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Construction of Badminton Training Program to Improve Physical Fitness of University Students

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Abstract
Background and Aim: The Internet era has revolutionized various aspects of office work, daily life, and numerous fields. During the critical stage of growth and development, the lifestyle choices made by college students profoundly impact their physical health. Therefore, to improve the physical fitness of university students through playing badminton, this research has constructed a training program to improve the physical fitness of university students, focusing on three main components: strength, speed, and flexibility.
Materials and Methods: This research is quasi-experimental. The population of this research consists of 135 second-year male students in the 2023 academic year at Shenzhen Technology University, who have chosen badminton as an elective course. From the annual physical fitness test, 40 male students who scored the lowest overall physical fitness scores, will be selected as a sample group for this research. The training program will be conducted for 8 weeks, with sessions scheduled 3 days per week, each lasting 2 hours. The physical fitness test (including flexibility, speed, and strength tests) will be conducted before training, after 4 weeks of training, and after 8 weeks of training. In this research, mean, standard deviation, and one-way repeated measures ANOVA were used to analyze the data. The level of significant difference was 0.05.
Results: After 8 weeks of training, there was a significant difference between the pre-test, after 4 weeks of training, and post-test of the results of the flexibility test, speed test, and strength test. The university students showed significant improvement in all three aspects of their physical fitness.
Conclusion: The developed badminton training program is effective in improving the physical fitness of university students and can be utilized in developing badminton education at the university level.
Keywords: Badminton Training Program; Physical Fitness; University Student

Introduction

In China, the objective of offering physical education courses in colleges and universities is to enhance students' overall quality, foster lifelong awareness of sports, and holistically promote physical and mental well-being. The advancement of badminton courses prioritizes the improvement of college students' skill levels. In alignment with diverse educational standards, promoting the concept of health serves as the ideological foundation guiding the systematic development of educational initiatives (Chen, 2020).

Despite the recognized benefits of physical activity and exercise for improving physical fitness and overall well-being, many university students face challenges in maintaining regular exercise routines. This sedentary lifestyle can contribute to poor physical fitness levels, increased risk of chronic diseases, and decreased academic performance. Furthermore, there is a lack of tailored physical fitness programs specifically designed for university students, which may hinder their motivation and adherence to exercise regimens (Liu, 2015).

The Internet era has revolutionized various aspects of office work, daily life, and numerous fields. In this era, individuals rely heavily on computers and mobile phones for both work and personal activities, blurring the lines between work and leisure. College students, being at the forefront of technological advancements and cultural shifts, integrate electronic devices such as computers and mobile phones seamlessly into their lives and studies. However, this increased reliance on technology has its downsides. During the critical stage of growth and development, the lifestyle choices made by college students profoundly impact their physical health. Unfortunately, many students struggle with poor self-control, leading to excessive use of computers and mobile phones late into the night. This unhealthy habit significantly disrupts their sleep patterns and dietary routines, both of which are vital for maintaining

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physical well-being. To address these issues, interventions, and guidance are necessary to curb excessive Internet usage and encourage regular participation in sports and fitness activities. By enhancing sports abilities and promoting healthy sports habits, college students can derive numerous benefits, including improved learning outcomes and better physical health. It is imperative to prioritize interventions that support the holistic development of college students, ensuring they adopt healthy lifestyle choices that positively impact their well-being (Sun, 2011).

Through the research, it has been discovered that maintaining health-related physical fitness serves as a vital metric for assessing the overall physical health of college students. Utilizing physical fitness as an assessment tool enables educators to promptly identify any health issues among students. Furthermore, analyzing the health and fitness status of college students offers valuable insights into the tangible benefits of various sports activities for their holistic development (Zhu, 2021).

