and after the experiment between the experimental group and control group

Table 14 Results of body composition tests before and after the expoeriment for the experimental and control groups

	BMI (kg/m^2)		Body fat percentage (%)		waist-to-hip ratio	
	control subjects	experimental group	control subjects	experimental group	control subjects	experimental group
pre-laboratory	28.63±1.65	27.62±1.36	24.63±2.15	24.34±1.87	0.95±0.01	0.93±0.018
post-experimental	26.33±1.81	24.92±1.25	23.02±1.93	19.42±1.65	0.93±0.01	0.90±0.01
T	1.524	3.532	1.425	3.636	1.425	4.623
p-value	0.521	0.002**	1.245	0.001**	0.314	0.003**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

Body Mass Index (BMI) is an important indicator for measuring obesity and assessing health status and is calculated as weight (kg) divided by height squared (m2). According to the BMI standard, underweight BMI is less than 18.5, normal range is between 18.5 and 22.9, overweight is between 23 and 24.9, and obesity is a BMI greater than 25. Studies have shown that the level of BMI is closely related to health, and that those who are out of the normal range are more susceptible to cardiovascular and cerebrovascular diseases. Specifically, for every 2 units of BMI, the risk of stroke increases by 6.1 per cent and the risk of coronary heart disease by 15.4 per cent.

Therefore, keeping BMI within the normal range is important for reducing the risk of disease and maintaining good health.

According to the data in Table 14, the BMI of the students in both the experimental and control groups improved after the experiment compared to before the experiment, and the overall trend was that the BMI of the students in both groups showed a decreasing trend after the experiment. Among them, the BMI of the students in the male experimental group improved significantly, and there was a highly significant difference (P-VALUE < 0.01) compared to the pre-experiment. In contrast, the improvement in the control group was not significant enough.

From the data analysis in Table 14, it can be seen that after badminton training, a significant improvement in BMI occurred in the experimental group. By performing independent samples t-test on the experimental and control groups, the p-values showed significant differences, further indicating that badminton training had a positive effect on the improvement of BMI. This result emphasizes the important role of targeted physical activity in controlling body weight and promoting physical health, providing an effective intervention for obese adolescents.

Body fat percentage is the proportion of body fat weight to body weight, which can effectively reflect the amount of body fat. The level of body fat percentage directly affects the level of health. When the body fat percentage reaches a certain range, it will be recognised as obese. In recent years, with the improvement of people's

living standards and changes in lifestyle, the problem of obesity has become more and more serious among adolescents, seriously affecting their healthy development. Surveys show that obesity in adolescence will significantly increase the probability of remaining obese in adulthood, with 40 per cent of obese students becoming obese youths and 75-80 per cent of obese adolescents remaining obese in adulthood.

Appropriate sports can improve the activity of fat metabolism enzymes, promote fat decomposition and utilization, and inhibit fat synthesis, so as to gradually eliminate excess body fat, improve lipid metabolism, and enhance the overall health level. In this experiment, the body fat rate of obese students before and after the experiment was tested using professional instruments, and the specific results are shown in Table 14.

From the data in Table 14, it can be seen that the body fat percentage of the students in the experimental group before the experiment was 24.34±1.87 and that of the students in the control group was 24.63±2.15.After 12 weeks of badminton training, the body fat percentage of the students in the experimental group was reduced to 19.42±1.65 and that of the students in the control group was 23.02±1.93.After the experiment, the body fat percentage of the students in both the groups underwent a different degrees of changes, and all of them showed significant differences compared with the pre-experiment (P-VALUE < 0.05). In particular, the change in body fat

percentage in the experimental group was more obvious, and the results of paired t-test showed that there was a very significant difference (P-VALUE < 0.01).

It can be seen that after a period of badminton training, the body fat percentage of obese students was significantly improved, which further indicates the positive effect of badminton training on students' body fat percentage. At the same time, in order to meet the demand of reducing body fat rate, it is especially necessary to carry out systematic physical exercise on the basis of reasonable diet. In the process of physical exercise, the movement of muscles can increase muscle content and improve the body's metabolic capacity, thus effectively consuming excess fat and achieving better weight loss. On the contrary, the control group, both men and women, did not see any significant improvement. The data in Table 14 also show that the body fat percentage of the experimental group is significantly lower than that of the control group, and the P-value shows a very significant difference through the independent samples T-test, which further confirms the far-reaching significance of badminton training on the improvement of students' body fat percentage.

Waist-to-hip ratio is an important indicator for determining central obesity, which is calculated as waist/hip circumference. Waist-hip ratio is used as an important indicator to assess the health of human body, the smaller the ratio, the healthier the body is. The data in Table 14 show that through the 12-week badminton training, the waist-hip ratio of both experimental and control group students improved compared to

the pre-experimental period, and the test results were all significantly different compared to the pre-experimental period. The waist-hip ratio of the students in the experimental group before the experiment was 0.94±0.012 and that of the students in the control group was 0.95±0.013. After the experiment, the waist-hip ratios of the students in the experimental group and the control group were 0.83±0.01 and 0.90±0.01, respectively. Though there was a change in the waist-hip ratio of the students in the control group, the difference did not reach to the level of significance.

