Analysis of Sport Emotion: Anger in Team Game Sports and Martial Arts

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Abstract

The purpose of this study is to investigate the differences in anger levels between athletes engaged in team game sports and those involved in martial arts. This research employs a quantitative approach using a causal-comparative method to explore emotional differences based on the type of sport. The population consists of athletes who participated in the 2018 West Java Provincial Sports Week (Porda). A purposive sampling technique was applied to select a total of 60 athletes, with 30 athletes representing team game sports (18 volleyball players and 12 basketball players) and 30 athletes from martial arts disciplines (18 karate practitioners and 12 taekwondo practitioners). Data were collected using the Sport Emotion Questionnaire (SEQ), which is designed to measure emotional responses in a competitive sports setting. The results reveal a significant difference in anger levels between the two groups. Specifically, martial arts athletes reported higher levels of anger compared to their counterparts in team sports. This finding suggests that the nature of individual competition and direct physical confrontation in martial arts may contribute to heightened emotional arousal, particularly anger. Meanwhile, athletes in team sports, who rely more on collective strategies and communication, may experience anger differently. These insights highlight the importance of emotional regulation strategies tailored to the specific demands of each sport.

Keywords: anger, emotion, martial arts, team game sports

INTRODUCTION

Emotion is one of the key aspects that influence an athlete's performance in sports. Emotions can effect performance, depending on the athlete and the type of sport (Jones, M. V., 2003). Sport emotion is a term that describes the emotions that arise during sports competition. There is sufficient empirical evidence to suggest that at least five emotions are particularly relevant to sport settings ... the emotions are anger, anxiety, dejection, excitement, and happiness (Jones, et al., 2005).

There are eight basic emotional dimensions, arranged in four pairs: joy versus sorrow, anger versus fear, acceptance versus disgust, and surprise versus expectancy (Mason & Capitanio, 2012). Among the various emotions that arise, anger is one of the most common emotions, especially in the context of competition and sports training. Anger is a frequent emotion in sport (Steffgen, 2017). This emotion can affect an athlete's performance both positively and negatively, depending on how the individual manages and expresses it.

In the context of sports, anger is often influenced by factors such as competition pressure, conflicts between players, or dissatisfaction with one's own or the team's performance. Anger is an emotion experienced by athletes in competition, and could impact performance (Jones, et al., 2005). If not managed properly, anger can disrupt performance, leading to loss of self-control, excessive aggression, or consequences that negatively affect both oneself and others. However, some studies suggest that negative emotions, including anger, can enhance an athlete's energy and focus in certain situations.

Previous research has revealed that physical contact sports such as martial arts always involve anger emotions. Athletes involved in physical contact sports often interpret their competitive anger as beneficial to sports performance (Steffgen, 2017). How about other types of sports, such as team game sports, where the pressure and responsibility are not solely dependent on the individual, but are instead shared among the members of the team? If viewed from the characteristics of individual sports, the sense of responsibility of victory is determined by each of them not by anyone, even the coach is only as an outside media that helps improve performance (Palgunadhi, F., &

Kardjono, K, 2020). This is an important point to consider, as different types of sports may also lead to variations in sports emotions.

Therefore, it is important to provide evidence regarding whether there is a difference in the level of sports emotion, particularly anger, experienced by athletes when facing competition in team game sports and martial arts. Does team sports have the same impact on anger, considering that in this type of sport, the pressure and responsibility are shared among multiple individuals working together within a team? Meanwhile, in martial arts, athletes compete individually, engage in physical contact, and may experience heightened emotional arousal as a result. This study aims to determine the extent of the difference in sports emotion (anger) levels between team game sports and martial arts. The hypothesis of this study is that there is a difference in sports emotion (anger) between team game sports and martial arts.

This study is expected to reveal how the characteristics of both types of sports (team game sports vs. martial arts) affect athletes' levels of anger and provide insights into the utilization or management of anger so that it does not interfere with athletes' performance in competition, but rather enhances their performance.

METHODS

The research method used is causal-comparative with a quantitative approach. In causal-comparative research, investigators attempt to determine the cause or consequences of differences that already exist between or among groups of individuals (Fraenkel, J. R., Wallen, N. E., & Hyun H. H., 2012). This research was conducted from October 6 to October 14, 2018. The research was conducted at the location where each sample was situated, or at the venue before the competition.

Research Design

The research design used in this study is the basic causal-comparative design. The basic causal-comparative design involves selecting two or more

Figure 1
The Basic Causal-Comparative Design
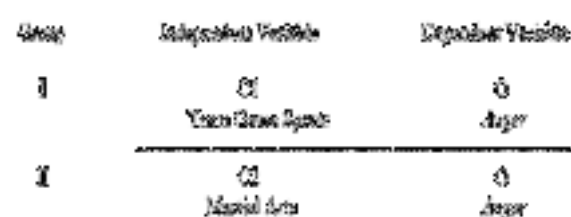
groups that differ on a particular variable of interest and comparing them on

another variable or variables (Fraenkel, J. R., Wallen, N. E., 2007). No manipulation is involved. The research process is carried out in one stage, which involves administering the test to the two specified groups. The result of the test is to assess the differences between the two groups. The research design of the basic causal-comparative design can be seen in Figure 1.

In this research design, there are two independent variables and one dependent variable. The independent variables in this study are team game sports and martial arts, and the dependent variable is anger.

Participants

The population in this study were athletes registered as players at the Regional Sports Week of West Java in 2018. The sampling technique used in this research is purposive sampling, which is a method of selecting samples based on specific criteria or considerations. For experimental and causal-comparative studies, we recommend a minimum of 30 individuals per group (Fraenkel, J. R. & Wallen, N. E., 2007).

Sample was 60 West Java athletes divided into 2 groups, each of 30 athletes for team game sports (18 volleyball athletes, 12 basketball athletes), and 30 martial arts athletes (18 karate athletes, 12 taekwondo athletes).

Instrument

The research instrument used in this study is the Sport Emotion Questionnaire (SEQ). The instruments used was Sport Emotion Questionnaire (SEQ) developed by Jones, et al. (2005) is a validated instrument for measuring emotions that occur in sports (before the competition).

Procedure

The research procedure begins with testing the validity and reliability of the instrument. Out of the 22 statements, 20 items were found to be valid, and 2 items were invalid, with a reliability level of 0.864. Therefore, 20 valid items were selected to be used in the research.

After the instrument has been validated and shown to be reliable, the next step is to test it to the sample. The sample is given the test shortly before the competition begins.

Data Analysis

The data obtained from the sample were analyzed using SPSS version 20. An independent samples t-test was performed to determine whether there were significant differences in anger levels between participants engaged in team game sports and those involved in martial arts.

RESULT

Descriptive analysis was conducted to examine the overall level of anger among participants involved in different types of sports. As shown in Table 1, the average anger score across all participants ($N = 60$) was $M = 1.21$, with a standard deviation of 0.93. The minimum score was 0.00, and the maximum was 3.75, indicating a wide range of reported anger levels.

To examine whether there was a significant difference in anger levels between participants in individual game sports and team game sports, an independent samples t-test was performed. The results, as presented in Table 1, indicate that participants involved in individual game sports (e.g., martial arts) reported significantly higher anger levels ($M = 1.61$, $SD = 0.87$) than those engaged in team game sports ($M = 0.93$, $SD = 0.63$).

The independent samples t-test revealed a statistically significant difference between the two groups, $t(58) = 3.14$, $p = .003$. The effect size was large ($d = 0.85$), suggesting a substantial difference in the level of anger experienced by participants based on the type of sport.

DISCUSSION

The purpose of this study is to determine the level of anger experienced in team game sports and martial arts, specifically before the competition takes place. Sport emotion is an experience that will always be felt in sports, especially during training or when a competition is taking place. The moments just before a competition are when every athlete experiences a mix of emotions within themselves. Anger experienced during the pre-competition phase will be felt by athletes in any sport, regardless of the type or characteristics of the sport. The characteristics of each sport will result in differences both in the athlete's personality and in the athlete's emotions

Table 1

Independent Samples t-test Comparing Anger Between Sports Types

Variable	Team Game Sport		Individual Game Sport		t (58)	p	Cohen's d
	M	SD	M	SD			
Anger	0.93	0.63	1.61	0.87	3.14	0.003	0.85

themselves. This indicates that anger will vary depending on the type of sport.

Based on the results, during the match, anger in martial arts is higher compared to team game sports, this shows that the level of anger in team game sports is lower compared to martial arts. This phenomenon can be explained through several psychological factors and social dynamics that differ between the two types of sports. First, martial arts, which often involve physical contact and one-on-one combat, tend to elicit higher levels of emotional tension. Martial arts athletes not only face their opponents but also must control their emotions in highly intense and high-pressure situations. Anger in this context may arise as a response to provocation, injustice, or failure to overcome the physical and mental challenges faced. This sport demands a high level of concentration and self-control, which often leads to an increase in the intensity of feelings of anger. In contrast, in team game sports, although tension between players can occur, the emotions experienced tend to be more distributed among the team members. Players are more focused on collaboration and team strategy than on direct interactions and personal confrontations with opponents. Therefore, although anger can occur in the context of the game, the level of anger expression in team game sports tends to be lower due to the role of communication and support among teammates.

In addition, another factor that influences this difference is the social and cultural norms present in both types of sports. In many martial arts cultures, anger is often seen as part of the "mental toughness" required to endure highly demanding competition. Athletes involved in physical contact sports often interpret their competitive anger as beneficial to sports performance (Robazza, C., & Bortoli, L, 2007). Anger emotions are used as a reference to increase morale and suppress fear so that it can improve sports performance or performance (Palgunadhi, F., & Kardjono, K., 2020). On the other hand, in team game sports, more controlled emotions are considered more important to maintain harmony and overall team effectiveness. Team sport athletes are more sociotropic than the individual sport athletes (Nia, M. E., & Besharat, M. A., 2010)

The results of this study suggest that understanding the differences in anger between these two types of sports can help coaches and sports psychologists design more effective strategies for managing athletes' emotions and enhancing their performance. Therefore, it is important to implement appropriate interventions based on the type of sport the athlete participates in, taking into account the unique characteristics of each discipline.

The factors of gender and age may also influence an individual's level of anger. Anger was associated with more interfering thoughts only in younger athletes (McCarthy, P. J., Allen, M. S., & Jones, M. V., 2013). It is hoped that future research will consider the aspects of gender and age of athletes.

CONCLUSIONS

It can be concluded that anger levels differ between team game sports and martial arts, with martial artists exhibiting higher levels of anger. This could be influenced by the individual nature of martial arts, which emphasize direct physical confrontation and self-discipline. Future research should explore factors such as gender and age to provide deeper insights into the psychological aspects of anger in different sports contexts.

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Implementation of Physical Test Measurement Using PJOK Application in Handball Sports

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Abstract

The study aims to evaluate students' physical condition. This study is descriptive and was conducted on fifth grade students of Elementary School 112 Palembang. The purpose of this study was to determine the average results of students' physical condition measurements in handball sports using the application. The dominant physical components in handball include speed, agility, leg muscle explosive power, strength, and endurance. A total of 30 students were the subjects of this study, consisting of 11 male students and 19 female students. Measurements were carried out through a 30-meter running test, agility test using the agility T-test, leg muscle explosive power was measured using a vertical jump test, strength was tested using a sit-up test, and endurance was measured using a beep test. The data obtained were analyzed using quantitative descriptive techniques. The results of the study showed that the average physical condition of fifth grade students of SD Negeri 112 Palembang in the handball sport was in the "very good" category with a percentage of 40%, the "good" category 7%, the "sufficient" category 9%, the "less" category 14%, and the "very less" category 30%. The conclusion of this study shows that most students have very good physical conditions. It is hoped that students can maintain and improve their physical condition in order to achieve higher achievements in the future.

Keywords: application, handball, physical fitness test, test implementation

Introduction

Handball is a sport played using the hands to score goals against the opposing team. It relies heavily on hand coordination (Susanto, 2020). Another source describes handball as a dynamic sport that enhances physical fitness, boosts enthusiasm, sharpens intelligence, and teaches players teamwork (Setiawan, 2019). Handball is a team sport played by two teams, each consisting of seven players (six outfield players and one goalkeeper). Each player tries to score by carrying the ball while running or walking and bouncing it on the ground (Rohman, 2018). The main objective of the game is to score points by throwing the ball into the opponent's goal while preventing the opponent from scoring (Yilkal, 2020). In handball, the primary skill that players must master is the throwing technique. This skill is fundamental to the game, as it is used both for passing and shooting at the goal. The goal of the game is to score as many goals as possible within a given timeframe (Setiawan, 2019). Handball is played on a 40-meter by 20-meter court, with each team made up of six field players and one goalkeeper. The game is played in two 30-minute halves with a 10-minute break in between (Susanto, 2017).

As a team sport, handball requires mutual agreement in terms of rules and social values such as honesty, cooperation, trust, and mutual respect (Setiawan & Rahmat, 2018).

Physical fitness plays an equally vital role in every sport. Outstanding achievements can be attained through athletes' optimal physical condition. An athlete is considered physically fit if they can perform physical activities without excessive fatigue.

According to Harsono (2018), the main factor in maintaining athletes' physical condition lies in the training program applied. A structured and systematic training program enhances the body's ability to adapt and perform optimally to achieve peak performance. To obtain optimal results, sports require testing and measurement that provide accurate insights into physical abilities and basic motor skills. Performance improvement is more clearly observed through structured physical and skill assessments—from initial, mid, to final testing—so that the results are more measurable.

Sport is a series of physical activities specifically designed to improve or maintain physical fitness (Hartati et al., 2019). A study by Gumelar et al. (2017) titled *"Development of Aerobic Capacity Software Using Android-Based Bleep Test"* employed a research and development (R&D) method. The study compared the effectiveness of manual versus Android app-based bleep tests, and the results revealed that the app-based method was more convenient, effective, and efficient, supported by questionnaire responses from the participants. Similarly, Gumantan et al. (2021) in their study *"Use of Android-Based Application for Physical Fitness Test Measurement"* found that the application was effective and represented an innovation in the field of physical fitness testing using Android programs.

Based on observations, students' physical conditions can be assessed through tests and measurements. One such test is the physical fitness test, which is specifically designed to monitor students' physical development to support their achievement at regional, national, and international levels.

However, advancements in science and technology (IPTEK), which should simplify tasks, have not been fully utilized by teachers in physical education classes, especially in physical test measurements. Proper integration of technology in this process is crucial for maximizing performance outcomes. Technology can significantly improve the accuracy of measuring students' physical conditions.

Currently, physical test measurements are still performed manually, from recording personal data and measurement results to data processing. This manual approach takes a lot of time and carries a higher risk of errors in recording test results.

The results of physical fitness tests are an important source of data for teachers to understand students' conditions and serve as a basis for improving their fitness levels. Therefore, applying an application to measure physical test results can assist teachers and students in achieving optimal performance.

According to Huda & Priyatna (2019), an application is software that serves as a front-end interface of a system used to manage various types of data and transform it into useful information for users and related systems.

Based on the explanation above, the researcher is interested in conducting a study titled "Application of Physical Test Measurement Using an Application in Handball Sports at SD Negeri 112 Palembang." With the help of an application-based tool, it is expected that PJOK teachers can improve the effectiveness of physical fitness testing and enhance students' physical condition through more accurate and efficient measurements.

Methods

Research Design

This research utilized a quantitative descriptive method aimed at describing and explaining

ongoing phenomena, as well as providing systematic, accurate, and factual problem-solving based on data regarding certain characteristics or factors being studied. The goal of this descriptive research is to offer factual and systematic explanations related to the realities and characteristics of the population. Data were collected through questionnaires, observations, and interviews. The research was conducted at SD Negeri 112 Palembang on May 13, 2024. The participants were Physical Education (PJOK) teachers who are members of the PJOK Teacher Working Group (KKG) in Palembang City.

Participants

According to Aprilianto & Fahrizqi (2020), a population refers to all members of a group—people, animals, events, or objects—that coexist in a particular space and are the target of research conclusions. The population in this study consisted of 30 fifth-grade students at SD Negeri 112 Palembang. The sampling technique used was purposive sampling, where samples are selected based on specific criteria or considerations. All 30 students were selected as research participants based on their relevance to the study's objectives.

Instrument

The instruments used in this study included physical fitness tests and structured questionnaires using a Likert scale. The physical fitness tests included:

1. 30-Meter Sprint Test
   Measures speed using a 30-meter track, cones, and stopwatch. The best time from two trials was recorded. The standard time for handball athletes is 4.74 seconds (Alica & Afrizal, 2019).
2. Shuttle Run Test (4x10 meters)
   Assesses agility through back-and-forth running. Participants must complete four sets of shuttle runs. The standard time for handball athletes is 12.56 seconds (Mirfan et al., 2020).
3. Sit and Reach Test
   Measures hamstring and lower back flexibility. Participants reach forward from a seated position to touch the farthest point on a ruler.
4. Sit-Up Test (30 seconds)
   Measures abdominal muscle strength. Participants perform as many correct sit-ups as possible in 30 seconds.

5. PACER Test (Progressive Aerobic Cardiovascular Endurance Run)
   Assesses cardiorespiratory endurance through 20-meter shuttles following an audio signal. Speed increases gradually, and the test ends when participants fail twice to reach the line on time. VO2Max standards for handball athletes range between 44.2–51.9 (Fauzan et al., 2016).

In addition, a closed-ended questionnaire based on the Likert scale was used to measure participants' perceptions. The scoring criteria are presented in Table 1.

Procedure

Participants completed five physical fitness tests representing physical conditions in handball. The data collection involved observation, direct testing, and the use of a Likert-scale questionnaire. Participants were informed about the procedures, and each test was conducted under standardized conditions to ensure accuracy and reliability. Each physical fitness component was explained and demonstrated prior to testing, and trials were conducted where necessary.

The quantitative questionnaire was administered after the tests to evaluate participants' perceptions and attitudes toward physical fitness in handball.

Data Analysis

Data were analyzed using quantitative descriptive statistics, with percentage formulas applied to interpret the frequency of responses and test results. The percentage was calculated using the following formula:

$$P: \frac{f}{N} \times 100\%$$

P=Percentage
f=Frequency
n=Number of participants
(Rizaldi Setiawan, 2017)

Result

Based on data obtained through tests and measurements in the handball sport branch using the 30-meter sprint test, agility T-test, vertical

Figure 1
Assesment Criteria

Response	Code	Score
Strongly Agree	SS	4
Agree	S	3
Disagree	TS	2
Strongly Disagree	STS	1

Table 2
Distribution of Physical Fitness Test Results – Speed (Boys)

Test Result	Frequency	%	Category
<5.4	0	0%	Excellent
5.4–6.6	6	54.5%	Good
6.6–7.2	0	0%	Fair
7.2–9.0	5	45.5%	Poor
>9.0	0	0%	Very Poor
Total	11	100%	

Table 3
Distribution of Physical Fitness Test Results – Speed (Girls)

Test Result	Frequency	%	Category
<5.2	5	26.3%	Excellent
5.2–6.0	2	10.5%	Good
6.0–6.4	3	15.7%	Fair
6.4–7.6	4	21%	Poor
>7.6	5	26.3%	Very Poor
Total	19	100%	

Table 4
Distribution of Physical Fitness Test Results – Agility (Boys)

Test Result	Frequency	%	Category
<9.4 seconds	0	0%	Excellent
9.5–10.5 seconds	2	18.18%	Good
10.6–11.5 seconds	0	0%	Fair
11.6–12.5 seconds	5	45.45%	Poor
>12.6 seconds	4	36.36%	Very Poor
Total	11	100%	

Table 5
Distribution of Physical Fitness Test Results – Agility (Girls)

Test Result	Frequency	%	Category
<10.1 seconds	0	0%	Excellent
10.2–10.10 seconds	1	9%	Good
10.11–11.12 seconds	16	84%	Fair
12.8–13.10 seconds	1	9%	Poor
>13.3 seconds	1	9%	Very Poor
Total	19	100%	

jump, sit-up, and bleep test on fifth-grade students at SD Negeri 112 Palembang, the physical condition of the students was assessed using an application. This was intended to determine the students' physical fitness level, which significantly affects their physical development. The results from the application-based measurements are described below:

Based on Table 2, the distribution of 30-meter sprint test results for boys in fifth grade at SD Negeri 112 Palembang (handball) shows that 0 students (0%) achieved an "Excellent" category, 6 students (54.5%) were in the "Good" category, and 5 students (45.5%) were in the "Poor" category. Therefore, it can be concluded that the 30-meter sprint performance of the boys is generally in the "Good" category.