Badminton enjoys significant popularity in China and is suitable for individuals of all ages. It is featured in various sporting events, both large and small, and has become integral to sports training and education across all levels of education. The research on badminton training methods is increasingly scientific and comprehensive. As a net-confrontational sport, badminton tests athletes' technical proficiency and physical fitness (Lan, 2014). Optimal physical fitness is crucial for transmitting force, maintaining balance, coordinating movement rhythm, and executing technical maneuvers in badminton. Chinese badminton players and global stars like Lin Dan have excelled in international competitions, demonstrating the importance of physical fitness in executing precise serving and receiving techniques and sustaining high-intensity movements throughout matches (Du, 2017).

In addition, the effect of badminton on the physical fitness of university students is considerable. Regular participation in badminton has been linked to improvements in various aspects of physical fitness among university students. Studies have shown that engaging in badminton activities can lead to enhancements in cardiovascular endurance, muscular strength, agility, speed, and flexibility (Hussain et al., 2019). Additionally, badminton provides a comprehensive workout that targets multiple muscle groups, contributing to overall physical fitness (Goh and Singhal, 2018). Therefore, to improve the physical fitness of university students through playing badminton, this research has constructed a badminton training program to improve the physical fitness of university students, focusing on three main components namely, strength, speed, and flexibility. This research focuses on improving these three components because they are aspects of physical fitness that can be improved through playing badminton. Finally, implementing a badminton training program can provide students with an enjoyable and engaging form of physical activity, fostering a lifelong appreciation for exercise and healthy living.

Objectives

Main Objective

To construct a badminton training program to improve the physical fitness of university students.

Subsidiary Objectives

1. To study the current situation and the problem of physical fitness of university students.
2. To draft the badminton training program to improve the physical fitness of university students.
3. To compare the physical fitness of university students before starting the training, after 4 weeks of training, and after 8 weeks of training.

Literature Review

1. The Effect of Badminton on Physical Fitness

Badminton, an Olympic sport, is growing increasingly popular among the masses. As modern training methods become more scientific, competition has intensified, and the speed of returns has increased, demanding greater strength and speed from athletes. To win, athletes must enhance their speed, with power serving as the foundation of that speed. Agility is equally important, as it determines the quickness of their reactions. Badminton players rely heavily on quick reactions and agile footwork, which

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are crucial for winning competitions. The speed of their footwork depends on both their reaction time and the strength of their lower limb muscles. To improve a badminton player's speed, mastering reaction training is essential. The speed of an athlete's nervous system reflexes directly influences their rhythm and pace. Agility is a prerequisite for increasing footwork speed. Fast and accurate movements on the court require strong and agile lower limbs. Therefore, developing lower limb strength is vital for enhancing footwork speed (Xie and Zhuang, 2009).

The impact of badminton on physical fitness is significant and multifaceted. Regular participation in badminton can lead to improvements in various components of physical fitness, including cardiorespiratory endurance, muscular strength and endurance, agility, speed, and flexibility. Badminton involves dynamic movements such as running, jumping, and lunging, which contribute to cardiovascular fitness and overall endurance. The rapid changes in direction and quick reflexes required in badminton enhance agility and coordination. Additionally, the repetitive swinging of the racket and movements involved in badminton shots build muscular strength and endurance, particularly in the arms, legs, and core muscles. The sport also promotes flexibility as players reach and stretch to return shots. Overall, badminton provides a comprehensive workout that contributes to the development and maintenance of physical fitness (Wang and Sun, 2017).

Muscle Strength

Muscle strength encompasses several facets, including absolute muscle strength, relative muscle strength, muscle explosive power, and muscle endurance. Absolute muscle strength, generally regarded as the primary form of muscle strength, denotes the tension generated when muscles contract at their maximum capacity. Muscular fitness comprises muscle strength, endurance, contraction ability, and resistance, all of which play pivotal roles in supporting the execution of sports techniques. In an experimental approach, students were instructed to engage in 5-minute badminton confrontation exercises. Following the exercise, students' grip strength improved significantly, increasing from an initial range of 59-68 to 71-82. Moreover, there were noticeable enhancements in students' one-minute sit-up performance, rising from 17-22 times to 21-24 times. These quantitative changes before and after the experiment highlight the positive impact of badminton on students' muscular fitness (Liu et al, 2019).