As can be seen from the data in Table 14, the waist-hip ratio of all students in the experimental group is lower than that of the control group. Through the independent samples t-test of the experimental and control groups, the p-value shows a significant difference, which indicates that systematic badminton training can effectively improve the waist-hip ratio of obese students and promote the healthy development of their physical functions. Therefore, the combination of badminton training and reasonable diet will bring better health results for obese adolescents.

3.3 Comparative analysis of the results of the strength quality test before and after the experiment between the experimental group and the control group

Table 15 Strength test results before and after the experiment for the experimental and control groups

quality of strength	Badminton throw (cm)		Standing long jump (cm)	
	control subjects	experimental group	control subjects	experimental group
pre-laboratory	522.73±13.26	536.12±13.48	130.1±4.595	130.3±3.591
post-experimental	536.12±13.48	560.13±22.22	135.9±4.605	140.6±3.502
T	2.525	5.342	2.735	4.824
p-value	0.421	0.012	0.535	0.024

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

After the badminton teaching training, the data of badminton long throw indexes of experimental group and control group before and after the experiment were analysed, and the pre- and post-tests of experimental group and control group were compared and analysed by SPSS 22.0. The results are shown in Table 15: the mean value of the badminton long throw index of the experimental group before the experiment was 522.12 cm, and the mean value of the experimental group after the experiment was 560.13 cm; the mean value of the control group of students before the experiment was 522.73 cm, and the mean value of the experimental group after the experiment was 536.12 cm. The results in Table 15 show that the p-value of the

performance of the badminton long throw index of the students of the experimental group before and after the experiment is 0.012 <0.05, so it can be concluded that there is a significant difference between the performance of the experimental group in badminton long throw test before and after the experiment; while there is no significant difference between the performance of the control group in badminton long throw test before and after the experiment.

After the badminton teaching training, the data of standing long jump indexes of the experimental group and the control group before and after the experiment were analyzed, and the pre- and post-tests of the experimental group and the control group were also compared and analyzed by SPSS 22.0. The results are shown in Table 15: the mean value of the students in the experimental group before the experiment was 130.3 cm, and the mean value of the students after the experiment was 140.6 cm; the mean value of the students in the control group before the experiment was 130.1 cm, and the mean value of the students after the experiment was 135.9 cm. The results in Table 15 show that the P-value of the students in the experimental group before and after the experiment was 0.001 < 0.05, and thus it can be concluded that the standing long jump achievement of the students in the experimental group was 0.001 < 0.05 before the experiment. 's standing long jump performance before and after the experiment has a very significant difference, while the control group students'

standing long jump performance before and after the experiment has no significant difference.

Sports have a significant role in improving physical fitness. In badminton teaching and training, in the process of learning and improving a certain technical action, students often need to repeatedly perform actions such as swinging and running. The quality of strength is a key quality that can be improved through acquired exercise, and strength can be divided into absolute strength, speed strength and relative strength. The improvement of absolute strength is especially obvious for those who regularly participate in badminton. Strength quality is the basic quality of participating in sports activities, and is the basis for achieving excellent performance and improving sports technology.

By reviewing the literature, it is known that the sensitive period for the growth of strength quality is 11-13 years old for juvenile students and 10-12 years old for girls. The technical movements of badminton, whether it is rolling, pushing, hooking, pouncing and releasing the ball in the front court, or swinging and hanging the ball in the back court, or dunking, all need a certain amount of strength of the wrist, back of the hand, shoulder and lumbar back muscle groups. Therefore, badminton requires high strength of the upper limbs and shoulders.

Due to the special characteristics of badminton, in each teaching training, students need to constantly repeat multiple sets of swinging and hitting exercises,

footwork movement, and even fast movement on the court facing different directions and lengths of incoming balls. In addition, some auxiliary special quality exercises between lessons also played a role. It is obvious through Table 15 that the test scores of badminton long throw of the students in the experimental group after the experiment are significantly higher than those of the control group, and there is a significant difference between the test scores of the experimental group before and after the experiment. This result is closely related to the characteristics of badminton sports and the technical characteristics of movements.

Badminton participants in the practice process constantly swing the racket to hit the ball, carry out long time and multi-frequency repetitive movements, can effectively promote the improvement of the quality of upper limb strength. At the same time, secondary school students are in the sensitive period of strength quality development, long-term badminton teaching training meets the needs of secondary school students' strength quality development. Therefore, long-term badminton training can better promote the development of upper limb strength quality of secondary school students.

During badminton games, due to the uncertainty of the incoming ball, the sport participants may be faced with variable speed and direction changes, force reduction and force addition at any time. Under the influence of these characteristics, the explosive power, absolute power and speed power of people who have been

playing badminton for a long time will be significantly improved. Good upper and lower limb strength enables badminton participants to have quicker footwork and more reasonable stroke points during normal training and competition. Especially for beginners, a solid foundation of strength can help them better master the technical movements of badminton; while for badminton participants with a certain level of performance, a good foundation of strength can prevent injuries and illnesses that occur in the course of the sport.