Based on Table 3, the 30-meter sprint results for fifth-grade girls show 5 students (26.3%) achieved "Excellent", while 4 students (21%) were categorized as "Poor", and 5 students (26.3%) were in the "Very Poor" category. Although some students performed well, the overall distribution indicates that performance varies widely among female students.

From Table 4, the agility performance of boys in the fifth grade is mostly in the "Poor" (45.45%) and "Very Poor" (36.36%) categories, indicating a general need for improvement in agility among male students.

According to Table 5, the majority of girls (84%) are in the "Fair" category, while the remaining fall into either "Good", "Poor", or "Very Poor". This suggests that most female students have moderate agility.

Table 6
Sit and Reach Test Results – Boys

Test Result	Frequency	%	Category
>14	0	0%	Excellent
11–14	0	0%	Good
7–10	6	54%	Fair
4–6	5	45%	Poor
<4	0	0%	Very Poor
Total	11	100%	

Table 7
Sit and Reach Test Results – Girls

Test Result	Frequency	%	Category
>15	0	0%	Excellent
12–15	0	0%	Good
7–11	6	31.57%	Fair
4–6	10	52.63%	Poor
<4	3	15.78%	Very Poor
Total	19	100%	

Table 8
Sit-Up Test Results – Boys

Test Result	Frequency	%	Category
>45	0	0%	Excellent
40–45	0	0%	Good
35–39	3	27.2%	Fair
25–34	4	36.3%	Poor
<25	4	36.3%	Very Poor
Total	11	100%	

Table 9
Sit-Up Test Results – Girls

Test Result	Frequency	%	Category
>40	0	0%	Excellent
35–40	0	0%	Good
30–34	1	5.26%	Fair
20–29	8	42.1%	Poor
<20	10	52.6%	Very Poor
Total	19	100%	

Table 10
Sit and Reach Test Results – Boys

Test Result	Frequency	%	Category
>12	0	0%	Excellent
9–12	0	0%	Good
7–8	3	27.2%	Fair
5–6	4	36.3%	Poor
<5	4	36.3%	Very Poor
Total	11	100%	

Table 11
Sit and Reach Test Results – Girls

Test Result	Frequency	%	Category
>10	0	0%	Excellent
8–10	0	0%	Good
7–8	2	10.52%	Fair
5–6	3	15.78%	Poor
<5	14	73.6%	Very Poor
Total	19	100%	

The results in Table 6 indicate that most boys are in the "Fair" category (54%) for flexibility, while 45% fall into the "Poor" category, showing limited flexibility among the male students.

Table 7 shows that the majority of female students fall into the "Poor" category (52.63%), and only a small portion reached "Fair" (31.57%).

None of the students achieved "Good" or "Excellent", indicating a need for flexibility development.

Table 8 shows that none of the male students achieved "Good" or "Excellent" levels of abdominal strength and endurance. Most students were in the "Poor" (36.3%) and "Very Poor" (36.3%) categories, with only 3 students (27.2%) categorized as "Fair". This suggests a general lack of core strength among the boys.

From Table 9, it is clear that more than half of the female students (52.6%) are in the "Very Poor" category for sit-up performance. None achieved "Good" or "Excellent", and only one student (5.26%) reached a "Fair" level. This shows that abdominal muscle endurance is a major area for improvement among the girls.

Table 10 reveals that the boys' aerobic endurance is mostly in the "Poor" and "Very Poor" categories, each with 4 students (36.3%). Only 3 students (27.2%) were in the "Fair" category. None achieved "Good" or "Excellent", which suggests low levels of cardiovascular fitness.

As seen in Table 11, a significant number of female students (73.6%) are in the "Very Poor" category in the bleep test. Only 2 students (10.52%) are in the "Fair" category, and none performed in the "Good" or "Excellent" ranges. This highlights the urgent need for aerobic endurance training.

Discussion

The physical fitness tests serve as a foundation for handball athletes at SD Negeri 112 Palembang to effectively carry out each training session and to support their performance during competitions. A good level of physical fitness is expected to help athletes perform well in both training and competitions, ultimately achieving optimal results. The physical fitness tests reflect the individual abilities of each athlete, providing insight into their initial fitness level in the sport (Hartati et al., 2021).

Based on the data collected from the physical fitness tests and the measurement results obtained using the application, it is necessary to discuss the implementation of the physical fitness test measurements in handball using an application. The use of this application aims to assist teachers and coaches in determining or compiling the results of the physical fitness tests that have been conducted.

From the speed test results, the first step involved students performing a 30-meter sprint test at SD Negeri 112. Thirty students participated in this test, with 11 male students and 19 female students. The speed indicator value, with a percentage of 30%, falls into the "Poor" category. Speed is the ability to perform continuous movements in the same form as quickly as possible. It is the result of muscle contraction at a high speed and strength (powerful) through smooth movements (Matitaputty, 2019). Meanwhile, (Cahyo B et al., 2012) state that speed is the body's ability to direct all of its systems to counteract the load, distance, and time, thereby producing body movement in the shortest possible time.

Based on the explanation above, the results of the agility test show an agility indicator value with a percentage of 53.3%, which falls into the "Fair" category. The T-Test agility test serves to improve students' agility in handball. Agility is closely related to the body's flexibility; thus, the better the flexibility, the better the agility that will be developed in athletes.

Based on the explanation above, the results of the sit-and-reach test show an indicator of flexibility with a percentage of 50%, which falls into the "Poor" category. According to (Kurnia et al., 2020), flexibility is a physical condition element that determines the ability to learn movement skills. Flexibility is the ability to move a joint or several joints without restriction and pain. The importance of flexibility is to allow the body to perform movements more easily and freely without requiring excessive energy. One reason for poor muscle flexibility is a lack of physical activity over a long period.

Based on the explanation above, the results of the sit-up test show an indicator of strength with a percentage of 60%, which falls into the "Fair" category. According to (Kartika et al., 2018),

strength is related to the dynamic and explosive contraction speed of muscles and the release of maximum muscle strength in the shortest possible time.

Based on the explanation above, the results of the bleep test show an endurance indicator value with a percentage of 86.6%, which falls into the "Very Poor" category. According to (Warni et al., 2017), endurance is one of the physical components that need to be trained and developed as it significantly supports the technical and tactical ability in playing sports.

Based on all the test results, including running, agility test, sit-and-reach, sit-up, and bleep test, the findings from the trial indicate that the overall physical condition of the 5th-grade students at SD Negeri 112 Palembang falls into the "Poor" category with a percentage of 38.8%. This is because the students at SD Negeri 112 Palembang do not yet possess good physical fitness, with many categorized as "Fair" or even "Poor" and "Very Poor." This can be attributed to the insufficient and poorly structured training programs. Physical education teachers or coaches are still focused more on techniques and tactics rather than overall physical conditioning.

Conclusions

Based on the research results, it can be concluded that the physical fitness test measurements for the 5th-grade students at SD Negeri 112 Palembang in the sport of handball fall into the following categories: excellent 3.32%, good 7.30%, fair 33.98%, poor 23.3%, and very poor 29.3%. From all the categories above, it can be concluded that the average physical condition of the students at SD Negeri 112 Palembang is categorized as "Fair" with a percentage of 33.98%. The implication of this research is that teachers, coaches, and athletes can use the application-based physical fitness test measurements to assess and select athletes for handball competitions, ensuring that selected players possess the necessary physical qualities categorized as good.

Acknowledgment

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Physics in Sport Education: Insights from a decade of bibliometric analysis

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Abstract

This study aims to analyze trends in scientific publications related to the application of physics in sports education over the past decade using a bibliometric approach. Data were obtained from the Scopus database using the keywords "TITLE-ABS-KEY(Physics AND Sport AND Education)" within the publication range of 2015 to 2024, resulting in 83 relevant documents. The data were exported in CSV and RIS formats and analyzed using VOSviewer 1.6.20 and Microsoft Excel 365 to perform co-authorship and co-occurrence analyses. The findings reveal that research in this domain predominantly centers on biomechanics, coaching strategies, and the integration of technology in sports learning and training. Notably, there has been a significant rise in studies involving digital monitoring systems, indicating a growing emphasis on data-driven performance analysis. The bibliometric mapping also highlights limited collaboration among authors across different institutions and countries, suggesting opportunities for broader academic partnerships. Overall, the study concludes that the application of physics in sports education continues to develop in alignment with technological innovations. However, gaps remain in translating these advancements into effective teaching and coaching practices. Future research is encouraged to adopt a multidisciplinary framework that bridges physics, education, and sports science to optimize the implementation of physics-based technologies in educational and athletic settings.

Keywords: bibliometric analysis, physics, sport science, sport education.

Introduction

In the last decade, sports education has developed rapidly with increasing research highlighting the application of physics in the learning process. Physics plays a fundamental role in understanding various aspects of sports, such as biomechanics of motion, force, momentum, energy, and the interaction between the athlete's body and its environment (Chaeroni et al., 2024; Fratiwi et al., 2020). A deeper understanding of these principles allows sports education students to develop more effective learning strategies, improve movement efficiency, and understand the factors that influence athlete performance in various sports (Farrow & Robertson, 2017; Hastie & Wallhead, 2016; Wang & Wang, 2024). In addition, technological advances have encouraged the use of various physics-based devices, such as motion capture, force plates, and biomechanical sensors in the analysis of athlete performance. These tools not only help in understanding sports techniques but also support a more objective and data-driven science-based learning approach (Feng et al., 2020; Saura et al., 2023).

The application of physics in sports education has made significant contributions in various sports. In athletics and swimming, an understanding of aerodynamics and hydrodynamics allows for the optimization of movements to reduce air and water resistance, leading to increased athlete efficiency (Manshahia et al., 2016; Takagi et al., 2016; Zamparo et al., 2020). Meanwhile, in sports that require accuracy, such as archery and basketball, the concept of projectile trajectory and ball rotation dynamics can be utilized to improve shot accuracy (Adesida et al., 2019; Soltani & Morice, 2020). In other sports, such as soccer and tennis, aspects of friction and angular momentum also play a role in improving game strategies, such as optimizing the spin effect on the ball or controlling player movement (Liu et al., 2023; Naik et al., 2022). Not only in technical aspects, physics also plays a role in the development of sports equipment. The design of shoes with special soles, rackets with optimal balance, and aerodynamic clothing are real examples of how the use of physics principles can improve athlete performance and reduce the risk of injury (Harifi & Montazer, 2017). Therefore, understanding the concept of physics in sports education is crucial in supporting the development of sports science more broadly.

Several studies have explored the application of physics in various aspects of sports education, showing how the principles of mechanics, thermodynamics, and waves are used to enhance students' understanding of sports learning (Kirya et al., 2021; Kranjc Horvat et al., 2022; Parisoto & Pinheiro, 2016). More specific studies, such as those by Barbosa et al. (2023), highlight the role of biomechanical analysis in sports technique learning, while Hernández-Mustieles et al (2024) examine the use of biomechanical sensors to support technology-based learning processes. However, most studies are more oriented towards athlete performance and direct sports technique analysis, while studies that specifically examine how sports education students understand and apply physics concepts in learning are still limited. In fact, in the context of education, a deep understanding of physics principles can help students develop more effective science-based learning strategies, both in terms of theory, practice, and performance evaluation (Berie et al., 2022; Herodotou et al., 2019).

The rapid expansion of scholarly literature in this field underscores the critical need for a systematic review to synthesize existing knowledge, track evolving research trends, and map the intellectual structure of the discipline. Such an analysis not only identifies dominant themes and frequently debated topics but also illuminates the contributions of key researchers, institutions, and collaborative networks that have driven the field's progress. Among the methodologies available for analyzing research trends, bibliometric analysis has emerged as a powerful quantitative tool. By employing statistical techniques and data visualization, this approach enables large-scale evaluation of scientific publications, revealing patterns in citations, authorship dynamics, and thematic evolution (Skute et al., 2019). Beyond quantifying academic output, bibliometrics provides a holistic perspective on the field's development, highlighting research gaps and emerging frontiers. These insights are invaluable for designing future studies, particularly in underexplored or rapidly advancing areas. Against this backdrop, the present study utilizes bibliometric methods to examine publication trends over the past decade (2013–2023) in the application of physics to sports education.

Therefore, this study aims to analyze the trend of scientific publications related to the application of physics in sports education over the past decade using the bibliometric method. By exploring various publications over this period, this study is expected to provide broader insights into scientific developments in this field, identify emerging research directions, and provide perspectives for academics and practitioners in designing a more optimal physics-based sports education curriculum.

Methods

Design and Methods

This study employs bibliometric analysis to explore the trend of scientific publications related to the application of physics in sports education over the past decade. Bibliometric analysis was chosen because it provides a systematic approach to measuring and mapping research trends, identifying influential authors, institutions, and research themes in a particular field (Klarin, 2024). This method allows for a comprehensive assessment of the evolution of research topics and the structure of academic collaboration.

Data for this study were obtained from the Scopus database, one of the largest and most widely used academic databases for bibliometric analysis. Scopus was selected as the primary source because it covers a broad range of peer-reviewed literature across various disciplines and provides structured metadata for bibliometric studies (Donthu et al., 2021). The literature search was conducted using the query "TITLE-ABS-KEY (Physics AND Sport AND Education)" within the title, abstract, and keywords fields. The search covered the publication years 2015–2024 to capture the latest trends in this research area. The inclusion criteria were restricted to peer-reviewed journal articles, conference proceedings, review papers, book chapters, and other scholarly documents to ensure a comprehensive representation of research developments. Publications that were not relevant to the study, such as those focusing solely on general physics or unrelated sports sciences, were excluded through manual screening based on title and abstract analysis.

The selection of the 2015–2024 timeframe is justified by several factors. Over the past decade, there has been a significant increase in the integration of technology and physics-based approaches in sports education (Baca et al., 2022). This period has also seen rapid advancements in sports biomechanics, motion analysis, and physics-based training methodologies, particularly with the rise of data-driven sports science (Feng et al., 2020; Saura et al., 2023). Additionally, analyzing this specific period allows the study to identify emerging research trends and potential gaps to guide future studies (Skute et al., 2019).

After the initial search, a total of 83 documents were extracted, consisting of 42 journal articles, 26 conference papers, 5 errata, 4 review papers, 3 book chapters, 2 conference reviews, and 1 note. All data were exported in CSV and RIS formats and subsequently analyzed using VOSviewer version 1.6.20 and Microsoft Excel 365. VOSviewer was utilized to generate bibliometric maps that visualize co-authorship networks, keyword co-occurrences, and research clusters, while Microsoft Excel was used for statistical analysis of publication trends, including distributions by year, country, and institution. The selection process involved automatic filtering based on search criteria, manual screening of titles and abstracts to ensure relevance, and the removal of duplicate records or publications outside the intended scope of research.

Several bibliometric techniques were applied in this study. Co-authorship analysis was used to identify leading authors, institutions, and collaborative networks in the field of physics in sports education, allowing the mapping of research collaboration structures and highlighting key contributors. Co-occurrence analysis was conducted to examine the relationships between frequently appearing keywords, helping to identify major research themes and emerging trends in the field (Klarin, 2024). In addition, publication trend analysis was

Figure 1
Research workflow
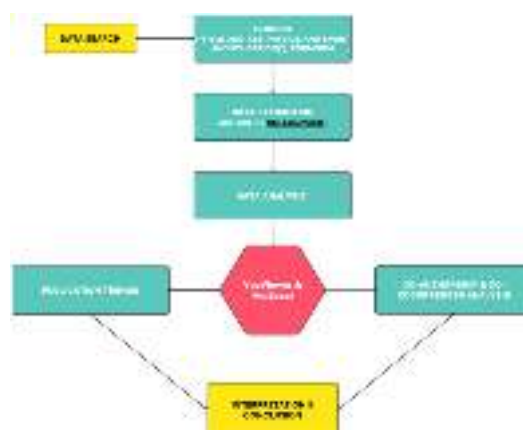
carried out using Microsoft Excel to track annual publication distributions, subject areas, and country-wise contributions, providing insight into the global research landscape. By integrating these bibliometric techniques, this study aims to offer a comprehensive overview of the development of physics applications in sports education, identify gaps in existing research, and provide insights for future investigations. The workflow of this research is illustrated in Figure 1.

Result

Recent Research Trends

The number of publications on a particular research topic serves as an indicator of research development and direction (Donthu et al., 2021). As shown in Figure 2, the research trend on Physics in Sports Education has fluctuated over the past decade, reflecting varying levels of academic interest in this field. In 2015, only five studies were published, followed by a slight increase to seven in 2016. A significant rise occurred in 2017, with the number of studies reaching 11. However, this momentum did not continue, as 2018 saw a sharp decline to just four publications. The trend rebounded in 2019 with eight studies and continued upward in 2020, returning to 11—the same peak as in 2017. The highest number of publications was

recorded in 2021, with 13 studies, marking the peak of research activity in this field. However, this was followed by another decline in 2022, where only six studies were published. In contrast, 2023 and 2024 showed stabilization, with nine studies each year. This fluctuation suggests that while interest in the topic remains present, it has yet to establish a consistent growth trajectory.

From a geographical perspective, as shown in Figure 3, the United States (US) leads in publication output, contributing 21 studies, making it the most active country in this research field. China follows with 12 publications, while Indonesia ranks third with 10 studies. Other countries such as Japan and Russia each

contributed six studies, whereas nations like the United Kingdom (UK), Canada, Italy, and Australia had a relatively lower number of publications, ranging between three and four. These differences in publication numbers may indicate regional variations in research priorities, funding availability, and institutional focus on the intersection of physics and sports education.

Co-Authorship Analysis

Collaboration among researchers plays a crucial role in shaping the development of a research field. In this study, Table 1 presents the co-authorship network based on Total Link Strength (TLS), which measures the intensity of an author's collaborative connections. A higher TLS value suggests a strong and well-established research network. The number of links represents direct collaborations between authors, while the number of documents reflects individual productivity in scientific contributions. The co-authorship network visualization, presented in Figure 3, reveals several research clusters that represent distinct approaches within the field. Among the most prominent clusters is Gabdrakhmanov et al. (2016) (TLS = 4), which explores pedagogical strategies for integrating physics concepts into sports curricula. Another key cluster is led by Suzuki et al. (2020) (TLS = 10), which focuses on the application of technology and simulation in physics-based sports training. Meanwhile, Sari et al. (2021, 2022) (TLS = 4) examines experimental methods for introducing physics concepts through sports activities, while Tang et al. (2021) (TLS = 4) specializes in biomechanics and motor skills development. The most influential contributions come from Fadly et al. (2017) and Zulfaris et al. (2017) (TLS = 18), whose research significantly advances the understanding of environmental factors, sports physiology, and the complex interplay between physics, health, and athletic performance.