Flexibility

Flexibility refers to the inherent quality of human bones that permits the body to move through its full range of motion without discomfort. Engaging in badminton confrontation techniques necessitates continuous execution of complex technical maneuvers, including attacking and defending at extreme states. This results in an accelerated body movement speed and an expanded range of motion in the body's joints. Following experimental research involving a week of badminton confrontation practice, students demonstrated tangible improvements in flexibility. Specifically, their forward bending distance increased from 17-22 cm to 20-24 cm, indicating noticeable changes before and after the experiment (Liu, 2015). Flexibility denotes the capacity to extend the range of motion while exerting force. Its efficacy is contingent upon the joint structure, the extensibility of surrounding tissues, and the nervous system's ability to regulate skeletal muscles. Flexibility typically diminishes with age, underscoring the importance of flexibility training during the college years. Badminton, being a full-body sport, necessitates agility in both the upper and lower extremities. For instance, when executing a shot from the backcourt, players must raise their arms and stretch to achieve the optimal hitting position, demanding adequate shoulder joint flexibility. Standard footwork across the front, middle, and backcourt relies on flexible knees and ankle joints. Furthermore, executing various types of saves throughout the court requires sufficient overall body flexibility. In essence, playing badminton entails the ability to strike the shuttlecock from diverse body positions—front, back, left, right, and overhead—thus necessitating high coordination and ample flexibility in the limbs (Zhang et al, 2020).

2. Physical Fitness

2.1 The definition of physical fitness

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Currently, physical fitness is globally recognized as a primary objective of fitness endeavors. It is categorized into sport-related physical fitness and health-related physical fitness to cater to different individual needs. Sport-related physical fitness primarily encompasses qualities such as speed, reaction time, explosive power, coordination, and agility, which athletes strive for to achieve optimal performance in competitive events. On the other hand, health-related physical fitness includes qualities such as cardiovascular endurance, body fat composition, muscle strength and endurance, and flexibility, which ordinary individuals pursue to promote overall health. This type of physical fitness aims to prevent diseases and enhance daily life, work, and academic efficiency, aligning closely with the health promotion goals within school sports (Bi et al, 2003)

Physical fitness has emerged as a significant public health concern, with implications for various health-related outcomes such as cardiovascular diseases, mental health, and skeletal health. Recent years have witnessed a decline in PF levels among both adults and adolescents (Knuth & Hallal, 2009). Moreover, there is a hypothesis suggesting that PF during childhood can predict Physical fitness in adulthood, thereby influencing the risk of cardiovascular diseases (Dennison et al., 1988). Given the rising prevalence of non-communicable diseases among younger age groups, the impact of PF levels on health outcomes in this demographic is expected to be increasingly pronounced (Gore et al., 2011).

2.2 The significance of health-related physical fitness

Health-related physical fitness encompasses cardiorespiratory endurance, muscle strength and endurance, flexibility, body composition, and muscle and nerve relaxation. Body composition, determined largely by body fat percentage, serves as a defense against diseases. Muscle strength and endurance are essential for normal bodily function, providing energy for physical activities. Cardiorespiratory endurance is vital for maintaining overall bodily function and is a key component of healthy physical fitness. Flexibility refers to the maximum range of motion of bones, muscles, and tendons without pain, playing a crucial role in preventing sports injuries. Muscle and nerve relaxation significantly impact reaction time, explosive power, and coordination, reflecting overall bodily function.

Health-related physical fitness represents the ultimate life skill and is intricately linked to the physical and mental well-being of college students. By examining the different components of Health-related physical fitness, we gain insight into the current physical condition and overall health of college students. Analyzing these components also helps identify any shortcomings in physical education courses, guiding the improvement of teaching practices in colleges and universities. Health-related physical fitness serves as the cornerstone of college students' athletic abilities, aiming to foster well-rounded physical development (Smith & Jones, 2018).