According to the characteristics of badminton, participants need to constantly adjust their positions according to different incoming ball routes. In a match, players often need to perform dozens of stomps, straddles, crossovers and quick movements in order to better choose the hitting position. These rapid movements not only require reaction speed, but also good lower limb strength as a support. Therefore, in the process of badminton teaching and training, some footwork exercises are often added, as well as jumping rope double swing, in situ tuck jump and other auxiliary quality training.

It is obvious through Table 15 that the performance of the experimental group students in the standing long jump test was significantly improved after the experiment. It can be seen that, after 12 weeks of badminton teaching training, the experimental group students' back-and-forth pace practice and special auxiliary practice on the badminton court made them obviously feel more rapid movement and

higher accuracy in hitting the ball in the game. At the same time, the significant improvement of the standing long jump test score also well illustrates the promotion effect of badminton teaching training on lower limb strength.

3.4 Comparative analysis of agility test results before and after the experiment between the experimental group and control group

Table 16 Agility test results before and after the experiment for the experimental and control groups

agility	T-shaped run (s)		Cross-quadrant jump test (s)	
	control subjects	experimental group	control subjects	experimental group
pre-laboratory	20.36±1.152	20.53±1.014	20.83±1.479	21.11±1.102
post-experimental	19.79±0.772	19.29±1.202	20.12±1.067	19.87±1.352
T	3.624	5.426	1.632	5.842
p-value	0.635	0.001**	0.742	0.001**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

Agility is the ability of an athlete to adapt to external changes by having complete control of his/her body and changing the position and direction of the body's movement under a variety of suddenly changing conditions. Agility is mainly measured

by athletes' rapid, accurate and coordinated reaction movements under different change conditions. In addition, agility plays a very important role in the formation of athletes' motor skills, the improvement of technical and tactical level and competition ability. Agility is generally categorized into conventional agility and specialized agility.

After the badminton teaching training, we tested the agility indexes of the experimental group and the control group after the experiment, and the test results are shown in Table 16: the average value of the cross change running indexes of the students in the experimental group before the experiment was 20.53 seconds, and the average value after the experiment was 19.29 seconds. In terms of the overall average, the performance of the students in the experimental class before and after the experiment was significantly improved; the average value of the students in the control group before the experiment was 20.36 seconds, and the average value of the students in the control group after the experiment was 19.79 seconds, and the performance of the students in the control group before and after the experiment had been improved, but it was small in comparison with that of the experimental group.

The results in Table 16 show that the P-value of the performance of the students in the experimental group before and after the experiment is $0.001 < 0.01$, indicating that there is a highly significant difference in the performance of the students in the experimental group in the cross change of direction running before and after the experiment. While the P-value of the students in the control group before and after the

experiment was 0.635 > 0.05, indicating that although the performance of the students in the control group in the cross change of direction running was improved, there was no significant difference.

After the badminton teaching and training, we analyzed the pre- and post-experiment data of the cross quadrant jump of the experimental group and the control group, and the pre- and post-measurements of the experimental group and the control group were compared and analyzed by SPSS 22.0. The test results are shown in Table 16: the mean value of the students in the experimental group before the experiment was 21.11 seconds, and the mean value after the experiment was 19.87 seconds. In terms of the overall mean, the pre- and post-test scores of the students in the experimental class have a significant improvement; the mean of the students in the control group was 20.83 seconds before the experiment and 20.12 seconds after the experiment, and even though there was an improvement in the pre- and post-test scores of the students in the control group, the improvement was small compared with that of the experimental group.

The results in Table 16 show that the P-value of the performance of the students in the experimental group before and after the experiment is 0.001 < 0.01, indicating that there is a highly significant difference in the cross quadrant jump performance of the students in the experimental group before and after the experiment. While the P-value of the students in the control group before and after the experiment

was 0.239 > 0.05, indicating that although there was an improvement in the cross quadrant jump performance of the students in the control group, there was no significant difference.

Students at secondary school level are in a sensitive period of physical development. However, due to the heavy study load of secondary school students as well as the popularity of technological products such as mobile phones and computers in recent years, students tend to be indulged in studying or online information for a long period of time, which in turn delays their agility improvement. In addition, obese students generally have poorer agility. Through the experimental data, we found that students who regularly participated in badminton teaching and training had faster growth and higher scores in agility test indexes after 12 weeks of training than the control group students who only performed normal activities without prolonged exercise. Although the data show that the test scores of the control group were slightly higher than the preexperimental average, the difference was not significant.

It can be seen that obese secondary school students' long-term participation in badminton teaching training can effectively improve their agility. At the same time, through the experimental data, we provide a good theoretical basis for the promotion of badminton in secondary schools to promote more students to participate in badminton, so as to promote the better popularity and development of badminton while improving physical fitness.