Co-Occurrence Analysis

Figure 2

Publication trends by year
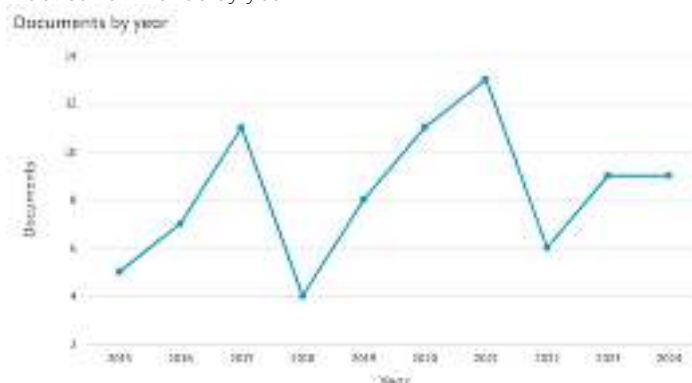
To gain a deeper understanding of the dominant research themes, a co-occurrence analysis was conducted, as summarized in [Table 2]. This analysis utilized two key metrics: occurrence, which represents the frequency of a keyword in the dataset and indicates its relevance to the field, and Total Link Strength (TLS), which measures the strength of a keyword's connection with other terms, highlighting its interdisciplinary significance. Initially, 778 keywords were extracted from publication titles and abstracts. To refine the analysis, a minimum occurrence threshold of two was applied, narrowing the selection to 104 relevant keywords for further examination.

The results reveal that the most frequently occurring keyword is "Sports," appearing 22 times with a Total Link Strength (TLS) of 30, indicating that the majority of research focuses on the application of physics in sports settings. Similarly, the keyword "Students" appears 20 times with a TLS of 46, highlighting the pedagogical emphasis on how learners grasp physics concepts within sports education.

This pedagogical relevance is further reinforced by the presence of "education" (13 occurrences, TLS = 22) and "physical education" (13 occurrences, TLS = 27), confirming the strong connection between this field and instructional strategies as well as curriculum development.

Beyond the educational focus, the analysis also points to an increasing integration of technology in sports physics education. Keywords such as "augmented reality," "interactive graphics," "tangible interaction," and "visualization" exhibit relatively high TLS values (ranging from 32 to 34), suggesting a growing reliance on digital tools for immersive learning experiences. This trend aligns with the co-authorship network, where Suzuki et al. (2020) emerged as a leading contributor to research on artificial intelligence, digital modeling, and simulation-based training.

In addition to technology, biomechanics and physiology have also emerged as significant research directions. Keywords such as "Biomechanics" (5 occurrences, TLS = 15), "Dynamics" (3 occurrences, TLS = 35), and "Physiology" (4 occurrences, TLS = 17) indicate that studies in this domain extend beyond education, emphasizing the role of physics principles in optimizing athlete performance and training methodologies. This focus is consistent with the Tang et al. (2021) cluster, which explores biomechanics and physical performance in sports.
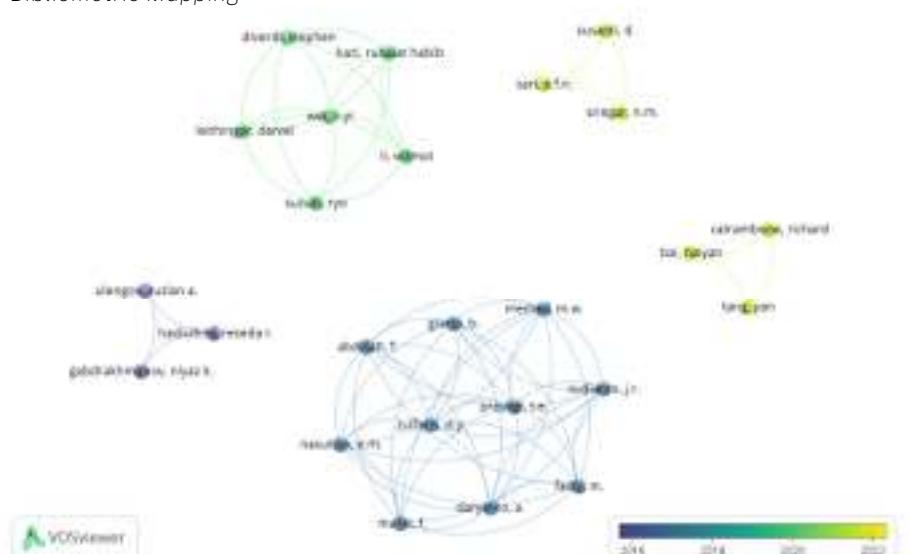
Discussion

The findings from the bibliometric analysis provide valuable insights into research trends, collaboration patterns, and thematic connections within the field of Physics in Sports Education. The fluctuations in publication trends over the past decade, as observed in Figure 2, may be attributed to various factors, such as shifts in researcher interest, funding availability, and technological advancements that influence the direction of research. The increases in 2017, 2020, and 2021 may indicate the impact of innovations or new discoveries in applying physics principles to sports training, whereas the declines in 2018 and 2022 might reflect reduced interest or challenges in conducting research during those periods.

The global distribution of research publications suggests that Physics in Sports Education has

Table 1
Co-Authorsip Analysis

No	Authors	Documents count	Total Link Strength	Cluster

Figure 3
Bibliometric Mapping

gained significant attention in specific regions. The high number of publications from the United States indicates the presence of a strong research ecosystem, substantial funding support, and an emphasis on integrating technology into education and sports. China's notable contribution aligns with its national policies aimed at advancing science, technology, and sports education. Indonesia's position as the third-largest contributor highlights its growing efforts to enhance physics education and sports science development. Meanwhile, Japan and Russia, with moderate publication numbers, may reflect their respective emphases on technology-driven education and sports science traditions. The lower publication numbers from the UK, Canada, Italy, and Australia suggest that while research in this domain exists, academic focus in these countries may be directed toward other aspects of science or sports education.

Beyond publication trends, the analysis of co-authorship patterns reveals important insights into the nature of collaboration in this field. Bibliometric mapping using VOSviewer identified several research clusters that reflect different approaches to understanding and applying physics concepts in sports education. The prominent cluster is the Gabdrakhmanov et al. (2016) cluster, which has a TLS of 4. Research in this cluster focuses on pedagogical approaches to integrating physics concepts into sports curricula. Many studies in this cluster explore concept-based learning strategies, the effectiveness of teaching methods, and their impact on students' understanding in connecting physics theories with everyday sports phenomena.

On the other hand, the Suzuki et al. (2020) cluster shows a dominance of research that links technology and simulation in physics learning and sports training. With a TLS of 10, research in this group focuses more on the use of augmented reality (AR), artificial intelligence (AI), and digital modeling to analyze athlete movements and improve training effectiveness. This cluster provides an important perspective in the development of technology-based learning aids, which can help students understand physics principles more deeply and interactively. Then, the Experimental and Laboratory-based Approach is seen in the Sari et al. (2021, 2022) clusters, with a TLS of 4. Studies in this cluster discuss experimental methods that can be applied to introduce physics concepts such as force, energy, and momentum in sports activities. This approach is a strategy that can strengthen students' critical thinking skills, especially in analyzing sports events using scientific principles. Meanwhile, the Tang et al. (2021) clusters are more oriented towards biomechanics and motor skills, with a TLS of 4. The main focus of research in this cluster is how the laws of physics can be used to improve athlete performance in various sports. This study highlights how a deep understanding of physics can help in modifying training techniques and optimizing body posture and balance, which are not only relevant to athletes but can also be applied in movement-based learning in the classroom.

Finally, the Fadly et al. (2017) and Zulfaris et al. (2017) clusters reflects research with a broader scope, covering various aspects such as the environment, sports physiology, and the relationship between physics, health, and athlete performance. This cluster has the highest TLS, which is 18, indicating a wider collaboration network than other clusters. External factors such

Table 2
Co-Occurence Analysis

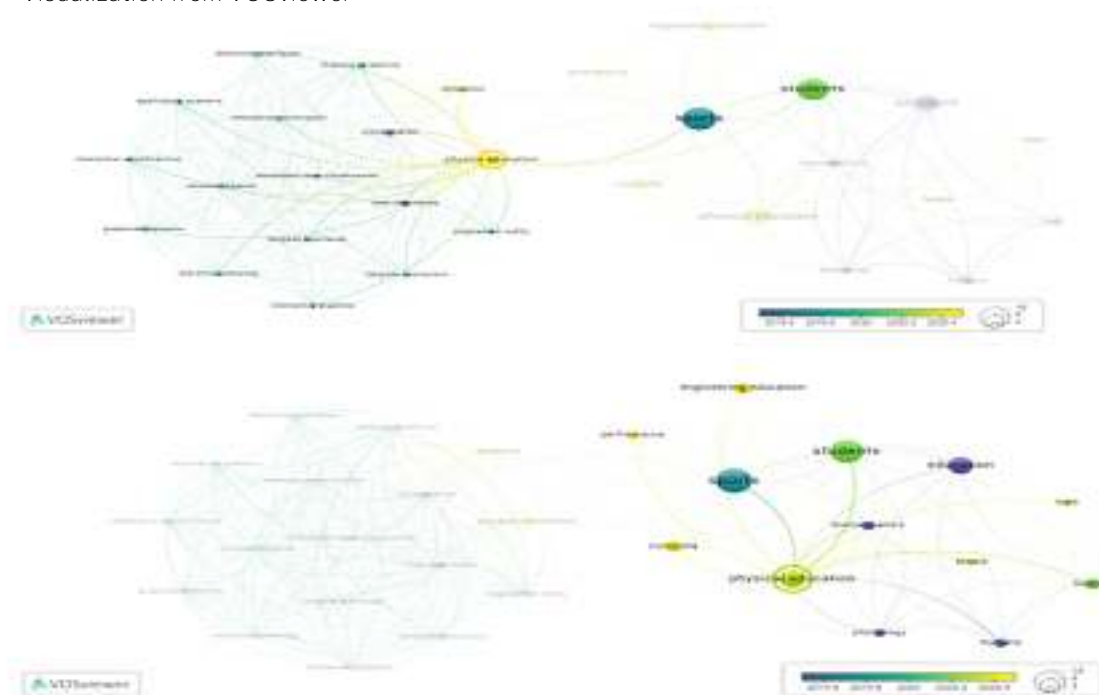| No	Keywords	Occurrences	Total Link Strength
	Students	20	46
	Dynamics	3	35
	physics education	6	35
	user interfaces	3	34
	Visualization	3	34
	application scenario	2	32
	augmented reality	2	32
	drawing (graphics)	2	32
	embedded data visualization	2	32
	graphical elements	2	32
	interaction techniques	2	32
	interactive graphics	2	32
	interactive visualizations	2	32
	physical objects	2	32
	real-time authoring	2	32
	sketching interfaces	2	32
	tangible interaction	2	32
	tangible interfaces	2	32
	Sports	22	30
	physical education	13	27
	Human	7	24
	Education	13	22
	Humans	5	21
	Curricula	7	19
	Physiology	4	17
	Biomechanics	5	15
	engineering education	7	14
	Female	3	13
	Male	3	13
	Performance	4	11

as temperature, humidity, and air quality are the main concerns in this study, indicating that physics learning in the context of sports is not only limited to mechanical aspects, but also involves interaction with environmental conditions. From the results of the co-authorship analysis, it can be seen that although research on physics in sports education is developing in various directions, there are still challenges in building connections between clusters. Most research is still fragmented, with limited collaboration within a particular discipline. In fact, strengthening connections between these fields is very important to encourage interdisciplinary research, which can lead to a more comprehensive approach to teaching physics to students. This finding is in line with the bibliometric study conducted by Liu et al. (2023), who found that research in this field still tends to be separated into different clusters, thus hampering innovation in learning methodology and application of technology in the field of sports.

In the context of this study, the bibliometric analysis conducted aims to understand how a systematic approach to problem solving can play a role in improving students' analytical skills, especially in filtering and evaluating information in the digital era. This is reinforced by the research of Deák et al. (2021), which highlights that science-based learning that integrates an interdisciplinary approach can significantly improve students' critical thinking skills. With the increasing trend of research in this field, there is a great opportunity to develop a science-based learning model that not only teaches physics concepts theoretically, but also trains critical and systematic thinking patterns in dealing with information circulating in society. Research by Naylor et al. (2015) highlights that a science-based approach in sports education has the potential to strengthen students' critical thinking skills, especially in evaluating athlete performance data objectively.

These findings provide perspectives for academics and practitioners to strengthen integration between fields, encouraging interdisciplinary research, and optimizing science-based curriculum in sports education. With closer cooperation, it is hoped that studies on the application of physics in sports education can continue to develop and provide a more significant impact on strengthening scientific literacy and critical thinking skills of students. Despite the diversity of research directions, the co-authorship analysis also reveals a challenge: the fragmentation of research clusters. Most collaborations remain confined within specific disciplines, limiting interdisciplinary connections. Strengthening linkages between these research areas is crucial for fostering a more integrated approach to teaching physics in sports education. This aligns with the findings of Liu et al. (2023), who noted that research in this field remains divided into distinct clusters, hindering broader methodological innovation. Encouraging cross-disciplinary research can bridge these gaps, facilitating a more holistic application of physics concepts in sports education.

Figure 4
Visualization from VOSviewer

The keyword co-occurrence analysis further reinforces these findings. The results of the co-occurrence analysis show that the most dominant keywords in this study are sports with 22 occurrences and a total link strength of 30, and students which appeared 20 times with a total link strength of 46. The dominance of these two words indicates that most studies in this field focus on how physics concepts are applied in the world of sports and how students understand and apply them in the context of learning. In addition, the presence of the keyword's education and physical education, each with 13 occurrences and a total link strength of 22 and 27, further emphasizes that this study has a strong pedagogical orientation, both in the context of teaching physics and physical education. In addition to the pedagogical aspect, this analysis also reveals trends in the use of technology to support physics learning in sports. Keywords such as augmented reality, interactive graphics, tangible interaction, and visualization have a fairly high total link strength, ranging from 32 to 34, which shows that interactive visualization and augmented reality-based technology are increasingly used in learning. This finding is in line with the results of the co-authorship analysis, where one of the main clusters consisting of Suzuki et al. (2020) focus on the development of technologies such as artificial intelligence, digital modeling, and simulation for athlete motion analysis and improving training effectiveness.

On the other hand, research related to biomechanics and physiology aspects in sports also shows considerable significance in this research network. Keywords such as biomechanics with 5 occurrences and a total link strength of 15, dynamics with 3 occurrences and a total link strength of 35, and physiology with 4 occurrences and a total link strength of 17, illustrate that this field does not only focus on learning aspects, but also on how the laws of physics can be applied to improve athlete performance and develop more effective training techniques. This finding is in line with the Tang et al. (2021) cluster in the co-authorship analysis, which shows that research in this field is often closely related to physical performance and biomechanics aspects in sports.

Visualization from VOSviewer in Figure 4 further clarifies the pattern of keyword associations in this study. Physics education has a fairly strong relationship with various concepts of data visualization and interaction, such as interactive visualizations, augmented reality, and user interfaces, indicating that technological approaches are increasingly being used to enhance physics learning in the context of sports. In addition, sports are closely related to students, education, and biomechanics, while physical education is often associated with sports, curriculum, and performance, which confirms that there is a lot of research on how physics is applied in physical education, both in the curriculum and in improving athletic performance. In terms of research trends based on publication year, there are differences in color in the visualization that reflect the development of this field. More yellow

colors indicate that topics such as performance and engineering education are newer areas (2020 and later), while bluish green colors indicate that areas such as students and sports have been widely researched since around 2019. The focus on interactive visualization and augmented reality in physics education emerged earlier but remains an important area. In addition, the close relationship between physics education and various visualization methods on the left side of the graph, such as interactive visualizations, embedded data visualization, and augmented reality, further confirms that this technology-based approach is an important part of teaching physics in the context of sports.

Although research in this area continues to grow, the analysis also reveals limitations in the interrelationships between the fields. The visualization results show that research in the field of Physics in Sports Education is still fragmented, with collaborations tending to be limited to a specific disciplinary scope. In fact, strengthening the connections between physics, technology, biomechanics, and pedagogy can produce a more holistic approach in science and sports education. This is supported by the findings of Abrahamson & Mechsner (2022), who highlighted the importance of synergy between physics and sports science in developing more effective learning methods. In addition, Cossich et al. (2023) emphasized that the integration of data-driven technology in sports education not only improves students' scientific literacy but also helps them develop stronger analytical skills. As this research trend continues to grow, further attention is needed to how the various approaches in this field can be integrated to create more comprehensive learning and research models.

Future Implication

The findings of this study provide deeper insights into the development of physics in sports education, revealing established research patterns over the past decades. Through bibliometric analysis, it was identified that studies in this field extend beyond understanding theoretical physics concepts. They encompass applications in biomechanics, athlete training technologies, and curriculum development for students and prospective coaches. This aligns with Ji et al. (2022), who emphasized the crucial role of physics-based biomechanics in optimizing athletic techniques and designing more effective training strategies.

Moving forward, this study highlights opportunities to further integrate science-based approaches into sports education. The co-occurrence analysis suggests a growing trend in the use of technologies such as augmented reality, interactive visualization, and tangible interfaces in learning, indicating a shift toward more simulation-based and interactive training methods. Supporting this, Li et al. (2024) found that virtual reality-based simulations significantly enhance athletes' comprehension of motion mechanics, while Cossich et al. (2023) demonstrated that artificial intelligence-based performance analysis provides more accurate feedback for athletic improvement.

Moreover, the study underscores the importance of stronger interdisciplinary collaboration between physics, biomechanics, education, and technology to develop more effective and applicable teaching methods. Integrating sports physics research with coaching curricula can foster evidence-based training methods that align with technological and scientific advancements.

A systematic approach to curriculum design is needed. Fundamental physics concepts—such as mechanics, dynamics, and thermodynamics—should not only be taught theoretically but also applied in real sports practice. The increasing use of digital simulations in training presents an opportunity to develop learning modules that combine laboratory-based experiments with virtual technology, enabling students to better understand the direct relationship between physics principles and athletic performance. Clyne & Billiar (2016) found that integrating biomechanics laboratories with digital simulations significantly enhances students' learning experiences, reinforcing the potential benefits of such an approach.

Furthermore, this study provides insights for educational institutions in optimizing physics-based coaching curricula. By recognizing the strong link between physics and various aspects of sports, future coaches can be equipped with scientific insights to analyze athlete movements, design more effective training strategies, and leverage emerging technologies for performance optimization. This transition toward research-based learning could establish a scientific foundation for coaching methodologies, fostering a more analytical approach to athlete development.

Recent trends indicate a shift in sports education from merely understanding physics concepts to applying them in performance optimization and data-driven coaching strategies. This aligns with advancements in training systems engineering and the increasing use of digital simulations, artificial intelligence, and biomechanical modeling. Future research could focus on leveraging these technologies to personalize training programs and enhance coaching efficiency. Rana & Mittal (2021) demonstrated that machine learning-based analysis in sports

biomechanics allows real-time adjustments to training programs based on data collected from motion sensors, highlighting the growing role of artificial intelligence in sports science.

While these developments offer promising prospects, several challenges must be addressed. The integration of physics-based training methodologies may face barriers such as limited access to advanced technologies in developing countries, resistance from traditional coaching systems, and the need for interdisciplinary expertise among educators and coaches. Strengthening institutional support and fostering collaboration among physics educators, sports scientists, and technology developers will be essential in overcoming these obstacles.

Given these findings, research in physics and sports education still has vast potential for expansion. The integration of physics, technology, and pedagogy will be crucial in developing more effective teaching and coaching methods while enhancing scientific literacy among students and sports practitioners. Strengthening interdisciplinary collaboration and embracing cutting-edge technology will accelerate progress in this field, ensuring that physics education in sports remains relevant to contemporary needs and continues to provide meaningful contributions to both academia and the sports industry.

The results of the study show that the study of physics in sports education has grown significantly in the last decade, with a wider focus including biomechanics, coaching strategies, and optimizing athlete performance. Bibliometric analysis reveals that the integration of physics concepts in the education of prospective coaches is not only theoretical, but also applied, with the use of technology in motion simulation and athlete performance analysis. In addition, the mapping of academic collaborations shows that research in this field increasingly involves various institutions and disciplines, especially in developing evidence-based approaches to improve the effectiveness of learning and coaching. These findings confirm that understanding physics in the context of sports has an important role in improving the quality of learning and coaching practice, thus requiring a more structured and innovation-based approach.