2.3 The significance of skill-related physical fitness

Skill-related fitness comprises six distinct components: agility, speed, power, balance, coordination, and reaction time. These components encompass movements essential for individuals to proficiently exhibit various motor skills and movement patterns. Despite their significance, these skill-related fitness elements are not regularly utilized or emphasized in the physical education setting, though they have the potential to provide students with immensely enjoyable experiences.

Speed refers to an individual's ability to execute a movement or traverse a distance within a brief timeframe. Virtually all physical activities rely on speed to gain an edge over opponents. For instance, a basketball player sprinting for a fast break to execute a lay-up, a tennis player swiftly advancing to reach a drop shot, or a football player outpacing the defense to receive a pass. Incorporating competition into lessons is a way for teachers to emphasize the significance of speed training. Various types of races, whether individual or team-based, can infuse excitement and energy into elementary or middle school physical education classes (Shape America — Society of Health and Physical Educators, 2014).

3. Badminton Training Program

A Badminton Training Program is a structured regimen designed to enhance the skills, physical fitness, and competitive performance of badminton players. It typically includes a combination of skill development exercises, physical conditioning drills, strategic training, and match practice tailored to the

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individual needs and goals of players. The program may encompass various aspects such as footwork, racket techniques, agility, strength training, endurance, mental preparation, and tactical understanding of the game (Tony, 2008). Currently, with the global growth of badminton, the sport has become widely popular in colleges and universities across my country, promoting its development at the collegiate level. As the playing and training methods of world badminton continue to evolve, it is essential for college badminton programs to update and improve their training methods to keep pace. Physical education teachers must engage in thorough research and practical application in their teaching practices, tailoring their guidance to the actual skill levels of college students. By helping students discover personalized training methods, educators can continuously enhance their badminton skills, leading to better development and improvement of college badminton programs (Ji, 2020).

A well-rounded badminton training program is based on principles of exercise science and sport-specific demands. The primary goal is to enhance an athlete's performance by improving various physical and technical attributes. The theoretical framework for designing a badminton training program includes several key components as follows:

1. Periodization: Periodization involves dividing the training program into distinct phases, each with specific objectives and training focuses. This approach helps in managing the training load and optimizing performance while minimizing the risk of injury and overtraining (Bompa & Haff, 2009).

2. Specificity: Training should be tailored to mimic the physical and technical demands of badminton. Exercises and drills must target the specific muscle groups, movements, and energy systems used during play (Reilly & Secher, 1990).

3. Progressive Overload: Progressive overload involves gradually increasing the intensity, duration, and frequency of training to continuously challenge the athlete's body, leading to improvements in strength, endurance, and overall performance (Fleck & Kraemer, 2014).

4. Variety: Incorporating a variety of exercises and drills prevents monotony, reduces the risk of overuse injuries, and ensures comprehensive development of all physical and technical aspects (Wilmore & Costill, 2004).

5. Recovery: Adequate rest and recovery are essential for muscle repair, adaptation, and preventing overtraining. This includes incorporating rest days, proper sleep, and nutrition (Smith, 2003)

In the current physical education teaching in colleges and universities, badminton has achieved good development. However, some problems restrict and hinder the further development of badminton in colleges and universities. The most important factor is that there are certain problems with the training methods of badminton in colleges and universities. Since badminton is a relatively complex sport, it has high requirements for the technical and tactical level of athletes. In the process of participating in badminton, students must learn and master some basic sports techniques and competition tactics in badminton to better train badminton. For example, students must learn and master badminton sports techniques such as badminton forehand high serve, badminton forehand and backhand picks, and running steps in the front and back courts. Learning and strengthening some basic sports techniques in badminton must be achieved through scientific and reasonable badminton training methods. Teachers can adopt two badminton training methods in daily teaching: First, carry out basic badminton technical training for students, so that students can carry out each badminton sports technical training on the premise of learning and mastering the theoretical knowledge of badminton technology, constantly strengthen students' sports technical awareness, and let students form sports psychological reflexes through repeated training. When playing badminton, they can naturally make relevant technical movements through badminton training and competition, so that their sports technology can be solidified. However, such sports technology solidification is not static and must be developed with the times. Teachers must also guide students to improve and perfect their badminton sports technology; second, carry out badminton competition training. For badminton, badminton training must be carried out in the way of "training through competition". Through actual competitions, students can test their training level, find and discover the problems they have in badminton training, and effectively improve and perfect their badminton sports technology (Liu, 2015).