3.5 Comparative analysis of self-confidence test results before and after the experiment between the experimental group and the control group

Table 17 Test results of self-confidence scale scores before and after the experiment for the experimental group and the control group

Self-confidence scale score	control subjects	experimental group
pre-laboratory	29.22±2.517	29.22±2.517
post-experimental	29.40±1.528	30.72±0.891
T	-1.095	-3.68
p-value	0.284	0.001**

Note: * indicates a significant difference at P-VALUE < 0.05 and ** indicates a highly significant difference at P-VALUE < 0.01.

As shown in Table 17, the confidence scale score of the control group increased after the experiment compared to the preexperiment, but the difference between the pre- and post-test means of the confidence scale scores was not statistically significant (p-value > 0.05). In contrast, the experimental group's self-confidence scale score increased after the experiment compared to before the experiment, and the difference between the pre- and post-test means of the self-confidence scale scores was statistically significant (p-value < 0.05). The difference between the experimental and control groups was also statistically significant (p-value <

0.01) in terms of self-confidence scale scores. The difference between the pre- and post-tests of the experimental group was 1.5, and the difference between the means of the control group was 0.18, reflecting the fact that the experimental intervention was able to effectively improve the subjects' self-confidence.

Compared with the control group, the experimental group showed a significant improvement in the self-confidence score scale. This is mainly due to the fact that the characteristics of badminton require athletes to have the technical and tactical characteristics of "fast, fierce, accurate and stable". In the fierce competitive confrontation, the athletes must show the best technical and tactical level, which requires the subjects to have a higher level of wit, flexibility, boldness and the will quality of fighting. Long-term participation in badminton training not only improves the physical fitness of the exerciser, but also continuously hones and enhances the participants' self-confidence.

CHAPTER 5

Discussion and Conclusion

This study investigates the impact of badminton training on the agility and self-confidence of overweight students. Thirty overweight junior high school students were selected and divided into an experimental group and a control group. The experimental group underwent 12 weeks of badminton training, while the control group participated only in regular physical education classes. The results showed that students in the experimental group exhibited significant improvements in physical fitness, height, weight, and body composition. Their agility test scores improved, and their Rosenberg Self-Esteem Scale scores increased significantly. The study concludes that badminton training notably enhances the agility and self-confidence of overweight students and has a positive impact on their physical fitness

Discussion

1.1Increase the frequency of badminton training and enhance students' physical fitness

Badminton is a long-term high-intensity aerobic exercise that can help improve the body's cardiovascular fitness. Long term badminton exercise can increase the athlete's muscle mass (L. Wang, 2017). Badminton not only stimulates muscle fibers, thickens them, and increases body weight, but also effectively improves the flexibility of the hip joint in male and female college student (B. Li, 2015). When conducting badminton teaching and training in middle school, in order to effectively improve the physical fitness of obese middle school students, teachers should add simple endurance training appropriately as the training intensity increases. This not only helps students gradually adapt to the increasing technical requirements, but also lays the foundation for the development of endurance qualities. At the same time, it is recommended to add easy to organize and safe net separating sports such as badminton in middle school physical education classes or extracurricular activities.

These sports can stimulate students' interest in learning and comprehensively improve their physical fitness.

1.2 Reasonably arrange badminton training content to develop students' sport performance

Badminton requires a high level of athletic ability from athletes. It not only requires athletes to have good speed, strength, and endurance, but also requires athletes to have good agility and flexibility. During the exercise, athletes can also exercise their basic physical fitness well. Middle school students are in a sensitive period of strength development. At this stage, badminton teaching and training should not only improve students' technical level, but also arrange strength training reasonably to promote the improvement of their strength during the critical period of strength development. Through systematic and regular badminton training, students' physical fitness can be significantly improved, mainly reflected in varying degrees of improvement in aerobic fitness indicators, muscle fitness, flexibility, body composition, and basal metabolism (Liu, 2018). Targeted training plans should be developed based on students' different physiological characteristics and actual growth and development situations, avoiding excessive exercise load, following the principle of small and multiple training sessions, actively promoting students to participate more in badminton, forming good habits of participating in physical exercise, cultivating their lifelong sports concept, and laying the foundation for better promoting their healthy physical fitness and physical self-esteem development. The progress of badminton not only depends on good technical skills, but also on speed and quality. In training, the practice of speed literacy should not rely solely on footwork training, but should be scientifically designed with corresponding speed training plans. This can effectively improve the speed literacy of middle school students and further enhance their technical level.

1.3 Join badminton quick response exercises to improve students' agility

Based on the characteristics of badminton and the sensitive period of agility development in obese middle school students, special attention should be paid to agility practice in badminton teaching and training. In the process of badminton specific quality training, a long-term, scientific, and targeted training plan should be developed

in order to achieve excellent competition results. In future training, exercises such as changing the direction and form of movements, as well as quick reflexes, can be added to effectively improve the agility of obese middle school students (Y. X. Zhu, 2023). Reasonable arrangement of training load plays a crucial role in improving athletes' competitive level, provided that there is an accurate understanding of the training load borne by the body (Wang, 2023). Currently, research on exercise load in badminton training is not yet perfect. Badminton training has a positive promoting effect on the improvement of students' physical fitness, while fully mobilizing their interest in participating in badminton sports. It not only enables students to master badminton skills, but also promotes their physical and mental health and comprehensive development through sports exercise (He, 2019). When conducting badminton teaching activities in middle school, it should be recognized that although badminton training can improve students' physical fitness, it cannot fully meet the needs of comprehensive development. Therefore, teachers should adopt diverse methods and combine different training methods during the preparation activities and quality practice stages to comprehensively promote the physical fitness development of middle school students.