In line with these developments, further exploration is needed regarding the integration of technology such as augmented reality and interactive visualization in physics learning for prospective sports coaches to improve conceptual and applied understanding. In addition, cross-disciplinary collaboration between physics, education, and sport science must be strengthened to develop a more innovative curriculum based on the needs of the sports

industry. Strengthening academic networks and practice-based research is also a strategic step in ensuring that the developed approach is not only theoretical, but also able to provide concrete solutions for the world of coaching. Thus, scientific literacy in sports can be increasingly relevant and contribute significantly to improving athlete performance and the effectiveness of coaching methods in the future.

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Game Analysis of Scoring Strokes in Men's Singles and Men's Doubles Badminton

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Abstract

This study aims to analyze the effectiveness of various strokes in scoring points in men's singles and doubles badminton, as well as to determine the contribution of each stroke to overall scoring performance. Badminton requires a blend of technical skill, tactical awareness, and physical endurance, with notable differences in strategy and stroke selection between singles and doubles formats. A descriptive comparative research design was employed, using game analysis as the primary method. The study involved eight randomly selected active players from a population of 30 athletes in the UPI Badminton Club. Data were collected through simulated matches consisting of eight sets, with stroke occurrences recorded using the sign system method. Statistical analyses were conducted using the Independent Samples T-Test or the Mann-Whitney U Test, depending on data distribution. The results indicate that Smash Shot, Drive Shot, and Cut Drop Shot showed statistically significant differences in effectiveness between singles and doubles formats ($p < 0.05$). In contrast, Drop Shot, Net Shot, Clear Shot, Jump Smash Shot, Cut Smash Shot, and Net Kill Shot did not present significant differences ($p > 0.05$). These findings suggest the importance of tailoring training strategies based on the specific demands of singles and doubles play. Singles players are advised to prioritize strokes that emphasize control and endurance, while doubles players should focus on rapid, well-coordinated shot execution. This study offers practical insights for coaches and athletes aiming to optimize performance through format-specific training.

Keywords: badminton, game analysis, playing strategy, scoring, stroke techniques

Introduction

Badminton is a sport that requires a combination of technical skills, tactical awareness, and physical endurance (Faude et al., 2009; Milon, 2014). The differences between singles and doubles matches influence the playing styles, strategies, and techniques used by athletes (Alcock & Cable, 2009). In men's singles, players must cover the entire court independently, requiring them to develop endurance, precise shot placement, and a variety of stroke techniques (Armstrong et al., 2023; Morgans et al., 1987). On the other hand, men's doubles rely on teamwork, quick reflexes, and specialized shot selection to optimize court coverage and counter opponents' strategies (Armstrong et al., 2023; Terry et al., 1996).

Understanding the technical differences between singles and doubles play is crucial for improving training methodologies, optimizing performance, and guiding player development. Additionally, researchers have developed models to identify significant shots and their influence on rally outcomes, incorporating both technical and contextual variables (Sheng et al., 2022; Wang et al., 2022). With the increasing competitiveness in university-level badminton, a deeper insight into effective scoring strokes is necessary to enhance player performance. Despite numerous studies on general badminton techniques, there is still a gap in research specifically addressing scoring strokes and their impact in different playing formats.

Previous studies have highlighted variations in movement patterns and stroke execution between singles and doubles players. Singles players exhibit higher heart rates, take more steps, and move at higher velocities compared to doubles players (Alcock & Cable, 2009; Morgans et al., 1987). In badminton, singles play involves more shots to the extreme fore- and rear-court, while doubles feature a greater diversity of shots (Alcock & Cable, 2009). Tennis movement patterns reveal distinct sequences, with split steps as initial movements, followed by side steps and strides to reach the ball, and strides and side steps for recovery (Hughes & Meyers, 2005). A dynamical systems perspective in badminton reveals in-phase and anti-phase patterns of player movements, with speed scalar product serving as a potential collective variable to distinguish cooperative and competitive play (Chow et al., 2014). However, these studies did not specifically examine the most effective strokes in scoring points, making this research essential to bridge the existing knowledge gap.

This study offers a novel perspective by focusing on game analysis to determine which strokes are most effective in scoring points. Unlike prior research that mainly emphasized general stroke mechanics or tactical approaches, this research provides empirical data on scoring efficiency in different game formats. By employing video analysis and statistical methods, this study contributes new insights to badminton performance optimization.

The findings of this research will be beneficial for coaches, athletes, and sports educators in refining training regimens and tactical strategies. By identifying which strokes contribute most to scoring points, this study can help optimize skill development programs tailored for both singles and doubles players. Furthermore, this research will serve as a reference for future studies in the field of sports science and badminton performance analysis.

This study aims to investigate stroke utilization and performance in badminton among players at UPI Badminton Club, focusing on men's singles and doubles matches. Specifically, the research seeks: (1) to analyze the frequency and effectiveness of different strokes (e.g., smashes, drops, clears) in both singles and doubles play, identifying patterns and preferred techniques; (2) to compare scoring efficiency between singles and doubles players, examining how stroke selection and execution impact point outcomes; and (3) to develop evidence-based recommendations for tailored training programs that address the distinct demands of each format. By combining quantitative stroke analysis with practical insights, this study intends to enhance player development strategies and optimize competitive performance at the club level.

Methods

Design and Methods

This study employs a descriptive comparative research design, which aims to analyze and compare scoring strokes between men's singles and men's doubles players. Descriptive research is used to collect and analyze ongoing events, while comparative research compares different variables—in this case, stroke techniques leading to scoring.

The primary variable in this study is badminton stroke techniques. The research design focuses on analyzing the characteristics of stroke techniques in men's singles and men's doubles play through game analysis.

Participants

The participants in this study are active members of the UPI Badminton Club who have consistently trained for the past year. The selected participants are male players willing to participate in simulated games, with each game consisting of

8 sets. A total of 8 players were randomly selected from the club's population.

The study population consists of all male badminton players at the UPI Badminton Club, totaling 30 individuals. The research sample was selected using a simple random sampling technique, ensuring each member had an equal chance of being chosen. This method was employed to obtain a representative sample of 8 players, allowing for an unbiased comparison between singles and doubles performances.

Instrument

The primary instrument used in this study is the sign system method, where observations are recorded using tally marks on a scoring sheet. The scoring sheet, adapted from Rahmi (2014) and Brahms (2010), categorizes different stroke techniques and their contributions to scoring points. This method ensures systematic data collection by tracking each successful stroke leading to a score.

Procedure

The study was conducted in several stages. First, the research problem was formulated to identify key questions regarding stroke effectiveness in singles and doubles play. Next, a descriptive comparative approach was selected to analyze and compare the effectiveness of different strokes.

The research instruments were then determined, with a sign system employed to systematically record scoring strokes. The study population, consisting of active male players at the UPI Badminton Club, was identified, and a random sampling method was used to select 8 participants.

Data collection was carried out through match simulations, with each game consisting of 8 sets. During these simulations, all strokes leading to a score were recorded for analysis. Finally, the collected data were processed and analyzed to compare stroke effectiveness between singles and doubles play, providing insights into optimal techniques for scoring points.

Data Analysis

The collected data were analyzed using statistical methods to determine scoring stroke effectiveness. The normality of the data was first tested. If the data followed a normal distribution, the Independent Sample T-Test was used to compare singles and doubles stroke efficiency. If the data were not normally distributed, the Mann-Whitney U test was applied. The confidence level for statistical analysis was set at 95% (α = 0.05). All analyses were performed using SPSS 21.

This structured approach ensures the reliability and validity of the findings, contributing to a deeper understanding of scoring stroke effectiveness in men's singles and men's doubles badminton.

Result

The analysis of scoring strokes in men's singles and men's doubles badminton at UPI Badminton Club focused on the effectiveness of different stroke techniques. The study recorded the frequency and impact of each stroke type to determine their contribution to scoring points.

Table 1 presents the statistical results for each stroke type, including the T-value, significance level (Sig. 2-tailed), and whether the difference is statistically significant.

The hypothesis testing was conducted using the Independent Sample T-Test to determine whether there were significant differences in scoring stroke effectiveness between singles and doubles players. The decision criteria were based on a significance level of α = 0.05.

The analysis revealed significant differences in the effectiveness of specific strokes between singles and doubles matches. The smash shot demonstrated a statistically significant difference (p = 0.041), suggesting that its

Table 1

Independent Samples t-test Comparing Stroke Techniques Between Men's Singles and Men's Doubles Players

No	Stroke Technique	Men's Single		Men's Double		t	Sig
		M	SD	M	SD		
1	Smash Shot	8.2	1.5	6.7	1.8	-2.252	0.041*
2	Drop Shot	5.1	0.9	4.3	1.2	1.735	0,084
3	Net Shot	3.8	0.7	3.8	0.6	0.000	1.000
4	Drive Shot	7.5	1.2	9.1	1.4	-2.750	0.016*
5	Clear Shot	6.4	1.1	5.9	1.3	-1.141	0,189
6	Jump Smash Shot	4.7	0.8	5.3	1.0	-1.655	0,083
7	Cut Smash Shot	3.9	0.6	4.3	0.7	-1.414	0,124
8	Net Kill Shot	2.5	0.5	3.1	0.6	-2.252	0.073
9	Cut Drop Shot	4.2	0.9	5.1	1.1	-2.213	0.027*

*Significance

execution and impact vary depending on the format of play. Similarly, the drive shot (p = 0.016) showed a significant distinction, indicating that players employ this technique differently in singles compared to doubles. Additionally, the cut drop shot (p = 0.027) exhibited a meaningful difference, reinforcing the notion that stroke selection is influenced by the tactical demands of each match type.

On the other hand, several other strokes, including the drop shot, net shot, clear shot, jump smash shot, cut smash shot, and net kill shot, did not show statistically significant differences (p > 0.05) between singles and doubles play. This suggests that these strokes are utilized with relatively similar effectiveness across both match formats.

Discussion

The findings of this study align with previous research highlighting the differences in stroke execution between singles and doubles play. According to (Phomsoupha & Laffaye, 2020), singles players tend to prioritize endurance and precise shot placement, whereas doubles players focus on aggressive, fast-paced exchanges requiring quick reflexes. Male singles players show higher cardiopulmonary endurance, while male doubles players demonstrate superior strength and agility. Doubles disciplines generally have lower work-to-rest ratios, with men's and mixed doubles characterized by shorter rally times and higher shot frequencies (Gawin et al., 2015). This is consistent with our findings, where Drive Shot and Smash Shot were significantly more effective in doubles play, supporting the notion that doubles play emphasizes speed and power over sustained rallies.

Furthermore, the effectiveness of Cut Drop Shot in singles play reinforces the findings of (Cabello Manrique & González-Badillo, 2003), who stated that controlled strokes like drop shots are more advantageous in singles, where maintaining court control and disrupting the opponent's positioning are crucial strategies. The stroke performance relevance (SPR) method reveals that deeper and closer-to-sideline shots yield better scores across court surfaces in men's single match (Liu et al., 2022). Skilled players intentionally disguise backhand drop shots by using exaggerated shoulder rotation and forward body movement, making their shots less predictable (Iwatsuki et al., 2016). The lack of significant differences in strokes such as Clear Shot and Net Shot suggests that these techniques hold similar strategic value across both formats, further supporting research by (Abián et al., 2014), which indicated that clear shots are essential for

both defensive and attacking transitions. The overhead defensive clear, in particular, is an essential skill for beginners to master (Alkhawaldeh & Altarawneh, 2023). Research has shown that the clear is one of the most frequently used shots in international competitions, along with lifts and net shots (Lee et al., 2005). To improve clear shot technique, visual search feedback has been found to be effective, with players showing significant improvement after incorporating visual search ability exercises into their training (Xiao & Tasnaina, 2025).

These results provide crucial insights for training strategies, as they highlight the necessity for singles players to refine endurance-based techniques while doubles players must enhance reaction speed and teamwork in executing aggressive strokes.

Conclusion

Based on the data analysis, this study demonstrates that there are significant differences in the effectiveness of certain stroke techniques between men's singles and men's doubles at the UPI Badminton Club. Statistical tests revealed that Smash Shot, Drive Shot, and Cut Drop Shot showed significant differences in their contribution to scoring performance in both game formats.

In contrast, Drop Shot, Net Shot, Clear Shot, Jump Smash Shot, Cut Smash Shot, and Net Kill Shot did not exhibit significant differences, indicating that their effectiveness remains relatively consistent across singles and doubles matches.

These findings provide valuable insights for coaches and players in developing more effective training strategies. Singles players should focus on shot accuracy and endurance, whereas doubles players should enhance reaction speed and coordination for dynamic strokes such as Drive Shot and Smash Shot.

Thus, this study contributes to the development of more specialized training methods tailored to the distinct demands of singles and doubles play. It also serves as a reference for performance analysis in badminton, helping to optimize player development and game strategies.

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The Effect of Target Training Model Interpass Shoot on Football Shooting Accuracy of SSB Talang Pantai Students

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Abstract

This research stems from the issue of insufficient application of shooting training methods, leading to frequent inaccuracies in shooting accuracy, improper foot-to-ball contact, and inconsistent power output. These factors contribute to students' poor mastery of shooting techniques. This study aims to determine whether target training and interpass shooting exercises influence the shooting accur. This study is an experimental research with a quantitative approach. The population in this study consists of all students of SSB Talang Pantai, Muara Bungo, totaling 20 individuals. The sampling technique used is total sampling, resulting in a sample of 20 students. The results of this study indicate that: (1) The first hypothesis, which states that target training influences shooting accuracy in SSB Talang Pantai students, is supported by a t-value of 7.216, while the critical t-table value is 2.262 at a significance level of 0.05. Since the t-value is greater than the t-table value, the alternative hypothesis (Ha) is accepted, and the null hypothesis (Ho) is rejected. (2) The second hypothesis, which states that interpass shooting training influences shooting accuracy in SSB Talang Pantai students, is supported by a t-value of 7.606, while the critical t-table value is 2.262 at a significance level of 0.05. Since the t-value is greater than the t-table value, Ha is accepted, and Ho is rejected. (3) The third hypothesis, which states that there is a difference in the effect of target training and interpass shooting training on shooting accuracy in SSB Talang Pantai students, is supported by a t-value of 2.357, while the critical t-table value is 2.100 at a significance level of 0.05. Since the t-value is greater than the t-table value, Ha is rejected, and Ho is accepted, indicating that there is a significant difference between the two training methods.

Keywords: accuracy, intercept shoot, shooting, target aim

Introduction

Football is one of the most popular competitive sports worldwide, enjoyed by people of all ages, including in Indonesia, particularly among males ranging from children to adults. Many individuals engage in football as a way to pursue their hobby. Psychologically, boys tend to be more attracted to games that require various types of movements, as they often showcase their motor skills in different situations.

Peak performance achievement can be attained through a structured development process, starting from the beginner level to elite athletes or from early childhood to adulthood. The development of young or early-age football players requires coaches, physical education teachers, and football trainers to carefully and precisely guide their students or athletes. Therefore, coaches, physical education teachers, and football trainers must understand the characteristics of their students or athletes according to their age level.

Developing skilled football players requires proper education or Football Schools (SSB) that serve as a platform for nurturing young talents and advancing football in Indonesia. In Jambi Province, particularly in Muara Bungo Regency, football has experienced significant growth, with many regions establishing football schools to foster a new generation of players. One of the most actively growing football schools in the area is SSB Talang Pantai.

Achieving excellent performance in football requires mastery of fundamental football techniques. To maximize performance in the sport, an athlete must pay close attention to key determining factors. These determining factors can be categorized into four main aspects: (1) physical condition or fitness level, (2) accuracy of techniques or acquired skills, (3) supporting factors, and (4) environmental influences.

The fundamental techniques that a football player must master include kicking, stopping, dribbling, heading, tackling, throw-ins, and goalkeeping. One of the most crucial fundamental techniques for beginners is kicking, particularly passing and shooting. Passing and shooting are essential skills used to transfer the ball from one location to another using the foot or specific parts of the foot. A football player who fails to master proper kicking techniques will struggle to become a skilled and proficient player.

Shooting is the act of kicking the ball forcefully toward the goal to score. It is one of the most challenging aspects of football, as it requires precision, skill, and strategic thinking to make the shot unreachable or difficult for the goalkeeper to save. The fundamental shooting technique can be categorized into two types: shooting with the instep (top of the foot) and shooting with the toe or the tip of the shoe.

Based on field observations conducted from October 4–6, 2022, at the Talang Pantai field, it was evident that students still had a low level of proficiency in shooting techniques. SSB Talang Pantai students often failed to direct their shots accurately toward the target. This lack of mastery in basic football techniques and skills has contributed to their low achievement levels. Additionally, other issues identified include improper foot-to-ball contact and unstable power output during shooting. These problems are primarily caused by a lack of shooting training variations or inadequate implementation of effective shooting training methods, which has hindered SSB Talang Pantai students from achieving optimal performance.

Literature Review

Definition of Soccer

Football is a team sport played with a soccer ball between two teams, each consisting of 11 players. During play, players are allowed to use all parts of their body except their hands and arms, with the exception of the goalkeeper, who is permitted to handle the ball within the penalty area. According to Wahyudi (2020:2).

According to Mahfud in Syukur (2022:149), football is the most popular team sport in the world and has even become a national sport in almost every country. Compared to other sports, football has a unique appeal. Its attractiveness lies in ball-handling skills, physically demanding performance, dynamic movements, and tactical surprises that captivate spectators. Football matches are among the most widely enjoyed sports today, as evidenced by their presence across nearly every part of the world. This sport serves various purposes, including education, recreation, and achievement development.

According to Kumbara (2017:28), football is a team sport that incorporates a wide range of movements. The desire to win and satisfy spectators is always present in every player. This strong ambition, combined with encouragement from coaches, management, and other elements within the competitive environment, often leads to the emergence of new performance styles among athletes. However, despite the strong desire to win, some athletes may experience psychological challenges due to social pressures in the competitive setting, such as demands from coaches, spectators, and management, as well as the overall intensity of the match. As a result, athletes may exhibit psychological reactions such as emotional fluctuations, anger, joy, or anxiety.

Based on the opinions of the experts mentioned above, it can be concluded that football is a team sport played by two teams, each consisting of 11 players, including a goalkeeper. The objective of the game is to score goals by sending the ball into the opponent's net while defending one's own goal to prevent conceding goals. The match duration is 2 × 45 minutes.

Football Shooting

According to Anam (2021), shooting is a powerful kick directed toward the goal. Although shooting is relatively easy to execute, it requires a high level of accuracy to make it difficult for the goalkeeper to anticipate, thereby increasing the likelihood of scoring a goal.

According to Wardana (2018), shooting is a fundamental technique of kicking the ball toward the goal with the aim of scoring. To execute an effective shot, several principles regarding timing must be considered, including having sufficient space to kick, adequate time to perform the shot, and ensuring that no teammate is in a more advantageous position.

Shooting is a kick performed by a football player using the instep to score a goal against the opponent's net. Shooting is a fundamental technique in football and plays a crucial role in finishing. Poor shooting technique often results in missed goal-scoring opportunities (Hidayat, 2018).

According to Sucipto, as cited in Faisal (2018:18), shooting is a kick that begins by placing the supporting foot beside and parallel to the ball. The knee is slightly bent, and the kicking foot is swung backward before making contact with the ball using the instep. After executing the shot, body balance should be maintained using both arms.

Based on the explanation above, it can be concluded that shooting in football is a kick performed by a player by striking the ball with maximum power and directing it toward the goal with the aim of scoring against the opponent.

Target Practice

One variation of training to improve shooting accuracy is by modifying the target. Target modification is implemented to enhance players' attention. The function of visual attention has been reported as crucial for sports performance in high-pressure situations (Brimmell in Anam, 2021). Shooting training variations that incorporate target modification fall under the classification of game-based approaches in tactical training, focusing on activities that require precision and high accuracy to achieve points.