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In summary, badminton training in colleges and universities requires instructors to align teaching objectives and content with tailored training methods. By employing diverse teaching approaches and training techniques suited to college students, instructors can ignite students' interest and enthusiasm for learning. This approach not only enhances students' badminton skills but also fosters a lifelong commitment to physical activity and healthy exercise habits.

4. Summary

Currently, there is a growing body of research focused on constructing badminton training programs to enhance the physical fitness of university students. These studies typically involve interventions that aim to improve various physical fitness components such as agility, speed, power, balance, coordination, and muscular strength and endurance through structured badminton training sessions. Researchers often design randomized controlled trials or longitudinal studies to assess the effectiveness of these training programs, employing outcome measures such as physiological assessments, performance tests, and subjective evaluations from participants. The findings of these studies contribute valuable insights into the design and implementation of evidence-based badminton training programs tailored to the specific needs and goals of university students, ultimately promoting their physical fitness and overall well-being. Therefore, this research aims to construct a badminton training program to improve the physical fitness of university students, with a focus on muscle strength, speed, and flexibility.

Conceptual Framework

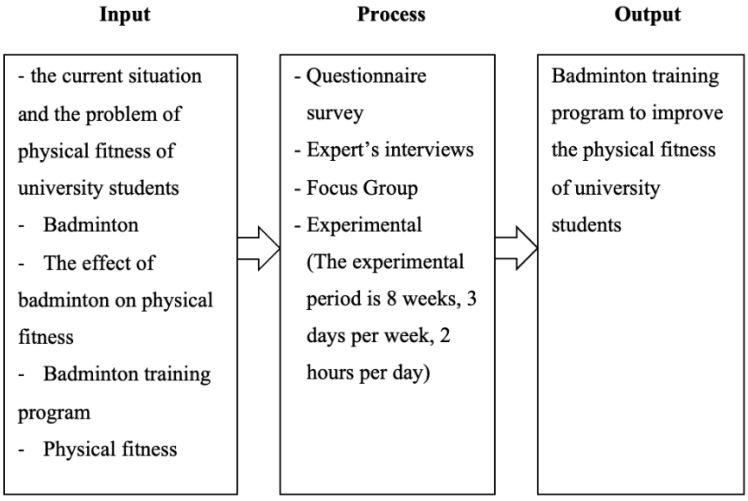

Figure 1 Conceptual framework

Methodology

Research Tools

In this research, research tools are as follows: (1) Questionnaire for university students; (2) Interview form; (3) The badminton training program; (4) Sit and reach test (flexibility test); (5) 40-meter sprint test **(**speed test); (6) Push-up test **(**strength test).

Population and Sample

Population specification and size: The population of this research consists of 135 second-year male students in the 2023 academic year at Shenzhen Technology University, who have chosen badminton as an elective course. All students have basic badminton skills.

Sample: 40 male students who scored the lowest overall physical fitness scores, based on China's physical fitness testing criteria, and who voluntarily enlisted for the experiment, will be chosen as the research sample group.

Data Collection

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1. The questionnaires will be handed out to all 40 male university students on-site to examine the present state and issues concerning badminton training among university students, as well as their physical fitness status.

2. 3 experts evaluated the questionnaire framework for expert interviews, by using the index of Item-Objective Congruence (IOC).

3. 5 experts, including badminton coaches, physical education teachers, and badminton academic experts, were chosen using the purposive sampling method. Expert interviews were conducted to develop a question framework for focus group discussions among experts, regarding the creation of a badminton training program and the factors to be considered.