1.4 Based on the laws of students' physical and mental development, enhance their self-confidence

There are differences in the influencing factors of overweight and obesity and central obesity among primary and secondary school students. Sleep duration and negative emotions are only the independent influencing factors of overweight and obesity, while age and family socio-economic status are only the independent influencing factors of central obesity. Although badminton can improve students' obesity and agility, and improve students' self-confidence, it should follow teenagers' interests and physiological characteristics in the process of training, adjust measures to individual conditions, and step by step; When using sports intervention to improve students' obesity, if the purpose is to enhance the executive function, long-term and systematic physical education or sports intervention should be carried out, and the training cycle should be increased as much as possible, in order to obtain more ideal

results. It is suggested that parents or schools should incorporate badminton training into daily physical exercise, and cultivate teenagers' habit of adhering to lifelong physical exercise (He, 2022). We should strengthen the popularization of health science knowledge, let students develop healthy eating and living habits, and strengthen physical exercise in daily life, so as to avoid the occurrence of obesity at the root (Xue, 2016). Moderate intensity exercise can significantly improve students' physical self-esteem and self-confidence. At the same time, physical self-esteem plays an intermediary role in the process of improving students' self-confidence. Regular extracurricular physical exercise on campus can effectively improve students' physical self-esteem and indirectly improve their self-confidence (Yan, 2019). In this regard, schools should actively promote the positive impact of badminton on physical health, and encourage more students to participate in badminton learning and training. This will not only help improve the overall health level of students, but also cultivate reserve forces for the development of China's national badminton sport, and promote the overall improvement of middle school students' physical quality.

Conclusion

This article investigates the impact of badminton training on the agility and confidence of obese students. Thirty obese junior high school students were selected for the study and divided into an experimental group and a control group. The experimental group received 12 weeks of badminton training, while the control group only participated in routine physical education teaching. The results showed that the experimental group of students had significant improvements in strength, height, weight, and body composition, as well as improved agility test scores and confidence scale scores. Research suggests that badminton training can significantly improve the agility and confidence of obese students, and have a positive impact on their physical fitness. It is recommended to arrange strength and speed training reasonably, focus on agility exercises, and appropriately increase endurance training to comprehensively improve students' physical fitnes

REFERENCES

Cabello-Manrique, D., Lorente, J. A., Padial-Ruz, R., & Puga-González, E. (2022). Play badminton forever: A systematic review of health benefits. *International journal of environmental research and public health*, *19*(15), 9077.

Chen, T. Q. (2016). The effects of moderate-intensity badminton exercise on heart rate and mood in adolescents. *Contemporary Sports Technology, 6(05), 139+141.*

Cugusi, L., Manca, A., Bergamin, M., Di Blasio, A., Yeo, T. J., Crisafulli, A., & Mercuro, G. (2019). Zumba fitness and women's cardiovascular health: a systematic review. *Journal of cardiopulmonary rehabilitation and prevention*, *39*(3), 153-160.

Dandona, P., Aljada, A., Chaudhuri, A., Mohanty, P., & Garg, R. (2005). Metabolic syndrome: a comprehensive perspective based on interactions between obesity, diabetes, and inflammation. *Circulation*, *111*(11), 1448-1454.

Dubois, L., Ohm Kyvik, K., Girard, M., Tatone-Tokuda, F., Pérusse, D., Hjelmborg, J., Skytthe, A., Rasmussen, F., Wright, M. J., & Lichtenstein, P. (2012). Genetic and environmental contributions to weight, height, and BMI from birth to 19 years of age: an international study of over 12,000 twin pairs. *PLOS one*, *7*(2), e30153.

Fu, Q. (2015). A study on the influence of badminton training on the physical fitness of middle school students (Master's thesis). *Huaibei Normal University.*

Gao, J. H., Xu, H. Q., et al. (2024). A study on the relationship between obesity and some biochemical blood indicators in middle school students. *Occupation and Health, 20(11), 115–116*.

Hao, H. T. (2019). A study on the influence of badminton education on the physical health development of elementary school students. *12(3), 58–61.*

He, J. J., Wang, J., & Yang, Y. (2019). Effects of badminton training on physical fitness of adolescents. *Sports Science Literature Bulletin, 25(04), 13–15*.

He, Y., & Xu, M. (2022). Correlation analysis of college students' physical exercise with depression levels and physical self-esteem levels. *Journal of Chengdu Sport University, (01), 65–68.*

Hou, Z. K. (2021). Experimental study on the effects of orienteering on middle school students' mental health. *Xi'an Physical Education University [Master's thesis].*

Huang, L. Y. (2015). Causes and countermeasures of inferiority complex among obese students in middle school physical education. *Journal of Lingling College, 26(2), 264–265*.