According to Juliansyah (2021), "Target games are games that demand concentration, composure, focus, and high accuracy in their execution." This type of game serves as a foundation for many other sports, as almost every sport involves a specific target or goal. For instance, basketball, football, and other sports feature various types of target-oriented objectives.

Based on the explanation above, target-based training is a shooting drill in football that utilizes target objectives as an aid to enhance accuracy and performance.

Interpass Shoot Practice

Interpass shooting is the act of striking the ball with power and accuracy toward a teammate—whether a defender, midfielder, or forward—who then continues the play to score a goal. This technique is one of the most challenging aspects of the game, as it requires players to be both precise and strategic in passing the ball to prevent opponents from intercepting it while creating shooting opportunities to score (Faisal, 2018).

The Nature of Exercise

Training is a systematic and repetitive process conducted over a relatively long period, with progressively increasing training loads to enhance the body's overall motor response and adaptation.

According to Bafirman (2013:40), training is a systematic and long-term sports activity that is progressively and individually increased, aiming to develop the physiological and psychological functions of humans to achieve specific goals. Through physical training, individuals work toward achieving particular objectives. From a physiological perspective, training aims to enhance the body's systems and functions to optimize athletic performance and overall sports achievement.

According to Harsono (2015:50), "Training is a systematic process of practicing or working repeatedly, with a gradual increase in the amount of training or workload over time."

Based on the explanations of the experts above, training is a form of physical activity conducted systematically according to training procedures. It is performed repeatedly with the aim of achieving physical improvements in an individual.

Methods

Type of Research

This study is an experimental research study with a quantitative approach. According to Sugiyono (2019:107), experimental research methods can be defined as research methods used to examine the effect of a specific treatment on other variables under controlled conditions.

According to Sugiyono (2019:17), quantitative research is defined as a research method based on positivist philosophy, used to study a specific population or sample. Data collection is conducted using research instruments, and data

analysis is quantitative or statistical in nature, aiming to test predetermined hypotheses.

The research design employs a two-group pretest-posttest design. This experimental design includes two sets of measurement data: pretest (O1) and posttest (O2). The selected data analysis technique is the two-sample t-test. The hypothesis tested is singular, namely, whether there is a difference between the mean pretest score and the mean posttest score.

The two-group pretest-posttest research design compares two training methods: target-based training and interpass shooting. In this study, tests are conducted twice, before and after the treatment. The difference between the pretest and posttest scores is assumed to be the effect of the treatment. This approach allows for a more accurate assessment of the treatment's impact, as it compares conditions before and after the intervention to determine which method is more effective in improving shooting accuracy.

This study applies target-based training and interpass shooting as treatments to assess improvements in shooting accuracy, with a total of 16 training sessions. Prior to the treatment, a pretest is conducted using a shooting accuracy test. Following this, participants undergo training using the target-based and interpass shooting methods. After completing the training, a posttest identical to the pretest is administered. The results from both groups are then compared by analyzing the pretest and posttest scores using a t-test.

Place and Time of Research

This study was conducted at the SBB Talang Pantai training facility, located at Talang Pantai Field, Muara Bungo Regency, Jambi Province. The research was carried out from July 26, 2023, to September 5, 2023. The study consisted of 14 sessions, including one pretest and one posttest.

Population and Sample

According to Sugiyono (2019:126), a population is a generalization area consisting of objects or subjects that possess specific qualities and characteristics determined by the researcher for study, from which conclusions are drawn. The population in this study consists of all active students of SSB Talang Pantai who are currently participating in training, totaling 20 individuals.

According to Sugiyono (2016:81), a sample is a subset of the population that shares specific characteristics, while the method used to select the sample is referred to as sampling. The sampling technique used in this study is total sampling. According to Sugiyono (2017:142), total sampling is a sampling technique in which the entire population is used as the sample. This method is applied because the population size is

less than 100. Therefore, the sample in this study consists of 20 students from SSB Talang Pantai.

In this technique, the selection of the sample is entirely determined by the researcher, making it highly subjective. Based on the sampling technique described above, this study includes a total of 20 participants. These participants are then divided into two groups: one group undergoes target-based training, while the other group practices interpass shooting. The participants are randomly and evenly assigned into two groups, with 10 individuals in the target-based training group and 10 individuals in the interpass shooting group.

Data Collection Technique

The data obtained in this study are the results of the shooting skill tests conducted by the students of SSB Talang Pantai. To collect the data, the following steps were first established:

Preparation Steps

The researcher prepared all necessary requirements for conducting the test, including obtaining a research permit from the academic office of Universitas Muhammadiyah Muara Bungo.

Determining the necessary equipment for the study: Before conducting the test, the researcher first ensured the feasibility of the data collection instruments. The required equipment includes a measuring tape, marker tape, ball, field, goalpost, and writing materials.

Initial Implementation of the Shooting Pretest. The test in this study utilizes a shooting test. The purpose of conducting this test is to assess the initial shooting ability of SSB Talang Pantai students. Before the experimental activities begin, the sample is first divided into two groups based on the results of the pretest. The grouping is conducted using a ranking system or ordinally matching pairing to ensure balanced group composition.

Providing Treatment/Training. The treatment or training given to the sample consists of 16 sessions, including target-based training and interpass shooting, divided into two groups. The training sessions are conducted three times per week at Talang Pantai.

Conducting the Final Test (Posttest). After the treatment, a final test (posttest) is conducted to evaluate the results achieved by each athlete following the training methods. The posttest procedure is identical to the pretest, utilizing a shooting skill test.

Data Analysis Technique

Data Analysis is a crucial part of research, as it allows for testing the validity of the established hypothesis and drawing conclusions. Once data collection is complete, the obtained data is analyzed using statistical methods. In this study,

the t-test formula is employed at a 5% significance level with degrees of freedom (n-1), and the analysis is facilitated by the SPSS application.

After data collection, the next step is data analysis. The paired sample t-test is used as the data analysis technique for experimental data. The statistical test applied is the t-test (Mean Difference Test), conducted at a 0.05 significance level to assess the differences between pretest and posttest results.

Results

This study aims to examine the effect of target-based training and interpass shooting on the shooting accuracy of SSB Talang Pantai students. The research findings are based on the pretest and posttest results of shooting accuracy among the students.

The study was conducted from July 26, 2023, to September 5, 2023. The treatment consisted of 16 sessions, including pretest and posttest, with a total of 20 respondents divided into two groups. The data obtained from each group are presented as follows:

Data Description

The results of the shooting accuracy test using target-based training revealed significant improvements in performance. Statistical analysis of the pre-test and post-test scores demonstrated that target-based training effectively enhances shooting accuracy among SSB Talang Pantai students.

Similarly, the results of the shooting accuracy test using interpass shoot training indicated a notable increase in performance. The analysis of pre-test and post-test scores confirmed that this training method positively influenced shooting accuracy.

To assess the extent of improvement in shooting accuracy among SSB Talang Pantai students, this study applies a percentage increase formula. This calculation determines the effectiveness of both target-based training and interpass shoot training, allowing for a comparative analysis of their impact on shooting accuracy.

Hypothesis Test

Hypothesis testing, specifically the t-test, was conducted in this study to evaluate the proposed hypotheses regarding the effect of target-based training and interpass shoot training on shooting accuracy among SSB Talang Pantai students. The results of the t-test are as follows:

The analysis indicates a significant effect of target-based training on improving shooting accuracy. The t-test results show that $t_{calculated}$ (7.216) > t_{table} (1.833) and p-value

(0.001) < 0.05, confirming that target-based training significantly enhances shooting accuracy. As a result, the alternative hypothesis (Ha) is accepted, while the null hypothesis (Ho) is rejected.

Similarly, the findings demonstrate a significant effect of interpass shoot training on shooting accuracy. The statistical analysis confirms that interpass shoot training contributes to a notable improvement in shooting performance among SSB Talang Pantai students. Further data analysis is needed to compare its effectiveness relative to target-based training.

Discussion

Based on the hypothesis testing results using the t-test, the findings indicate significant effects of both target practice and interpass shoot training on shooting accuracy among SSB Talang Pantai students. The data analysis confirms that target-based training effectively enhances shooting accuracy, as evidenced by a $t_{calculated}$ value of 7.216, which exceeds the t_{table} value of 2.262, indicating a statistically significant improvement. Similarly, interpass shoot training also leads to a notable increase in shooting accuracy, with a $t_{calculated}$ value of 7.606, further reinforcing the positive impact of this training method.

Furthermore, a comparison between the two training methods reveals a statistically significant difference in their effectiveness. The independent sample t-test results show that $t_{calculated}$ (2.357) > t_{table} (2.100), demonstrating that interpass shoot training is more effective than target-based training. The percentage analysis further supports this conclusion, with target-based training yielding a 40% improvement in shooting accuracy, while interpass shoot training resulted in a 71% increase—a 31% difference favoring interpass shoot training. These findings suggest that interpass shoot training is a more effective approach for enhancing shooting accuracy among SSB Talang Pantai students.

Conclusion

Based on the results of data analysis and discussion, it can be concluded that both target training and interpass shoot training significantly influence shooting accuracy in SSB Talang Pantai students. The t-test results indicate that target training has a positive effect on shooting accuracy, as evidenced by a calculated t-value of 7.216, which exceeds the critical t-table value of 2.262. Similarly, interpass shoot training also improves shooting accuracy, with a calculated t-value of 7.606, surpassing the same t-table threshold. Furthermore, a comparison between

the two training methods reveals a significant difference in their effectiveness. The independent t-test results show a calculated t-value of 2.357, which is greater than the t-table value of 2.100, indicating that the two training methods yield distinct impacts on shooting accuracy.

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Anxiety in Individual Game Sports and Team Game Sports

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Abstract

This study aims to examine the differences in anxiety levels between athletes participating in individual game sports and those involved in team game sports. Employing a quantitative research approach with a causal-comparative design, the study focuses on identifying emotional variations based on the type of sport. The population comprises athletes who competed in the 2018 West Java Provincial Sports Week (Porda). Using a purposive sampling technique, a total of 60 athletes were selected, consisting of 30 athletes from individual game sports (27 squash players and 3 badminton players) and 30 athletes from team game sports (18 volleyball players and 12 basketball players). Data were collected using the Sport Emotion Questionnaire (SEQ), which is widely used to assess emotional responses in competitive sports environments. The results indicate a significant difference in anxiety levels between the two groups. Athletes in individual game sports exhibit higher levels of anxiety compared to those in team game sports. This finding suggests that the solitary nature of individual competition, where the full responsibility for performance rests on one player, may contribute to elevated anxiety. In contrast, team sports may offer shared responsibility and greater emotional support, leading to lower anxiety levels. These insights underscore the importance of sport-specific psychological training to manage performance-related anxiety effectively.

Keywords: anxiety, emotional response, individual game sports, team game sports

Introduction

Emotion is a reaction of a person's feelings which is shown when feeling happy, afraid, even angry about something. We define emotions as episodic, relatively short-term, biologically based patterns of perception, experience, physiology, action, and communication that occur in response to specific physical and social challenges and opportunities (Ketlner & Gross, 1999). There are eight basic emotional dimensions, arranged in four pairs: joy versus sorrow, anger versus fear, acceptance versus disgust, and surprise versus expectancy (Mason & Capitanio, 2012). Emotion has many benefits in helping human life. Our emotions are often our best allies, helping us to respond energetically and effectively to the opportunities and difficulties we encounter (Lazarus, 1991). In the world of sports emotions are one of the factors that determine one's achievement. Emotion will always be involved in any type of sport. However, each branch of sport has different characteristics, which means that the emotions involved will be little or much different. Emotions can effect performance, depending on the athlete and the type of sport (Jones, 2003).

Emotions in sports play a crucial role in influencing an athlete's performance, interpersonal interactions, and overall experience in a competition. Not only are they related to physical reactions, but emotions also involve mental processes that can affect decisions, strategies, and an athlete's drive. In the context of sports, emotions such as anxiety, excitement, anger, and dejection can arise in various situations, both during training and competition. Therefore, understanding the relationship between emotions and performance in sports is key to optimizing achievement and the mental well-being of athletes.

There are several emotions related to sports and achievement. Anger is a frequent emotion in sport (Steffgen, 2017). Emotion that has received enough attention in performance situations is anxiety (McCarthy, Allen, & Jones, 2013). There is sufficient empirical evidence to suggest that at least five emotions are particularly relevant to sport settings … the emotions are anger, anxiety, dejection, excitement, and happiness (Jones, et al., 2005).

Previous research has revealed that physical contact sports such as martial arts always involve anger emotions. Athletes involved in physical contact sports often interpret their competitive anger as beneficial to sports performance (Steffgen, 2017). Table tennis players are confronted with multiple critical situations that instigate annoyance, frustration and anger (Steffgen, 2017). Based on research conducted that sports emotions are always involved in various types of sports, it becomes something that needs to be studied in a study.

An athlete competing in individual game sports, such as tennis or badminton, often experiences high levels of anxiety before and during the competition. This anxiety arises due to the pressure to perform individually, which can affect the athlete's performance and emotions. In contrast, in team game sports such as football or basketball, although athletes also experience anxiety, they feel more supported by their teammates, which can help reduce the impact of that anxiety. However, there are also feelings of anxiety related to the responsibility towards the team and the possibility of disappointing teammates

Therefore, it is necessary to provide evidence regarding whether there is a difference in the level of sport emotions, particularly anxiety, that athletes often experience when facing competition in different types of sports. And does team game sports have the same impact on anxiety, considering that this type of sport involves more than one individual? For this reason, this study aims to determine the level of difference in sport emotion (anxiety) in individual game sports and team game sports. The hypothesis in this study is that there are differences in sport emotion (anxiety) between individual game sports and team game sports.

This study can reveal how the characteristics of both types of sports (individual vs. team) affect athletes' anxiety levels and provide insights into ways to manage anxiety so that it does not interfere with athletes' performance in competition.

Methods

The research method used is causal-comparative with a quantitative approach. In causal-comparative research, investigators attempt to determine the cause or consequences of differences that already exist between or among groups of individuals (Fraenkel, J. R. & Wallen, N. E., 2007). The research was conducted at the location where each sample was situated, or at the venue before the competition. This research was conducted from October 6 to October 14, 2018.

Research Design

The research design used in this study is the basic causal-comparative design. The basic causal-comparative design involves selecting two or more groups that differ on a particular variable of interest and comparing them on another variable or variables (Fraenkel, J. R., Wallen, N. E., & Hyun H. H.,

Figure 1

The Basic Causal-Comparative Design

2012). No manipulation is involved. The research process is carried out in one stage, which involves administering the test to the two specified groups. The result of the test is to assess the differences between the two groups. The research design of the basic causal-comparative design can be seen in Figure 1.

In this research design, there are two independent variables and one dependent variable. The independent variables in this study are individual game sports and team game sports, and the dependent variable is anxiety.

Participants

The population in this study were athletes registered as players at the Regional Sports Week of West Java in 2018. The sampling technique used in this research is purposive sampling, which is a method of selecting samples based on specific criteria or considerations. For experimental and causal-comparative studies, we recommend a minimum of 30 individuals per group (Fraenkel, J. R. & Wallen, N. E., 2007).

Sample was 60 West Java athletes divided into 2 groups, each of 30 athletes for individual game sports (27 squash athletes, 3 badminton athletes), and 30 team game sports athletes (18 volley athletes, 12 basketball athletes).

Instrument

The research instrument used in this study is the Sport Emotion Questionnaire (SEQ). The instruments used was Sport Emotion Questionnaire (SEQ) developed by Jones, et al. (2005) is a validated instrument for measuring emotions that occur in sports (before the competition).

Procedure

The research procedure begins with testing the validity and reliability of the instrument. Out of the 22 statements, 20 items were found to be valid, and 2 items were invalid, with a reliability level of 0.864. Therefore, 20 valid items were selected to be used in the research.

After the instrument has been validated and shown to be reliable, the next step is to test it to the sample. The sample is given the test shortly before the competition begins.

Data Analysis

The data obtained from the sample were analyzed using SPSS version 20 software, specifically employing one-way ANOVA (Tukey HSD). This test is to determine the difference in anxiety between the two variables (individual game sports, team game sports).

Result

In Table 1, the descriptive statistics of anxiety are presented, with a mean value of 1.3211 and a standard deviation of 0.80326.

Besides, Table 1 shows that anxiety in individual game sports and team game sports has a sig. value of 0.003 < 0.05 at a 95% confidence level, indicating that there is a significant difference in the mean scores.

After testing the mean differences of each variable, the next step is the follow-up test. With the same sample size for each variable to be tested, the test used is the follow-up Tukey HSD (Honest Significant Difference) test. This test is used to determine which group's anxiety is the highest between the two groups using the Tukey HSD test in multiple comparisons with a confidence level.

Based on Table 1, the results show that individual sports have a value of 1.6067 with a subset for alpha = 0.05, and team game sports have a value of 0.9317 with a subset for alpha = 0.05. Therefore, individual game sports have a higher level of anxiety compared to team game sports.

Discussion

This study examined anxiety levels in individual and team sports, particularly in the pre-

Table 1

Independent Samples t-test Comparing Anxiety Between Sports Types

Variable	Team Game Sport		Individual Game Sport		t (58)	p	Cohen's d
	M	SD	M	SD			
Anger	0.93	0.63	1.61	0.87	3.14	0.003	0.85

competition phase. The findings indicate that athletes in individual sports experience significantly higher anxiety compared to those in team sports. This difference can be attributed to the unique psychological demands of each sport type. In individual sports, athletes bear full responsibility for their performance and outcomes, creating greater pressure and self-imposed expectations. In contrast, team sports provide a collective environment where teammates share responsibilities, which may alleviate some of the stress associated with competition.

The results align with previous research highlighting the psychological distinctions between individual and team sport athletes. Palgunadhi and Kardjono (2020) emphasize that in individual sports, success and failure rest solely on the athlete, with coaches serving only as external facilitators rather than direct contributors to performance. Furthermore, Nia and Besharat (2010) found that individual sport athletes exhibit higher levels of conscientiousness and autonomy compared to team sport athletes, suggesting a greater predisposition to self-regulation and responsibility — factors that may contribute to elevated anxiety levels.

Social support also plays a crucial role in modulating pre-competition anxiety. Unlike individual sports, where athletes must rely solely on personal coping mechanisms, team sports allow for direct interaction among teammates, fostering motivation and encouragement. This dynamic can help mitigate anxiety by providing a sense of shared experience and emotional support before and during competitions.

Additionally, gender differences appear to influence anxiety levels in sports. Abrahamsen, Roberts, and Pensgaard (2008) reported that female athletes tend to experience higher levels of performance worry, concentration disruption, and somatic anxiety compared to male athletes. These findings suggest that beyond sport type, biological and psychological factors may contribute to variations in anxiety responses. Future research should explore how gender interacts with sport type to shape athletes' anxiety experiences.

Overall, this study underscores the importance of understanding anxiety dynamics in sports, particularly in relation to competition settings. Coaches, sport psychologists, and athletes can use these insights to develop targeted strategies for anxiety management, ensuring optimal mental preparation before competitions. Future studies should further investigate how factors such as experience level, coping mechanisms, and social support structures influence anxiety levels across different sports disciplines.

Conclusions

It can be concluded that anxiety levels differ between individual and team game sports, with individual athletes experiencing higher anxiety. This may be due to the greater personal responsibility and pressure in individual sports. Future research should explore gender differences and competitive situations to better understand anxiety in various sporting contexts.