4. 10 experts, comprising badminton coaches, physical education teachers, and badminton academic experts, were chosen using purposive sampling. The focus group was conducted to develop a badminton training program to improve the physical fitness of university students.

5. Try out the developed badminton training program with 20 university students to assess its suitability for student use. Evaluate whether the intensity of the training is appropriate or not. All 20 university students were not the sample university students in this research. However, they are university students who have similar characteristics to the sample group.

6. Implement the badminton training, the experimental group will train by using the developed badminton training program. Training for a total of 8 weeks, with sessions scheduled for 3 days per week, and 2 hours each day.

7. Conduct physical fitness tests (including flexibility, speed, and strength tests) before starting the training, after 4 weeks of training, and upon completion of the 8-week training. Afterward, analyze and compare the gathered test data to evaluate whether the badminton training program has been enhancing the physical fitness of university students.

Data Analysis

1. Descriptive statistical methods, such as the mean and standard deviation, were utilized to analyze the data collected from the questionnaire.

2. The content validity of the questionnaires and questions in the expert interview form was evaluated using the Indexes of Item-Objective Congruence (IOC). The IOC value for the questionnaire is 0.86.

3. The results of the pre-test, after 4 weeks of training, and post-test (after 8 weeks of training) were analyzed using one-way repeated measures ANOVA.

4. To analyze the data provided by experts, the researcher used the Likert scale to calculate the average score of the measures.

The meanings of 5 scale evaluation are 1 = Very Poor, 2 = Poor, 3 = Moderate, 4 = High, 5 = Highest. The details of the score criteria are as follows:

Average score range	Meaning
1.00 - 1.79	Very Poor
1.80 – 2.59	Poor
2.60 – 3.39	Moderate
3.40 – 4.19	High
4.20 – 5.00	Highest

Results

1. Investigate the current situation and the problem of physical fitness and badminton training for university students.

The questionnaires were distributed on-site to 40 university students to assess the present state and issues concerning badminton training, as well as their physical fitness status.

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Table 1 Questionnaire survey results on the current situation and the problem of physical fitness and badminton training for university students.

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Questionnaire Items	Total Score		Result
	$\bar{x}$	S.D.	
1. How often do you engage in physical exercise or sports activities per week?	2.92	0.76	Moderate
2. How would you rate your overall physical fitness level?	2.61	0.69	Moderate
3. Do you have any current physical fitness limitations or health issues?	4.20	0.60	Highest
4. Do you currently have any specific physical fitness goals?	4.04	0.71	High
5. Do you think the degree of your motivation to participate in badminton because you are interested in the improvement of physical fitness?	4.11	0.76	High
6. Do you think about badminton can improve your physical fitness?	4.34	0.72	Highest
7. Do you think the university's field equipment can meet the needs of your participation in badminton activities?	2.30	0.46	Poor
8. Do you think the content of the badminton class has guided you to improve physical fitness?	2.61	0.69	Moderate
9. Do you feel that the current badminton training program which ushing in the class meets your needs and expectations?	2.12	1.43	Poor

From Table 1, the questionnaire survey results on the current situation and the problem of physical fitness and badminton training for university students showed that students still need to improve their physical fitness, they have any current physical fitness limitations or health issues, this can be seen from question 3 “Do you have any current physical fitness limitations or health issues?”, the result of this question was in the “Highest” ($\bar{x}$ = 4.20). Moreover, they think now the content of badminton teaching content still cannot develop physical fitness as well as it should, this can be seen from question 8 “Do you

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think the content of the badminton class has guided you to improve physical fitness?", the result of this question was in the "Moderate" ($\bar{x}$ = 2.61). Additionally, they feel that the badminton training program cannot meet their needs and expectations, this can be seen from question 9 "Do you feel that the current badminton training program which is used in the class meets your needs and expectations?", the result of this question was in the "Poor" ($\bar{x}$ = 2.12).