Huang, S. H. (2023). An empirical study on the effects of badminton training on adolescents' physical and mental health (Master's thesis). *China University of Mining and Technology*.

Jin, D. B. (2022). Study on the impact of CrossFit training on the specialized physical fitness of badminton students in sports colleges (Master's thesis). *China University of Mining and Technology.*

Kamijo, K., & Masaki, H. (2016). Fitness and ERP indices of cognitive control mode during task preparation in preadolescent children. *Frontiers in human neuroscience*, *10*, 441.

Lassandro, G., Trisciuzzi, R., Palladino, V., Carriero, F., Giannico, O. V., Tafuri, S., Valente, R., Gianfelici, A., Accettura, D., & Giordano, P. (2021). Psychophysical health and perception of well-being between master badminton athletes and the adult Italian population. *Acta Bio Medica: Atenei Parmensis*, *92*(4), e2021253.

Li, B. (2015). A brief analysis of physical fitness training for young badminton players. Science and Technology Vision, . *Science and Technology Vision, (15), 294+308*.

Li, L. (2023). Experimental study on the effects of 8-week high-intensity interval training on the physical health and specialized athletic qualities of college badminton elective students (Master's thesis). . *Yangzhou University.*

Li, M. C., Chang, R. Q., Wang, Y. J., et al. (2024). The impact of extracurricular sports activities on the body shape of obese primary school students: A case study of Yuandong No. 1 Primary School. *No. 1 Primary School. In Shaanxi Sports Science Society & Shaanxi Student Sports Association (Eds.), Proceedings of the 2nd Shaanxi Sports Science Conference (Topic 8) (p. 5). Xi'an University of Arts and Science.*

Li, W. T. (2022). The effects of aerobic exercise combined with resistance training on the physical fitness of obese primary school students (Master's thesis). *Harbin Sport University.*

Li, Y. F. (2015). The influence of badminton on high school students' health-related physical fitness (Master's thesis). *Jilin Sport University.v*.

Li, Y. X. (2015). A study on the influence of badminton on college students' physical fitness and physical self-esteem (Master's thesis. *Xinjiang Normal University*.

Lin, W. T., & Cui, X. Y. (2023). Training agility and flexibility qualities in adolescents. . *Beijing Science Press.*

Liu, D. Z. (2017). Application of the "Rosenthal Effect" in children's badminton training and teaching (Master's thesis). . *Nanjing Sport Institute*.

Liu, X. L. (2018). The effects of badminton on children's health-related physical fitness and basal metabolism (Master's thesis). *Jimei University.*

Liu, Y., Yuan, J. X., & Yang, G. Y. . (2020). A literature review of badminton teaching and training research methods in colleges and universities over the past five years. *Sports Goods and Technology, (18), 72–73.*

Liu, Z. H. (2023). Study on the impact of soft ladder training method on specialized movement ability of 9–11-year-old badminton players. *Tianjin University of Sport [Master's thesis].*

Long, B. D. (2023). Study on the influence of basketball on middle school students' mental health. . *Educational Teaching Forum, (116)(35), 159–160.*

Lu, D., & Yin, H. G. (2022). The impact of functional training on the physical health of college teachers and students. *Sports Science and Technology, 43(04), 117–220.*

Ma, M. W. (2020). Experimental study on the impact of campus aerobics on endurance quality of obese junior high school students (Master's thesis). . *Shandong Normal University.*

Meng, F.-W., Yao, Z.-F., Chang, E. C., & Chen, Y.-L. (2019). Team sport expertise shows superior stimulus-driven visual attention and motor inhibition. *PLOS one*, *14*(5), e0217056.

Must, A., Jacques, P. F., Dallal, G. E., Bajema, C. J., & Dietz, W. H. (1992). Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. *New England journal of medicine*, *327*(19), 1350-1355.

Niu, L. L. (2020). Study on modern methods of sports weight loss. . *Sports Science Literature Bulletin, 28(22), 168–170.*

Oudejans, R. R., Heubers, S., Ruitenbeek, J.-R. J., & Janssen, T. W. (2012). Training visual control in wheelchair basketball shooting. *Research Quarterly for Exercise and Sport*, *83*(3), 464-469.

Ouyang, Q. (2021). Experimental study on the effects of basketball training on the physical fitness improvement of some obese adolescents (Master's thesis). . *Wuhan Institute of Physical Education.*

Pei, Q. (2020). An experimental study on the impact of Keep fitness app on the physical health of obese primary school students (Master's thesis). *Ningbo University.*

Racette, S. B., Evans, E. M., Weiss, E. P., Hagberg, J. M., & Holloszy, J. O. (2006). Abdominal adiposity is a stronger predictor of insulin resistance than fitness among 50–95 year olds. *Diabetes care*, *29*(3), 673-678.