Acknowledgment

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The effect of lower limb strength training on jump serve performance in elite volleyball players

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Abstract

This study aims to analyze the effects of lower body strength training on jump serve performance in elite volleyball players. A pretest-posttest experimental design was employed, involving 14 elite-level athletes who completed an eight-week lower body strength training program. The program consisted of targeted exercises, including squats, lunges, and plyometric drills, aimed at enhancing lower extremity explosive power. Data were collected through vertical jump tests using a standardized jump measurement device and jump serve accuracy assessments, which evaluated the percentage of successful serves landing within a designated target area. Statistical analysis showed a significant improvement in both vertical jump height ($p < 0.05$) and jump serve accuracy ($p < 0.01$) after the training intervention. Additionally, athletes who achieved greater strength gains also demonstrated enhanced postural stability and coordination during the execution of the jump serve. These results indicate that structured lower body strength training positively influences both the physical and technical aspects of performance in volleyball. The findings emphasize the value of integrating systematic strength training into volleyball conditioning programs to enhance athletic performance, particularly in explosive movements such as the jump serve. This approach can offer a competitive advantage in high-level matches by improving power output, movement control, and serve consistency.

Keywords: athlete performance, jump serve, lower limbs, strength training, volleyball

Introduction

Strength training is an important component of an athlete's training program, especially for volleyball athletes who require strength and explosiveness to perform jump serve techniques (Pereira et al., 2023). Jump serve is a service technique that requires a combination of strength, speed, and high coordination (González et al., 2022). Improved jump serve performance can contribute significantly to overall volleyball match results (Martínez et al., 2024).

In sport, the lower limbs play a critical role in providing the necessary propulsion to launch the body into the air during a jump serve (Pereira et al., 2023). Several studies have shown that optimal leg muscle strength can increase jump height and serve effectiveness (González et al., 2022; Yaşar et al., 2023). A number of professional athletes have adopted science-based strength training programs to improve their specific skills in various sports, including volleyball (Martínez et al., 2024).

However, while many studies have examined the effects of strength training on athlete performance in general, research specifically examining the effects of lower limb strength training on jump serve technique in volleyball is limited (Rodriguez et al., 2023). Lower limb strength training is thought to increase jump height, stability at ball contact, and serve speed, all of which contribute to jump serve effectiveness (Martins et al., 2022). Therefore, this study aims to further analyze how a lower limb strength training program can improve jump serve performance in elite volleyball players, taking into account relevant biomechanical and neuromuscular factors (Silva et al., 2024).

Based on sport theory, strong lower limbs can generate greater reactive force at take-off, which directly contributes to jump height and landing stability in jump serve (Andrade et al., 2024; Chimera et al., 2023). Previous research has shown that increased explosive strength in leg muscles is strongly associated with improved performance in jump-based skills, including the volleyball jump serve (Milanovic et al., 2023). Furthermore, the combination of strength and plyometric training has been shown to improve explosive speed and neuromuscular coordination, which play an important role in effective jump serve technique (Torres-Luque et al., 2024). Therefore, this study aims to provide empirical evidence for the importance of strength training in optimizing jump serve performance, while also providing more specific training recommendations for volleyball athletes.

The methodology used in this study was experimental with a pretest-posttest design. Using valid and reliable measurement instruments, we sought to gain a better understanding of the relationship between lower limb strength and jump serve performance. The importance of this study also lies in the stability and consistency of players' performance, which can be measured through structured training.

The focus of this study is to develop the strength of the major muscles involved in the propulsion and landing phases of the jump serve, namely the quadriceps, hamstrings, gastrocnemius (calf muscle), and gluteus maximus. The strength of these muscles plays a role in generating the explosive power needed to achieve optimal jump height, stability during landing, and efficiency in transferring energy to the upper body movement during the serve.

Several recent studies have shown that plyometric training, resistance training, and neuromuscular training can significantly improve jumping performance and body stability, which has a direct impact on jump serve effectiveness (Suchomel et al., 2023). In addition, training methods such as contrast training, which combines heavy weight training with explosive exercises, have been shown to increase muscle power production in volleyball athletes (Pereira et al., 2022). Volleyballs federations and coaches have emphasized the role of strength training as a key factor in improving performance during competition (Crespo & Potrac, 2019). Therefore, the results of this study are expected to guide the development of better strength training programs to improve volleyball sport performance.

A kinematics and biomechanic based approach was also utilized to understand the muscle activation patterns and force distribution during the preparation, take-off and landing phases of the jump serve. By analyzing these parameters, this study aims to provide evidence-based recommendations for coaches to develop effective, efficient, and athlete-specific training programs. The results of this study will not only be beneficial in improving jump height, but also in preventing injuries due to unstable landing techniques (Moran et al., 2023).

Methods

Research Design

This study employed a quantitative experimental design using a pretest-posttest one-group approach to evaluate the effects of a lower limb strength training program on jump serve performance in volleyball. The purpose of this design was to determine whether significant improvements occurred in jump height and serve accuracy following the intervention. Data were collected at two time points: before the

commencement of the training program (pretest) and after the eight-week training period (posttest).

Participants

The participants in this study were 14 male volleyball athletes from LAVANI Cikeas Club, Bogor, who are also active students at UNISMA Bekasi. These athletes were selected using a purposive sampling technique based on their experience in volleyball and regular participation in training sessions. All participants were aged between 18 and 22 years and were in good health, with no history of lower limb injuries in the past six months. Prior to participation, all athletes provided informed consent.

Instrument

The following instruments and tools were used in the study:

1. Vertical Jump Tester – to measure the jump height (in centimeters) of each participant. The vertical jump test is widely recognized for assessing lower limb explosive power.
2. Jump Serve Accuracy Score Sheet – to record the number and percentage of successful jump serves that landed within the designated opponent's playing area. Accuracy was measured during structured training sessions, with a minimum of 10 serves per trial.
3. Training Logbook – to document attendance, exercise performance, and load progression during the eight-week training program.

Procedure

The study was conducted in three main stages: pretest, intervention, and posttest.

1. Pretest: Prior to the training intervention, baseline data on jump height and jump serve accuracy were collected. Each participant performed three trials of vertical jumps and 10 jump serve attempts. The best vertical jump and the percentage of successful serves were recorded.
2. Training Intervention: Participants underwent a structured lower limb strength training program lasting eight weeks, with a frequency of three sessions per week. The training program focused on major lower limb muscle groups, including the quadriceps, hamstrings, gluteal muscles, and calves. Exercises included:
   a. Bodyweight and weighted squats
   b. Lunges (forward and reverse)
   c. Calf raises
   d. Box jumps (as a plyometric complement)

Each week, the principle of progressive overload was applied by increasing either the volume (repetitions and sets) or intensity (load/resistance) of the exercises to stimulate continuous muscular adaptation. All training sessions were supervised by a certified strength and conditioning coach.

3. Posttest: At the end of the eight-week intervention, the same performance tests were repeated using identical protocols to those in the pretest. This allowed for direct comparison of performance improvements.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical techniques. Mean and standard deviation values were calculated for each performance variable (jump height and jump serve accuracy) at pretest and posttest stages.

To evaluate the effect of the training program, a paired sample t-test was conducted to compare pretest and posttest scores. A significance level of $p < 0.05$ was set to determine statistical significance. Additionally, percentage change was computed to reflect practical improvements. All analyses were performed using SPSS software version XX (or any software used).

Result

After training for 8 weeks, a post-test was conducted to determine jump serve performance, the results are summarized in table 1.

The results of the data analysis in Table 1 showed a significant increase in the average jump height of the participants from 54 cm before the intervention to 66 cm after the intervention. The average jump height increased by 12 cm ($p < 0.05$). In addition, jump serve accuracy increased from 70% to 85% and average jump serve accuracy increased by 15% ($p < 0.01$). These data support the hypothesis that lower limb strength contributes to jump serve performance through improved jumping ability and stability while serving.

To determine whether or not the changes after the intervention were significant, the authors tested using the t-test, the results of which are shown in Table 1.

The analysis showed that jump height had a t-value of 7.93 with 13 degrees of freedom and a p-value <0.0001. This indicates that there is a highly significant difference between the pretest and posttest jump height scores, such that the null hypothesis (H0) of no difference cannot be accepted. This provides strong support that the strength training used contributed to the increase in jump height.

Tabel 1
Paired Samples t-test Comparing Jump Height and Jump Serve Accuracy Before and After Intervention

Variable	Pre-Test		Post-Test		t	df	p
	M	SD	M	SD			
Jump Height (cm)	54.0	5.2	66.0	4.8	7.93	13	< .001
Jump Serve Accuracy (%)	70.0	6.1	85.0	5.7	6.45	13	< .001

Similarly, there was a significant difference between the jump serve accuracy before and after the intervention, with a t-test result of 6.45 and a p-value <0.0001. This means that strength training has a positive effect on the player's ability to perform a more accurate jump serve, which also rejects the null hypothesis.

Discussion

The results of this study clearly demonstrate that lower limb strength training makes a significant contribution to improving jump serve performance in elite volleyball players. The observed increase in jump height suggests that the increase in leg muscle strength, specifically the quadriceps, hamstrings, and calves, has a direct effect on the athletes' ability to jump higher during the jump serve.

The increase in mean jump height from 54.0 cm to 66.0 cm indicates that the lower limb strength training program had a significant impact on the athletes' explosiveness. These results support recent findings that resistance training focused on leg muscles can improve vertical jump performance through neuromuscular adaptation and muscle hypertrophy (Jiménez-Reyes et al., 2019; Suchomel et al., 2020).

Some studies have also shown that increased jump height correlates with the strengthening of key muscles such as the quadriceps, hamstrings, gluteus, and calves, which play a role in generating optimal propulsive force during jumping (Loturco et al., 2021). Exercises such as squats, lunges, and plyometric exercises have been shown to increase power production, which is a key factor in effective jump serve technique (Rossi et al., 2022).

A 15% increase in jump serve accuracy is a significant indicator that lower limb strength training contributes to stability, coordination, and body control during serving. These findings are consistent with recent research that leg and core strength play an important role in consistency of stroke technique and control of movement in the air (Torres-Torrelo et al., 2022; Lehnert et al., 2023). By strengthening the quadriceps, hamstrings, gluteal muscles, and calf muscles, athletes are able to improve postural balance and body control during jumps and ball contact (Ramos-Campo et al., 2021). This stability allows them to adjust the angle of the shot and the speed of the ball with greater precision, which directly affects the accuracy of the serve to the opponent's target area (Campos et al., 2022).

In addition, the increased neuromuscular capacity resulting from strength training allows for faster and more efficient muscle responses that support the body's reactions in maintaining optimal position during jump serves (Slimani et al., 2023). This factor is critical in improving serve effectiveness, especially in match situations that require directional and powerful serves. Thus, the implementation of structured strength training not only contributes to jump explosiveness, but also improves jump serve accuracy through improved movement control, stability, and coordination.

The results of this study indicate that lower limb strength has a significant relationship with jump serve technique performance in volleyball. Optimal muscle strength allows athletes to generate more force, increase body stability during jumps, and improve control of arm and hand movements when making contact with the ball (Torres-Torrelo et al., 2023).

In sports that require quick reactions and high technical skills, such as volleyball, the balance between muscle strength and motor control is critical for executing an accurate and powerful jump serve (Katic et al., 2023). Increased lower limb strength not only contributes to jump height, but also allows players to adjust their timing and coordination between jumping and hitting the ball, which is essential for effective serve execution (Campos et al., 2022).

Other studies have also shown that specific strength training can improve neuromuscular capacity, allowing muscles to react more quickly and with better control during explosive movements such as the jump serve (Ramos-Campo et al., 2021). In addition, athletes with greater lower limb strength tend to have greater postural stability, reducing the likelihood of losing balance during technique execution (Slimani et al., 2023).

Thus, the results of this study confirm that a structured strength training program can directly contribute to the improvement of volleyball technical skills, particularly jump serve technique. Coaches and athletes can optimize training programs by focusing on the development of explosive strength and motor control, thereby

increasing the effectiveness and accuracy of serves in competition.

These findings suggest that coaches and trainers should consider incorporating structured strength training programs as an important part of their overall training regimen. Given the importance of lower limb strength in improving jump serve performance, it is recommended that a variety of exercises, including squats, lunges, and other plyometric drills, be incorporated into the weekly training program.

Conclusions

Thus, the results of this study provide scientific evidence to support the importance of strength training in improving jump serve performance in elite volleyball players. Training focused on lower limb strength not only improves physical skills such as explosive power and balance, but also directly contributes to technical skills including accuracy and stability during the jump serve. Furthermore, increased lower limb strength positively impacts performance consistency, reduces the risk of injury from repetitive jumping, and enables players to react more quickly in dynamic game situations. These findings suggest that a holistic training approach - combining strength training, technique development, and biomechanical strategies - can lead to optimal on-court performance improvements and provide a significant competitive advantage for athletes in high-level tournaments.

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Exploring Trends in Student Motivation in Sport Education in the Digital Age: A Bibliometric Analysis of Ten Years of Research

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Abstract

The objective of this literature review is to examine ongoing research trends regarding student motivation for physical education in the digital era. Over the past decade, research has demonstrated a significant paradigm shift toward the integration of digital technologies, such as online learning applications, educational games, and social media platforms, in enhancing student motivation. Additionally, studies have shown an increasing interest in incorporating digital technologies such as big data analytics and adaptive learning into physical education. A bibliometric analysis was conducted on research concerning student motivation in physical education from 2013 to 2023. This study identified citation growth patterns, key authors, journals, institutions, and leading countries. VOSviewer was utilized for visualization and analysis. These findings provide valuable insights for researchers, educators, and readers to understand the growth of student motivation topics in physical education and to identify potential current research areas. Spain emerged as the most productive country, contributing 38 publications related to student motivation in physical education, while also being the most influential country with 503 citations. Future research is expected to continue exploring the potential of emerging technologies and addressing existing challenges to enhance the understanding of student motivation in physical education. By focusing on the development of innovative and efficient solutions, both academia and industry can effectively leverage this knowledge to improve student motivation and participation in physical education, thereby advancing the field as a whole. The integration of these technologies enhances student engagement and participation while expanding possibilities for personalized learning approaches and performance enhancement strategies.

Keywords: bibliometric analysis, research trends, sports education, student motivation

Introduction

Explanation

Over the past decade, physical education has undergone a significant transformation driven by advancements in digital technology. The integration of digital technologies, such as online learning applications, educational games, and social media platforms, has reshaped how students interact and stay motivated in the context of physical education (Swim et al., 2024). Studies have shown that the use of these technologies not only enhances student participation but also facilitates more personalized learning approaches (Ambele et al., 2022).

Student motivation is crucial to the success of physical education. Motivation theories, such as intrinsic and extrinsic motivation theory, highlight the importance of internal and external factors in encouraging students to participate in physical education (Tendinha et al., 2021). Recent studies suggest that digital technology can influence both types of motivation in complex and diverse ways (Efremova & Huseynova, 2021).

The digital era has brought significant changes to data collection and analysis methods in physical education. Big data analytics and AI have enabled researchers to identify trends and patterns in student motivation with greater precision (Jastrow et al., 2022). This study employs bibliometric analysis to explore research trends in student motivation in physical education over the past decade (2013–2023).

Objective

Bibliometric analysis is an effective method for understanding the research landscape in a specific field. By using tools such as VOSviewer, researchers can visualize networks of authors, institutions, and dominant keywords in the literature (Van Eck & Waltman, 2010; Cobo et al., 2011). The objective of this literature review is to examine ongoing research trends on student motivation for physical education in the digital era. In the context of this study, bibliometric analysis helps identify publication and citation patterns, providing insights into the development and direction of research in the field of student motivation in physical education.

Method

This study begins by applying bibliometric analysis to collect a large body of literature on student motivation in physical education. This bibliometric approach serves as a crucial instrument for mapping the breadth of scientific literature, similar to a systematic literature review, to ensure the accuracy and reliability of the information used and the results obtained (C. J. Chen et al., 2022).

One of the most commonly used tools in bibliometric analysis is VOSviewer. We utilized VOSviewer software to construct and visualize relationships between bibliometric sources, leading authors, and journals, providing deeper insights into specific publications, scholars, or journals (Anandh et al., 2021; Kirby, 2023). Additionally, we conducted a parallel investigation to analyze publication trends and evolution within a specific domain, offering further insights into research dynamics. Through bibliometric analysis, we also identified key factors influencing scientific production, contributing to a deeper understanding of research content and its development. The parameters and analytical methods used were adapted from previous bibliometric studies (C. J. Chen et al., 2022). The generated outputs include relevant keywords across scholarly works, author connections, document counts, and researchers' countries of origin.

To achieve the research objectives and extend beyond the specified parameters, we conducted a structured literature review to ensure logical consistency in formulating our understanding of student motivation in physical education. Our analysis follows an approach supported by bibliometric processes in terms of clustering perspectives through bibliographic connections, focusing on the most recently cited documents on this topic. Additionally, we explored methods for transferring bibliometric details from documents into an Excel spreadsheet format. The final outcome of this analysis is a literature review that provides recommendations for future research based on bibliometric analysis trends.

Search Engines

For our systematic literature analysis focusing on student motivation in sports education, we selected the Scopus database through Elsevier as the primary source for bibliographic research. On June 4, 2024, we explored the Scopus database with the aim of collecting journals and articles. Within the bibliographic repository, which encompasses over 1,000 multidisciplinary subjects, we conducted a bibliometric study centered on similarity visualization methods. To enhance the relevance of our data, we refined our search to specifically focus on the topic of student motivation in sports education, extracting relevant information such as citations, bibliographic details, abstracts, keywords, findings, and other related data.

Figure 1
PRISMA Search and Filtering Strategy Flowchart
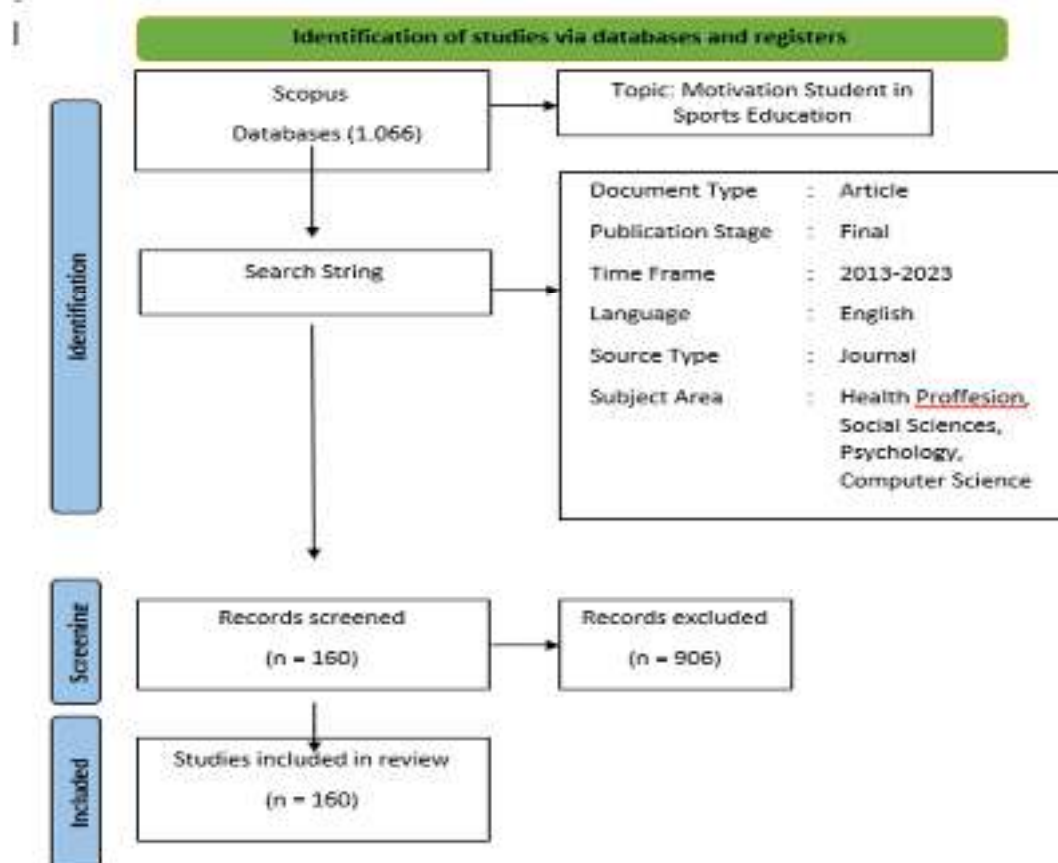
Search Strategy

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topic of student motivation in physical education, extracting relevant information such as citations, bibliographic details, abstracts, keywords, findings, and other related data.