2. Develop a badminton training program to improve the physical fitness of university students.

A focus group consisting of 10 experts was conducted to develop a badminton training program aimed at improving the physical fitness of university students. The resulting badminton training program will be conducted for 8 weeks, with sessions scheduled 3 days per week, 2 hours per day.

To study whether the developed badminton training program can improve university students' physical fitness, this research conducted physical fitness tests before the training, after 4 weeks of training, and upon completion of the 8-week training period. The physical fitness test includes flexibility, speed, and strength tests.

3. The results of physical fitness tests of university students

1) The results of the flexibility test of university students before, after 4 weeks of training, and after 8 weeks of training. For the flexibility test, this research used the sit-and-reach test. The results are as follows:

Table 2 The mean and standard deviation of the sit-and-reach test of students, as a sample group (n=40)

Sit-and-reach test	Mean ($\bar{x}$)	Std. Deviation (SD)
Pre-test	4.51	1.62
Week 4	6.85	1.59
Week 8	9.83	1.87

Table 2 shows the results of the sit-and-reach test for students before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. The sample group consisted of 40 students. The mean and standard deviation of the test results were as follows: before training with the developed specific training program, the results were 4.51±1.62; after 4 weeks of training, the results were 6.85±1.59; and after 8 weeks of training, the results were 9.83±1.87.

Table 3 Comparative results of sit-and-reach test results before, after 4 weeks of training, and after 8 weeks of training with the developed badminton training program by using one-way repeated measures ANOVA.

Source of Variance (Sov)	SS	Df	MS	F	Sig.
Between Group	567.16	2	430.00	315.97*	.00
Within Group	70.00	77	1.36		
Total	637.16	79	431.36		

*P＜.05

Table 3, showed the results of the sit-and-reach test before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. These results were analyzed using One-way repeated measures ANOVA. The analysis revealed a statistically significant improvement in the flexibility of students in the sample group between the before-training, post-4-week training, and post-8-week training assessments [$F_{(2,77)}$ = 315.97, sig. = .000]

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2) The results of the speed test of university students before, after 4 weeks of training, and after 8 weeks of training. For the speed test, this research used the 40-meter sprint test. The results are as follows:

Table 4 The mean and standard deviation of the 40-meter sprint test of students, as a sample group (n=40)

Sit-and-reach test	Mean ($\bar{x}$)	Std. Deviation (SD)
Pre-test	6.91	0.29
Week 4	6.49	0.24
Week 8	5.87	0.26

Table 4 shows the results of the 40-meter sprint test for students before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. The sample group consisted of 40 students. The mean and standard deviation of the test results were as follows: before training with the developed specific training program, the results were 6.91±0.29; after 4 weeks of training, the results were 6.49±0.24; and after 8 weeks of training, the results were 5.87±0.26.

Table 5 Comparative results of 40-meter sprint test result before, after 4 weeks of training, and after 8 weeks of training with the developed badminton training program by using One-way ANOVA

Source of Variance (Sov)	SS	Df	MS	F	Sig.
Between Group	21.80	2	10.90	746.82*	.00
Within Group	1.14	77	0.02		
Total	22.94	79	10.92		

*P＜.05

Table 5, shows the results of the 40-meter sprint test before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. These results were analyzed using One-way repeated measures ANOVA. The analysis revealed a statistically significant improvement in the speed of students in the sample group between the before-training, post-4-week training, and post-8-week training assessments [$F_{(2,77)} = 746.82$, sig. = .000]

3) The results of the strength test of university students before, after 4 weeks of training, and after 8 weeks of training. For the strength test, this research used the push-up test. The results are as follows:

Table 6 The mean and standard deviation of push-up test of students, as a sample group (n=40)

Sit-and-reach test	Mean ($\bar{x}$)	Std. Deviation (SD)
Pre-test	24.45	2.68
Week 4	28.23	2.18
Week 8	33.45	2.34

Table 6 shows the results of the push-up test for students before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. The sample group consisted of 40 students. The mean and standard deviation of the test results were as follows: before training with the developed specific training program, the results were 24.45±2.68; after 4 weeks of training, the results were 28.23±2.18; and after 8 weeks of training, the results were 33.45±2.34.