Sun, H. C., & Soo, A. D. (2023). . (2023). The relationship between participation in sport for all (especially badminton) and mental health and life satisfaction of the aged. *(2023), 651–658.*

Sun, Y. L., & Jiang, J. Y. (2019). (2019). Evaluation analysis of the influence of badminton individual case teaching on students' psychology, . *648–651.*

Tao, S. (2016). Investigation on the current status of badminton development in junior high schools in Changchun (Master's thesis). *Jilin Sport University.v*.

Teng, J. L. (2019). Effects of aerobic exercise combined with resistance training on weight loss in 48 students with simple obesity. . *Modern Preventive Medicine, 46(09), 1631–1634.*

Tian, Y. Y. (2021). Comparative analysis of the effects of traditional training and compound training methods on the physical fitness test scores of obese ninth graders

(Master's thesis). *Ningbo University.*

Wang, C., & Qin, X. L. (2023). Monitoring training and competition loads in badminton based on TRIMP. . *Sports and Science, 34(06), 71–76+80.*

Wang, J. L. (2017). On the impact of badminton on the mental health of middle school adolescents. *Science and Technology Information, 15(21), 239—240.*

Wang, L. (2017). Experimental study on the effects of soft ladder training on footwork movement and agility in badminton trainees aged 8–12 (Master's thesis). . *Yangzhou University.*

Wen, Q. (2022). Health‐Care Technology of Badminton Sports Based on Nanotechnology. *Journal of Nanomaterials*, *2022*(1), 8637768.

Wong, T. K., Ma, A. W., Liu, K. P., Chung, L. M., Bae, Y.-H., Fong, S. S., Ganesan, B., & Wang, H.-K. (2019). Balance control, agility, eye–hand coordination, and sport performance of amateur badminton players: A cross-sectional study. *Medicine*, *98*(2), e14134.

Wu, P. L. (2022). Effects of different badminton training frequencies on health-related physical fitness and self-esteem of primary school students (Master's thesis). . *Shanghai University of Sport.*

Xue, L. F., & Xu, J. Y. . (2016). Effects of different physical exercises on physical self-esteem. . *Journal of Beijing Sport University, (07), 916–917+920.*

Yan, J., Li, Q., Zhang, Z. K., Wang, B. Y., & Zhu, F. S. (2019). The influence of extracurricular sports exercise on physical self-esteem and self-confidence of senior primary school students. *Sports and Science, 40(02), 100–104.*

Yang, X. D. (2008). Experimental study on the effects of badminton specialized training on physical fitness (Master's thesis). *Liaoning Normal University.*

Zhu, Y. (2023). Application of multi-ball training in high school badminton training (Master's thesis). . *Guangzhou Sport University.*

Zhu, Y. X. (2023). Analysis and research on physical fitness training of specialized badminton students in colleges and universities (Master's thesis). *Liaoning Normal University.*

Zou, X. Z. (2014). Study on the impact of specialized physical training and related qualities on badminton technique learning (Master's thesis). *Shaanxi Normal University.*

APPENDIX

Rosenberg Self-Esteem Scale

Guideline: The following is a set of sentences about how you feel about yourself. Please answer truthfully according to your own situation and put a tick in front of the option that matches your situation“ √ ”, thank you for your co-operation.

No.	Issues	Totally agree	agree	disagree	Strongly disagree
1	I consider myself a person of value, at least equal to others.				
2	I think I have a lot going for me.。				
3	In a nutshell, I think I'm a loser. ®				
4	My ability to do things is as good as most.				
5	I don't think I have anything to be proud of.®				

6	I have a positive attitude about myself.				
7	All in all, I am satisfied with myself.				
8	I wish I had more respect for myself.®				
9	Sometimes I do feel useless.®				
10	Sometimes I think I'm useless.®				

Rosenberg Self-Esteem Scale Integration Method and Score Analysis

Note: Topics marked with "®" in the table are reverse scored.

I. Scoring methodology

4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree

Of these 10 entries, the counting of points for entries 3, 5, 8, 9 and 10 is reversed (i.e., 1 point is counted as 4 points and 4 points as 1 point; 2 points are counted as 3 points and 3 points are counted as 2 points).

II. Scoring explanations

10 - 15 points: people with low self-esteem

You lack confidence in yourself, especially in front of strangers and superiors, you always rush to be inferior to others in everything, you often feel inferior, you need to greatly improve your self-confidence.

16 - 25 points: those who feel normal about themselves

You feel neither too good nor too bad about yourself. You feel quite confident in your self in some situations but feel quite low only in others and you need to stabilise your self confidence.

26 - 35 points: Confident

You feel very good about yourself. You are confident in yourself on most occasions and you don't feel quite as self-conscious in front of strangers or superiors as you need to be to stabilise your self-confidence.

36 - 40 points: Super Confident

You feel too good about yourself. You are so confident in your self in almost every situation that you don't even know what it means to have low self-esteem. You need to learn to control your self-confidence and become a little more self-effacing.