TITLE-ABS-KEY (motivation AND student AND in AND sport AND education) AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "HEAL") OR LIMIT-TO (SUBJAREA , "COMP")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (EXACTKEYWORD , "Motivation") OR LIMIT-TO (EXACTKEYWORD , "Physical Education") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Sport") OR LIMIT-TO (EXACTKEYWORD , "Physical Activity")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")).

Time period

This study involved a comprehensive examination of the literature background, including approximately 1,066 articles over a ten-year period from 2013 to 2023. By limiting the search to the last ten years, the research avoids outdated conclusions or findings that may be less relevant to current physical education practices. This approach ensures that the analysis remains up-to-date, accurate, and serves as a valid foundation for further research recommendations. Another reason for selecting this time frame is that research on student motivation in physical education gained significant traction during this period, with a notable increase in related studies in 2023.

Eligibility criteria

The eligibility criteria used in this study include several aspects, such as document type, publication stage, language, and data sources. The selected articles must be journal articles, in their final publication stage, within the ten-year

period from 2013 to 2023, written in English, and originating from relevant disciplines such as Health Professions, Social Sciences, Psychology, and Computer Science. Articles that do not meet these criteria were excluded from the analysis.

Data refinement (data selection procedure)

The data screening process in this study was carried out systematically to ensure that only relevant literature meeting the established criteria was included in the analysis. The selection process involved several stages, beginning with the initial identification of articles aligned with the research topic. Next, a screening process was conducted by evaluating the relevance of articles based on abstracts and relevant keywords. Articles that did not meet the inclusion criteria were excluded from further analysis. Following this stage, a final selection was performed by reviewing the full content of the articles to ensure their alignment with the research focus. This process aimed to obtain high-quality data that could support a comprehensive analysis.

Data synthesis

Citation Network Analysis to uncover current trends in research on student motivation in physical education. Citation Network Analysis, a review method aimed at mapping the scholarly organization of a field through the analysis of citation patterns, has been the central focus of our study (C. D. McLaren & Bruner, 2022).

We collected metadata from the Scopus journal database using relevant keywords such as "motivation," "physical education," "sports," "students," and "physical activity." This metadata included information on article titles, authors, journals, publication years, and the number of citations received by each article. The data was organized and stored using Microsoft Excel 16.63.1

for further analysis. We processed this data using VOSviewer 1.6.18, a software tool that enables the visualization and analysis of citation networks and relationships between topics in scientific literature (Rodriguez-Marin et al., 2022).

Trough bibliometric analysis, we were able to track events and trends in scientific publications related to student motivation in physical education, as well as identify recurring citation patterns among related works (Jeong et al., 2020). Citation network analysis allowed us to understand the structure and dynamics of collaboration among authors, institutions, and countries in this field of research.

One of the main advantages of using VOSviewer is its ability to evaluate bibliometric data from major databases such as Scopus and Web of Science. With its advanced technology, VOSviewer enables us to gain deeper insights into the underlying patterns of scientific literature on student motivation in physical education (Perdima et al., 2023). This visualization aids in presenting data intuitively and enhances our understanding of the complexity of this research field.

Research Findings

Descriptive findings (statistics)

The research process began with the identification of data sources, where relevant articles were collected from the Scopus database. In this stage, a total of 1,066

initial articles related to the topic "Motivation Student in Sports Education" were found. To ensure that only relevant articles were included in this study, an initial screening process was conducted by applying predefined search strings. These search strings were constructed based on key terms related to the research topic, allowing

Figure 2
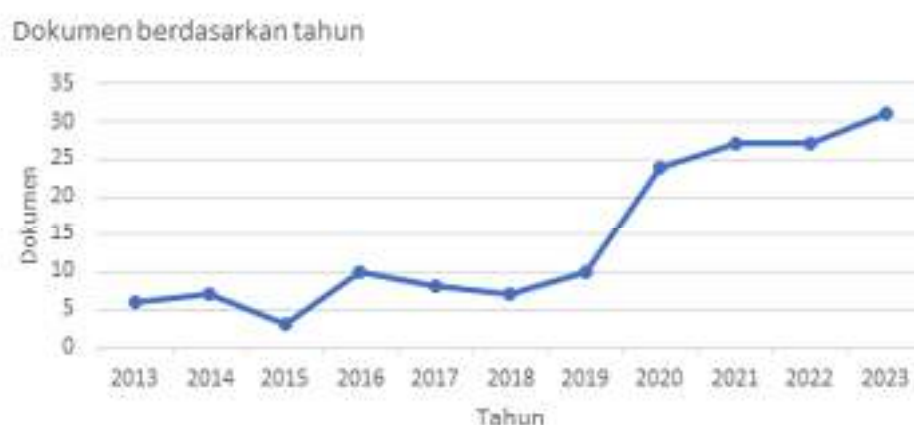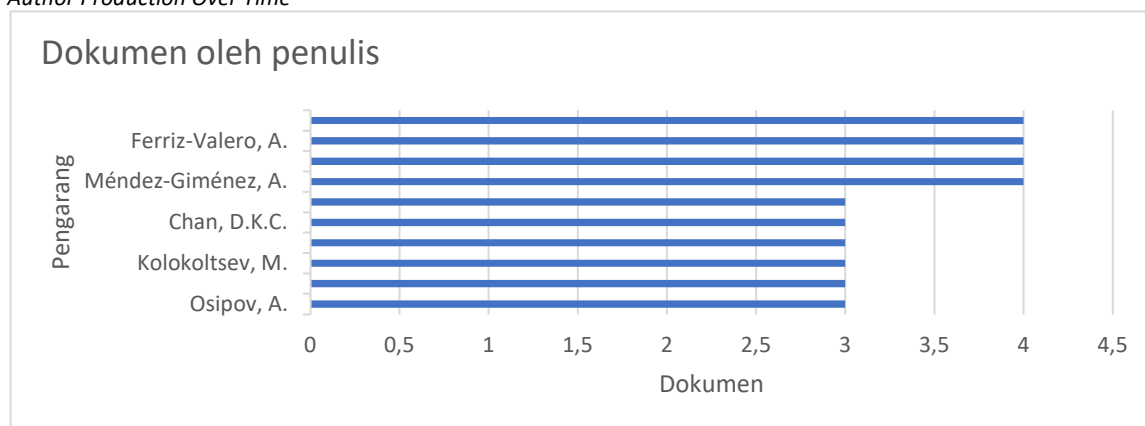Annual Total Publication Distribution

Figure 3
Author Production Over Time

for the elimination of articles that did not align with the study's focus from the outset.

Next, the screening stage was conducted on all collected articles. This process aimed to select articles based on predetermined inclusion and exclusion criteria. The inclusion criteria included document type (only final-published journal articles), publication timeframe (2013–2023), publication language (English), and relevant academic fields, including Health Profession and Social Sciences, psychology, and Computer Science. Articles that did not meet these criteria were excluded from the analysis. Out of the 1,066 articles examined, a total of 906 articles were eliminated for failing to meet the selection criteria.

Table 1
The Ten Most Cited Articles According to Scopus

No	Judul Dokumen	Penulis	Tahun	Total Kutipan
1	The Concept of Mental Toughness: Tests of Dimensionality, Nomological Network, and Traitness	Gucciardi, D.F., Hanton, S., Gordon, S., Mallett, C.J., Temby, P.	2015	232
2	Different combinations of perceived autonomy support and control: identifying the most optimal motivating style	Haerens L., Vansteenkiste M., De Meester A., Delrue J., Tallir I.., Vande Broek G., Goris W., Aelterman N.	2018	113
3	Impact of exergames on physical activity and motivation in elementary school students: A follow-up study	Sun, H.	2013	97
4	Sport education model versus traditional model: Effects on motivation and sportsmanship	Modelo de educación deportiva versus modelo tradicional: Efectos en la motivación y deportividad	Méndez-Giménez, A., Fernández-Río, J., Méndez-Alonso, D.	2015	78
5	Perceived physical competence towards physical activity, and motivation and enjoyment in physical education as longitudinal predictors of adolescents' self-reported physical activity	Timo, J., Sami, Y.-P., Anthony, W., Jarmo, L.	2016	76
6	Need-supportive professional development in elementary school physical education: Effects of a cluster-randomized control trial on teachers' motivating style and student physical activity	Escriva-Boulley, G., Tessier, D., Ntoumanis, N., Sarrazin, P.	2018	70
7	The impact of nonlinear pedagogy on physical education teacher education students' intrinsic motivation	Moy, B., Renshaw, I., Davids, K.	2016)	65
8	Sport education model and self-determination theory: An intervention in secondary school children pemain bola basket	Cuevas, R., García-López, L.M., Serra-Olivares, J.	2016	54
9	An analysis of weight perception and physical activity and dietary behaviours among youth in the COMPASS study	Patte, K.A., Laxer, R.E., Qian, W., Leatherdale, S.T.	2016	37
10	Experiences matter: Positive emotions facilitate intrinsic motivation	Løvoll, H.S., Røysamb, E., Vittersø, J.	2017	34

These exclusions included articles from non-academic sources, those irrelevant to the specified fields of study, non-English publications, or articles published outside the designated timeframe.

After a rigorous selection process, a total of 160 articles were retained for further analysis in this study. These selected articles were deemed highly relevant to the research objectives, allowing for a deeper understanding of the factors influencing student motivation in sports education. The final outcome of this stage ensured that only high-quality studies aligned with the research scope were included in the subsequent analysis.

Schematic map and trend

From 2013 to 2023, researchers from various countries have published articles related to student motivation in sports education. The overall publication trend on this topic from 2013 to 2023 is illustrated in Figure 2. Analysis based on the Scopus database indicates that in 2013, a total of six articles were published.
In 2014, the number of published articles increased to seven. However, in 2015, the number declined to three articles. In 2016, a significant increase occurred, with the number of publications reaching ten articles. In 2017, the number of published articles slightly decreased to eight, followed by a slight decline to seven articles in 2018. Nevertheless, in 2019, the number of publications rose again, with ten articles published.
significant increase in publications, reaching 24 articles. This upward trend continued in 2021 and 2022, where the number of publications peaked at 27 articles each year. In 2023, the number of publications continued to rise, reaching 31 articles. This trend indicates a growing interest in research on student motivation in sports education.

Overall, this study highlights the rising attention to student motivation in sports

education, especially in recent years. The increase in the number of publications reflects the importance of this topic in modern education and emphasizes the need for more effective strategies to enhance student motivation in sports education.
Tabulation and summarizing the findings

Top Authors and Most-Cited Publications

Figure 3 illustrates that among the ten most productive researchers in the field of student motivation in sports education, several scholars have made significant contributions through their publications. Baena-Morales, S., Ferriz-Valero, A., Moreno-Murcia, J.A.,
and Méndez-Giménez, A. have each contributed four articles, offering valuable insights into student motivation in sports education.

They are followed by Aunola, K., Chan, D.K.C., Fernández-Río, J., Kolokoltsev, M., Kudryavtsev, M., and Osipov, A., who have each made important contributions with three articles that highlight key aspects of this research area. These researchers demonstrate persistence and dedication to the study of student motivation in sports education. Their contributions enrich the literature and provide new perspectives on how motivation can be enhanced in the context of sports education. Their work not only helps in understanding current trends but also lays the foundation for future research in this field.

Table 1 presents the top 10 authors with the most influential articles on student motivation in sports education in the digital era. The first position is held by an article published by Gucciardi et al., which has received a total of 232 citations. The second position is occupied by an article published by Haerens et al., with a total of 113 citations. The third position is taken by an article published by Sun, with a total of 97 citations.

In the fourth position, an article by Méndez-Giménez et al. has accumulated 78 citations. Meanwhile, sequentially, the articles published by

Table 2. Source: Scopus Database, Country Distribution Based on Citations, Documents, and Total Link Strength

Peringkat	Negara	Kutipan	Dokumen	Kekuatan tautan total
1	Spain	503	38	10
2	Australia	499	12	18
3	United Kingdom	393	16	19
4	United States	323	13	14
5	Finland	277	9	14
6	Chile	81	3	3
7	France	74	3	2
8	Norway	55	5	2
9	Ukraine	54	8	2
10	China	48	15	8

Timo et al. have received 76 citations; Escriva-Boulley et al., 70 citations; Moy et al., 65 citations; Cuevas et al., 54 citations; Patte et al., 37 citations; and Løvoll et al., 34 citations. This demonstrates how several authors have made significant contributions to the research on student motivation in sports education. Their work has shaped academic discussions and provided valuable insights for further studies in this field.

Table 1 presents the top 10 authors whose articles have had the greatest impact on research related to student motivation in sports education in the digital era. The first position is held by an article published by

Gucciardi et al., which has received a total of 232 citations. The second position is occupied by an article published by Haerens et al., with a total of 113 citations. The third position is taken by an article published by Sun, with a total of 97 citations.

In the fourth position, an article by Méndez-Giménez et al. has accumulated 78 citations. Meanwhile, sequentially, the articles published by Timo et al. have received 76 citations; Escriva-Boulley et al., 70 citations; Moy et al., 65 citations; Cuevas et al., 54 citations; Patte et al., 37 citations; and Løvoll et al., 34 citations.

This data highlights how certain authors have made significant contributions to the field, shaping the discourse and advancing the understanding of student motivation in sports education. That have significantly contributed through their research, providing important insights into understanding student motivation in sports education. These articles serve as a crucial foundation for further research and the development of more effective strategies to enhance student motivation in the context of sports education.

Citation and Distribution Network by Country

Based on the number of citations received by published articles, Table 2 lists the top 10 countries. The country with the highest number of citations is Spain, with a total of 503 citations. Australia ranks second with 499 citations, followed by the United Kingdom in third place with 393 citations. The United States and Finland occupy the fourth and fifth positions with 323 and 277 citations, respectively. Meanwhile, Chile, France, Norway, Ukraine, and China have a total of fewer than 100 citations each.

Governments in industrialized countries can support researchers working in sports education by providing funding and additional data to analyze student motivation in sports education. The top five countries in this study are developed nations.

Illustrated in Figure 4. Darker colors indicate a higher number of citations from published articles. The majority of articles were published in Spain and Australia. According to these statistics, most publications were from Spain, with a total of 503 citations. Lighter colors indicate fewer citations from published articles. This suggests that research trends and breakthroughs in student motivation in sports education are significantly influenced by publications from Spain.

There are three main categories of collaboration networks: from researcher to student, from institution to institution, and from country to country. For this publication, we utilized the author collaboration feature in VOSviewer to generate a collaboration network with a minimum of one document and one citation, as shown in Figure 5. The number of articles submitted from each; country is represented by the size of the node in the graph; collaboration between countries is represented by lines different groups are distinguished by colors, and the similarity of research topics is indicated by the distance between nodes. Our observations indicate that the international collaboration network in the field of student motivation in sports education is divided into nine clusters, with major countries as follows: Cluster #1 – United Kingdom, Hungary, Romania, Saudi Arabia, Luxembourg,

Figure 4
Country-Based Scientific Production in the Context of Student Motivation in Sports Education

Table 3. Visualization of Network Articles and Sports Biomechanics Source: Processed by the authors using VOSviewer.

Cluster	Item	Color	Percentage	Total
Cluster 1	Academic Performance, amotivation, confirmatory factor analysis, extrinsic motivation, feeling, internal consistency, passion, physical literacy, pressure, reliability, secondary school, self esteem, structural equation modeling, student athlete, validity	Red	25%	15
Cluster 2	Autonomous motivation, autonomy support, physcial comptence, positive emotion, psychological need, secondary school student, sport injury prevention, sport injury prevention behavior, sports injury, sportsmanship	Green	16%	10
Cluster 3	Achievment motivation, boxing, life satisfaction, natural science, personality, psychological gender, sport science, sports dance, young adult	Blue	15%	9
Cluster 4	Accuracy, college, skill, speed, sports science, sports skill	Yellow	10%	6
Cluster 5	Badminton, healthy habit, learning task, situational interest, video game	Purple	8%	5
Cluster 6	Body, indicator, motor test, pedagogical experiment, young student	Light blue	8%	5
Cluster 7	College student, commitment, participation motivation, sports behavior motivation	Orange	7%	4
Cluster 8	Athlete, long jump, physyical fitness, positive impact	Brown	7%	4
Cluster 9	Effectivenes, sports volunteering, student teacher	Pink	4%	3
Total			100%	61

Slovakia; Cluster #2 – China, Kazakhstan, Russia, South Korea, Czech Republic; Cluster #3 – Spain, Norway, Mexico, Chile, Algeria; Cluster #4 – Finland, United States, Hong Kong, Greece; Cluster #5 – Brazil, Poland, Portugal, Ukraine; Cluster #6 – Australia, Sri Lanka, Vietnam; Cluster #7 – Indonesia and Malaysia; Cluster #8 – Austria and Germany; and Cluster #9 – France and India.

Characteristics of Internal Publications

"Keywords serve as important indicators of an article's content, and when two or more keywords appear together in the same article, they are referred to as co-keywords" (Li et al., 2016; Su & Lee, 2010). In the field of scientific knowledge, analyzing co-keywords can play a crucial role in identifying research hotspots and tracking shifts in research boundaries (C. Chen et al., 2014; Lee & Su, 2010). In this study, we utilized the co-keyword function in VOSviewer to generate a co-keyword graph, using the fractional counting method with a minimum occurrence of two for keywords, and author keywords as the unit of analysis. Each cluster has been categorized and visualized in Table 3 and Figure 6 based on its clustering.

Self-Esteem, Psychological Need, Achievement Motivation, Skill, Situational Interest, Indicator, College Student, Athlete, and Effectiveness are all displayed in the hierarchical map in Figure 7, illustrating the interdisciplinary nature of research on student motivation in sports education. With the term "Self- Esteem" appearing in 25% of the publications, it is evident that this aspect has garnered significant academic interest. Additionally, 16% and 15% of these publications include the terms "Psychological Need" and "Achievement Motivation," indicating a growing focus on this area. The importance of

psychological factors in enhancing student motivation becomes more apparent with the presence of terms such as "Skill" and "Situational Interest" in 10% and 8% of the publications, respectively, highlighting that a deep understanding of students' psychological needs and skill development is a key objective of this research. Furthermore, the terms "College Student" and "Athlete" appear in 7% of the publications, while "Effectiveness" is found in 4%, suggesting that this research also emphasizes specific populations and the effectiveness of interventions in sports education.

Discussion

Summary of Evidence

This study highlights the impact of the ten most cited articles in research on student motivation in sports education over the past decade. Using VOSviewer software, this study identifies key trends in the field, including frequently cited journals, authors, and topics. The analysis results indicate that these articles have significantly influenced the development of theories and practices aimed at enhancing student motivation. Several key topics frequently discussed in these articles include the use of digital technology in learning, student-centered instructional methods, and the implementation of educational games to enhance student engagement. Additionally, this study reveals that the coverage of the Scopus database has limitations in including articles published before 2013, which may affect the analysis results.