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Table 7 Comparative results of push-up test results before, after 4 weeks of training, and after 8 weeks of training with the developed badminton training program by using One-way ANOVA

Source of Variance (Sov)	SS	Df	MS	F	Sig.
Between Group	1634.02	2	817.01	1225.91*	.00
Within Group	51.98	77	0.67		
Total	1686	79	817.68		

*P＜.05

Table 7, shows the results of the push-up test before training, after 4 weeks of training, and after 8 weeks of training using the developed badminton training program. These results were analyzed using One-way repeated measures ANOVA. The analysis revealed a statistically significant improvement in the strength of students in the sample group between the before-training, post-4-week training, and post-8-week training assessments [$F_{(2,77)} = 1225.91$, sig. = .000].

Conclusion

After 8 weeks of training, it was found that the university students showed significant improvement in all three aspects of their physical fitness including strength, speed, and flexibility. Therefore, this indicates that the badminton training program is effective in improving the physical fitness of university students and can be utilized in the development of badminton education at the university level. It not only enhances university students' badminton skills but also improves their overall physical fitness. Coaches and physical education teachers can benefit from implementing this badminton training program.

Discussion

After the 8-week training period using the developed badminton training program, the physical fitness of university students in the sample group showed significant improvement in flexibility, speed, and strength. This is evident from the significant differences in the results of the pre-test, the test after 4 weeks of training, and the test after 8 weeks of training. These findings are consistent with the research conducted by Wang and Sun, 2017 that badminton has a significant and multifaceted impact on physical fitness. Regular participation can lead to improvements in various components, including cardiorespiratory endurance, muscular strength and endurance, agility, speed, and flexibility. The dynamic movements involved, such as running, jumping, and lunging, enhance cardiovascular fitness and overall endurance. The sport's rapid changes in direction and quick reflexes improve agility and coordination. Additionally, the repetitive swinging of the racket and the movements required for various shots build muscular strength and endurance, particularly in the arms, legs, and core. Badminton also promotes flexibility as players reach and stretch to return shots. Overall, it provides a comprehensive workout that significantly contributes to the development and maintenance of physical fitness.

From the results of this research, it can be concluded that after 8 weeks of training with the badminton training program developed by the researcher, university students can improve their flexibility. This finding is consistent with the research results of Zhang et al (2020)indicated that badminton, being a full-body sport, demands agility in both the upper and lower extremities. For instance, executing a shot from the backcourt requires players to raise their arms and stretch to achieve the optimal hitting position, necessitating adequate shoulder joint flexibility. Moreover, from the research results, after 8 weeks of training with the developed badminton training program, university student can also improve their strength. This finding is consistent with the research results of Liu et al (2019), which indicated that muscular fitness includes muscle strength, endurance, contraction ability, and resistance, all of which are crucial for executing sports techniques effectively.

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Therefore, the results of this research showed that the badminton training program developed by the researcher can improve the physical fitness of university students, such as flexibility, speed, and strength.

Recommendation

Recommendation for current research

1. Expand the research to include diverse participant groups, such as female students and students from different academic years, to generalize the findings across a broader population.

2. Incorporate the developed badminton training program into the university's physical education curriculum to provide students with structured and effective physical fitness training.

3. Utilize technology, such as wearable fitness trackers and performance analysis software, to monitor students' progress and provide real-time feedback.

Recommendation for further research

1. Integrate additional fitness components such as cardiovascular endurance, body composition analysis, and mental health assessments to provide a holistic view of the program's impact.

2. Experiment with varying levels of training intensity and volume to determine the optimal training load for maximum fitness benefits without risking injury or burnout.

3. Compare the effectiveness of the developed badminton training program with other physical fitness programs or sports to identify the relative benefits and potential areas for improvement

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