Expert information

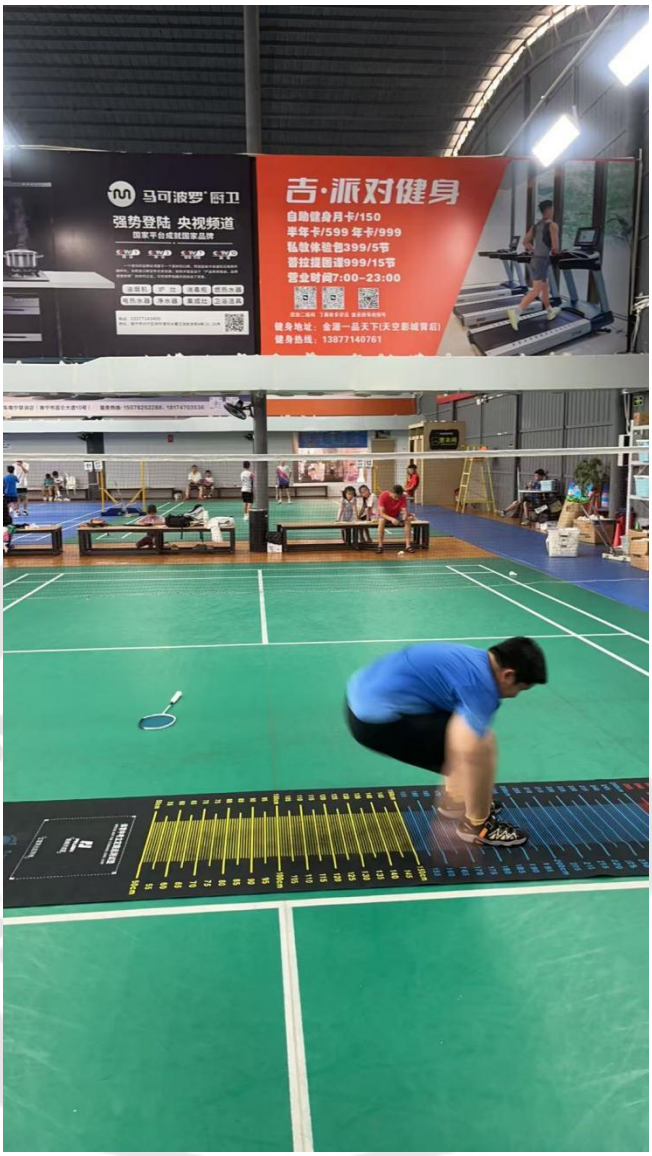
Name	Position
王**	Professor
张**	Professor
赵**	Professor
李**	Professor
谢*	Professor
杨**	Associate Professor
顾**	Associate Professor
周*	Associate Professor
朱**	Associate Professor
卢**	Associate Professor
姜**	Associate Professor
谢*	Badminton coach
蒋**	Badminton coach
周**	Badminton coach

Experimental process pictures

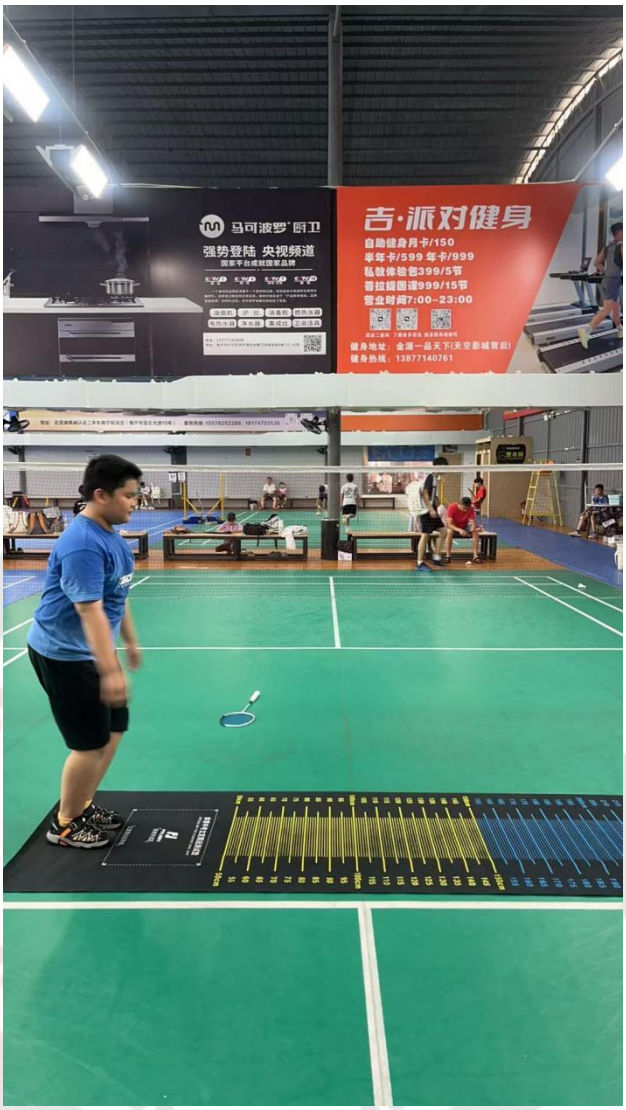
Experimental process picture 1

Experimental process picture 2

Experimental process picture 3



Experimental process picture 4



Experimental process picture 5

VITA