Interpretation

Figure 5. Citation Network Visualization by Country
Source: Scopus Database
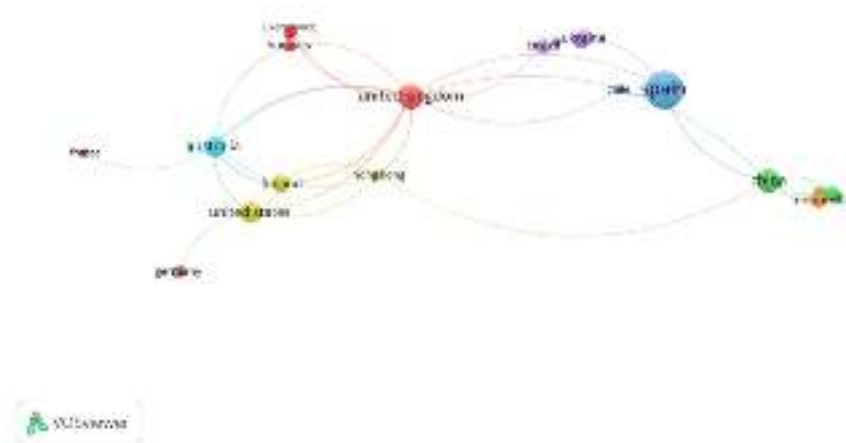
A high number of citations for certain articles indicates that research on student motivation in sports education holds significant academic appeal and continues to evolve. The findings of this study suggest that innovations in instructional methods, such as the use of artificial intelligence and project-based approaches, play a crucial role in enhancing student engagement and motivation. However, these results also reflect a bias inherent in the Scopus database, which only includes selected articles and does not fully represent the global research landscape. Therefore, the interpretation of these findings should consider the limitations of the data coverage used. Further analysis incorporating a more diverse range of sources is necessary to gain a broader perspective on research trends and impacts in this field.

Strengths and Limitations

This study has several strengths, particularly in its bibliometric analysis approach, which enables the identification of patterns and trends in research on student motivation in sports education. The use of VOSviewer software facilitates the identification of relationships between articles, authors, and frequently cited topics, providing deeper insights into the dynamics of research in this field. However, this study also has certain limitations, such as its reliance on the Scopus database, which may exclude important articles from other sources. Additionally, the study only considers articles published after 2013, potentially omitting older yet still relevant research from the analysis. For future research, it is recommended to incorporate multiple databases to ensure broader and more representative coverage, as well as to include expert reviews to validate the quality of the findings.

Conclusion

The field of student motivation in sports education has experienced significant growth between 2013 and 2023, reflecting an increasing interest in understanding the factors that influence student engagement and motivation in physical activity and sports. The analysis of publication and citation trends during this period indicates a consistent rise in scientific exploration

Figure 6

Co-occurrence Network of Student Motivation in Sports Education (Author Keywords)
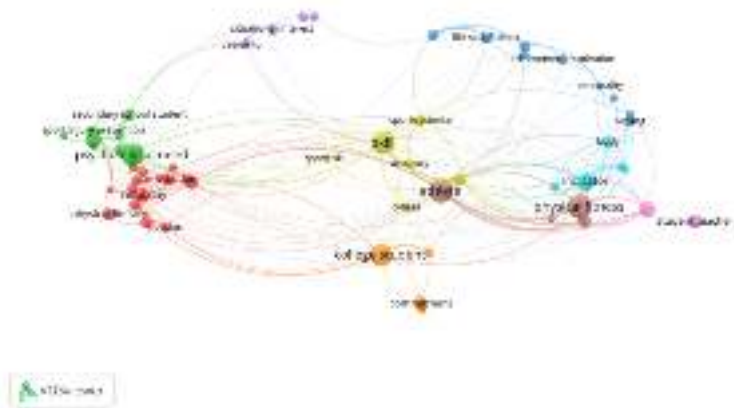*Source: Processed by the Authors Using VOSviewer*

Figure 7. Dominant Themes in Sports Biomechanics Studies. The data were processed by the author using Microsoft Excel

within this domain. Citations in the Scopus database suggest that the top 10 most cited articles likely had a significant impact on subsequent peer-reviewed literature. Several classic and highly cited articles published in this field's leading journals have made substantial contributions to advancing knowledge on student motivation and sports education. Spain has emerged as one of the major contributors, with 38 relevant publications, demonstrating its sustained commitment to advancing knowledge in this area. Furthermore, Spain is the most influential country, with 503 citations, highlighting the global recognition of research originating from the country. This information provides valuable insights for researchers and practitioners in navigating collaborative frameworks, shaping future research directions, and identifying key experts in the field. The author keyword network analysis has emphasized recent developments and ongoing trends in student motivation in sports education, strengthening our understanding of active research areas and offering insights into the future of the field. With increasing interdisciplinary collaboration, student motivation in sports education remains an exciting topic for academics and practitioners, offering boundless opportunities for growth and innovation.

Acknowledgment

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The Relationship Between Arm Muscle Strength, Arm Muscle Endurance, Backstroke Swimming Speed

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Abstract

This study aims to determine the relationship between arm muscle strength and arm muscle endurance with the 50-meter backstroke swimming speed of athletes from the Tirta Sriwijaya Aquatic Club. Employing a quantitative research approach, data were collected through observation as well as standardized tests and measurements. The total population consisted of 20 male athletes from the club, all of whom were included in the study using a total sampling technique. Data analysis was conducted using SPSS version 27, applying Pearson product-moment correlation, regression analysis, and multiple correlation tests. The results revealed a significant relationship between arm muscle strength and endurance with backstroke swimming speed, as indicated by a significance value of 0.00 (p < 0.05). The correlation coefficient value of R = 0.876 suggests a very strong relationship between the independent variables (arm muscle strength and endurance) and the dependent variable (50-meter backstroke speed). These findings suggest that improvements in both arm muscle strength and endurance can substantially enhance swimming performance, particularly in backstroke events. Based on the results, it can be concluded that there is a statistically significant and strong relationship between arm muscle strength and endurance and 50-meter backstroke speed among Tirta Sriwijaya Aquatic Club athletes. This study highlights the importance of targeted strength and endurance training in optimizing swimming performance at competitive levels.

Keywords: arm muscle strength, arm muscle endurance, backstroke, swimming speed

Introduction

Sports are a form of physical activity that involves the body in performing movements, which in turn can improve an individual's physical abilities (Ngurahdan & Santika, 2015). Sports play an important role in improving public health, mental development, achievement, and physical fitness. One way to maintain physical fitness is through swimming.

Swimming is one of the most popular water sports. It can be enjoyed by people of all ages, from children to adults. This is evident from the number of parents enrolling their children in swimming schools with certified instructors. Swimming is an activity that involves floating or lifting the body above the water's surface to enable breathing and directional movement. It is considered a measurable sport where performance is assessed based on time (limits), and the swimmer with the fastest time is declared the winner (Surahman, 2016). Factors that influence a swimmer's time include technique (start, turn, and finish), endurance, power, speed, and mental strength. This aligns with Usra's (2018) opinion, stating that the key to swimming ability is floating—once a swimmer can float, executing swimming movements becomes easier.

Swimming, with its variety of styles, offers numerous benefits. It is commonly used for recreation, fitness, safety, education, and competitive purposes. For safe swimming activities, it is recommended to swim in well-equipped, secure areas such as swimming pools. In achieving swimming performance, experienced and certified coaches are essential.

Swimming events are categorized based on distance, gender, and the four recognized styles. According to FINA (Fédération Internationale de Natation), official world records for both male and female swimmers are recognized for the following events:
1. Freestyle: 50 m, 100 m, 200 m, 400 m, 800 m, 1500 m;
2. Backstroke: 50 m, 100 m, 200 m;
3. Breaststroke: 50 m, 100 m, 200 m;
4. Butterfly: 50 m, 100 m, 200 m;
5. Individual Medley: 100 m (short course only), 200 m, 400 m;
6. Medley Relay: 4x100 m;
7. Freestyle Relay: 4x100 m, 4x200 m.

The four commonly contested strokes in swimming are freestyle (crawl), backstroke, butterfly, and breaststroke. Physically, swimming optimizes body development through muscle-driven movements. It is a complex activity involving almost every part of the body (Sriningsih, 2017). A swimmer's physical condition is crucial, as good physical condition allows for more effective arm and leg movements, which results in faster times.

Backstroke swimming is performed with the back facing the water's surface. The arm and leg movements are similar to freestyle but in a supine position. It involves pulling the arms towards the hips in a rowing motion. All competitive swimming styles are judged by time, emphasizing the need for speed. To swim fast, an athlete must master the correct techniques and have a strong physical condition to support these techniques. In backstroke, arm strength and endurance are essential, especially for 50-meter distances that require strength and speed, and for longer distances (100 m and 200 m), muscular endurance is also crucial. For optimal performance in the backstroke, swimmers need arm strength, arm muscle endurance, and leg muscle speed (Syaputra et al., 2016).

Relevant research by Grecelya (2022) states that arm muscle strength significantly affects 50-meter backstroke speed. This is because arm movement speed greatly impacts swimming outcomes. Arm muscle endurance is also essential, as continuous arm movement in water requires high endurance. Eye-hand coordination also significantly influences swimming direction. The study showed that the calculated t-value (t_count = 6.11) was greater than the t-table value (t_table = 1.796), indicating a significant relationship between arm muscle strength and 50-meter backstroke swimming speed.

Direct observation at the Tirta Sriwijaya Aquatic Club revealed that around 10 athletes have not yet optimized their backstroke performance. Although they possess good swimming techniques, their speed, strength, and endurance are not yet balanced. Many of these athletes lack adequate arm muscle strength and endurance, which is evident as their arm movements weaken over time during backstroke, resulting in slower speeds. Furthermore, some coaches pay insufficient attention to evaluating athlete capabilities in terms of technique and physical condition, especially strength and endurance, which are crucial for effective arm and leg movements.

Several factors contribute to suboptimal backstroke speed, including: lack of leg muscle strength, insufficient arm muscle endurance, poor physical condition, inadequate training facilities, and the absence of structured training programs. These factors ultimately result in underwhelming backstroke performance. The entire movement pattern in backstroke swimming requires strong and enduring arm muscles for pulling, pushing, and recovery movements.

Based on the background and previous studies, this research aims to examine the swimming speed performance of backstroke

athletes from Tirta Sriwijaya Aquatic Club and analyze the relationship between arm muscle strength and endurance on their 50-meter backstroke performance. Backstroke is an official event contested in various competitions; therefore, this study is titled: "The Relationship Between Arm Muscle Strength and Arm Muscle Endurance on 50-Meter Backstroke Swimming Speed Among Athletes of Tirta Sriwijaya Aquatic Club."

Methods

Research Design

This study employed a quantitative research design using correlational analysis (Product Moment Correlation). Correlational research involves the collection of data to determine whether a relationship exists between two or more variables, as well as the strength and significance of that relationship (Nasrudin, 2019). The purpose of this research was to identify whether there is a significant relationship between arm muscle strength and endurance and 50-meter backstroke swimming speed among athletes of Tirta Sriwijaya Aquatic Club.

Participants

The population in this study consisted of all male athletes aged 12–14 years from the Tirta Sriwijaya Aquatic Club, totaling 20 participants. The sampling technique used was total sampling, in which the entire population is taken as the sample. Therefore, the sample included all 20 male athletes who met the inclusion criteria.

Instrument

Data were collected using a series of tests and measurements to assess each variable:
1. Arm Muscle Strength Test
a. Instrument: *Pull and Push Dynamometer*
b. Procedure:
    1) Participants stood upright with feet shoulder-width apart.
    2) The dynamometer was held with both hands in front of the chest at shoulder level.
    3) Participants performed maximal pushing and pulling actions while keeping the posture correct.
    4) The best score of two trials was recorded in kilograms (kg).
c. Scoring:
    1) Norms were used to classify performance levels from "Very Poor" to "Excellent" (Wiriawan, 2017).
2. Arm Muscle Endurance Test
a. Instrument: *Push-Up Test* (1-minute maximum repetitions)

b. Procedure:
    1) Participants performed as many correct push-ups as possible in 1 minute while maintaining proper form.
    2) The test was terminated if the form was broken.
c. Scoring:
    1) Performance was classified using a norm table ranging from "Very Poor" to "Excellent" based on the number of correct repetitions (Putra et al., 2024).
3. Swimming Speed Test (50-meter Backstroke)
a. Purpose: To measure athletes' speed in the 50-meter backstroke.
b. Equipment: Stopwatch, swimming pool with lanes, whistle, evaluation form.
c. Procedure:
    1) Athletes started in the water, pushing off from the wall following official backstroke start technique.
    2) The time was recorded from the start signal until the athlete touched the wall at 50 meters.
d. Scoring:
    1) Swimming speed was categorized based on time standards ranging from "Very Poor" to "Excellent" (Wiriawan, 2017).

Procedure

The data collection process included:
1. Initial observation of training sessions at the Tirta Sriwijaya Aquatic Club to understand athlete conditions and routines.
2. Implementation of physical tests in a structured manner:
    a. Arm strength measured using a dynamometer.
    b. Arm endurance assessed via a push-up test.
    c. Swimming speed tested with a 50-meter backstroke race.
3. All test results were recorded and tabulated for further analysis.

Data Analysis

The data analysis technique involved both regression and correlation analyses, using Pearson's Product Moment Correlation. Regression analysis was employed to examine the relationship between one or more independent variables (arm strength and endurance) and the dependent variable (swimming speed). The Pearson correlation coefficient measured the strength and direction of the linear relationships between

variables, whether in simple or multiple forms (Sugiyono, 2022).

Result

This study was conducted to measure the arm muscle strength of athletes from the Tirta Sriwijaya Aquatic Club. The researcher used the Pull and Push Dynamometer test to measure the athletes' arm muscle strength. The study was carried out from December 2 to December 8, 2024. The results of the Pull and Push Dynamometer test are presented in Table 1.

Based on the table 1, it can be described that 5 athletes had arm muscle strength categorized as *Very Poor* (25%), 6 athletes were in the *Poor* category (30%), 2 athletes were in the *Fair* category (10%), and 7 athletes were categorized as *Good* (35%). No athlete achieved a *Very Good* score. It can be concluded that the overall arm muscle strength of the Tirta Sriwijaya Aquatic Club athletes is predominantly in the *Good* category.

This study was conducted to measure the arm muscle endurance of athletes from the Tirta Sriwijaya Aquatic Club. The researcher used the Push-Up test to assess the athletes' arm muscle endurance. The results of the Push-Up test are presented in Table 2.

Based on the table 2, it can be described that 1 athlete had arm muscle endurance categorized as *Very Poor* (5%), 3 athletes were in the *Poor* category (15%), 4 athletes were in the *Fair* category (20%), 9 athletes were in the *Good* category (45%), and 3 athletes were categorized as *Very Good* (15%). It can be concluded that the overall arm muscle endurance of Tirta Sriwijaya Aquatic Club athletes is predominantly in the *Good* category.

This study was conducted to measure the 50-meter backstroke swimming speed of athletes from the Tirta Sriwijaya Aquatic Club. The researcher used a 50-meter backstroke swimming test. The results are presented in Table 3.

Based on the table 3, it can be described that 4 athletes had backstroke swimming speed categorized as *Very Poor* (20%), 3 athletes were in the *Poor* category (15%), 5 athletes were in the *Fair* category (25%), 7 athletes were in the *Good* category (35%), and 1 athlete was in the *Very Good* category (5%). It can be concluded that the overall 50-meter backstroke swimming speed of the Tirta Sriwijaya Aquatic Club athletes is predominantly in the *Good* category.

Discussion

Based on the analysis of the research data obtained, it can be interpreted that arm muscle strength and arm muscle endurance are the abilities of a group of arm muscles to perform effectively, which contribute to improving the performance in the 50-meter backstroke swimming. Arm muscle strength is defined as the maximum ability of a group of arm muscles to receive and overcome a load coming from either internal or external sources (Hasanuddin, 2020).

Strong arm muscle movement assists athletes while in the water in achieving optimal results, especially in the backstroke swimming style, where the arms function as movers to perform swinging motions in the water that propel the body while still adhering to proper backstroke techniques. Backstroke is distinct from other swimming styles due to the body position on the surface of the water. According to Faradila in (Syaputra et al., 2016), in backstroke, the body and other frontal body parts face upward, unlike other styles such as freestyle, breaststroke, or butterfly, where the swimmer faces downward toward the pool. Thus, having good arm muscle strength and endurance can improve backstroke swimming performance.

Table 1
Arm Muscle Strength

No.	Category	Frequency	Percentage
1	Very Good	0	0%
2	Good	7	35%
3	Fair	2	10%
4	Poor	6	30%
5	Very Poor	5	25%

Table 2
Arm Muscle Endurance

No.	Category	Frequency	Percentage
1	Very Good	3	15%
2	Good	9	45%
3	Fair	4	20%
4	Poor	3	15%
5	Very Poor	1	5%

Table 3
50-Meter Backstroke Swimming Speed

No.	Category	Frequency	Percentage
1	Very Good	1	5%
2	Good	7	35%
3	Fair	5	25%
4	Poor	3	15%
5	Very Poor	4	20%

Conversely, lacking arm strength and endurance can negatively impact backstroke speed.

Endurance refers to a physical condition that enables continuous activity over an extended period. According to Saharulddin (Juliandri et al., 2024), if one has good endurance, they can quickly adapt to various physical skill and technical training to achieve performance goals. Endurance can be improved through consistent, measured, and sustainable training. Arm muscle endurance is one of the critical factors in backstroke swimming speed, as good endurance enhances swimming speed and helps prevent premature fatigue in the arm muscles.

Backstroke is performed with the back facing the water's surface. The arm and leg movements are similar to freestyle, but done in a supine position. In this style, arm muscle strength and endurance are crucial for generating forward motion and preventing fatigue, particularly during arm movements used to pull, push, and swing. Thus, arm strength and endurance are essential components for achieving optimal time performance in backstroke.

This perspective aligns with previous research showing that better arm muscle endurance correlates with improved 50-meter backstroke performance. This is evident from the sample results: when arm muscle endurance scores are good, so are the backstroke results (Syaputra et al., 2016). Athletes with strong arm muscles can perform longer hand swings, and thus arm muscle strength contributes significantly to swimming speed (Irhana, 2020). According to Hendromantono (2015), arm strength, leg muscles, abdominal, and back muscles all actively contribute to achieving maximum swimming speed in backstroke. Arm muscle strength specifically influences the swimmer's speed, especially in body propulsion; the stronger the arm muscles, the faster and more powerful the arm swings (Irhana, 2020). Therefore, to achieve optimal swim time, coaches and athletes must consider arm strength and endurance as major factors. Supporting factors also include physical condition, technique, mental readiness, and facilities.

Based on the results, it can be concluded that better arm strength and endurance correlate with better 50-meter backstroke results. This is evident in the individual sample data—good arm strength and endurance yield good backstroke performance. Thus, arm strength and endurance are among the key factors influencing 50-meter backstroke performance. These physical fitness components have shown a significant relationship with backstroke results. However, many other factors may support backstroke abilities, such as flexibility, coordination, and general strength. In this study, the researcher only focused on physical conditions, specifically arm strength and endurance, with the goal of improving the 50-meter backstroke speed at the Tirta Sriwijaya Aquatic Club.

This research is consistent with a study by Grecelya (2022) titled *"The Relationship Between Arm Muscle Strength and Backstroke 50m Speed in Athletes of Riau Aquatic Swimming Club in Pekanbaru City."* It also aligns with Syaputra et al. (2016), titled *"The Relationship Between Arm and Shoulder Endurance with 50-meter Backstroke Performance at Belibis Club, Pekanbaru City."* Their results showed a correlation coefficient of r = 0.677 > r-table = 0.666, which falls into the "strong" correlation category (0.60 ± 0.799). Similarly, the study by Saputra (2017) titled *"The Relationship Between Arm and Leg Muscle Endurance and Breaststroke 50m Speed in Male Physical Education Students"* confirms these findings.

Conclusions

Based on the results of the study and data analysis, the following conclusions can be drawn:

1. There is a significant relationship between arm muscle strength and 50-meter backstroke speed in athletes of Tirta Sriwijaya Aquatic Club. This is proven through regression testing with a significance value of 0.002 < 0.05, indicating a strong correlation (R = 0.658).
2. There is a significant relationship between arm muscle endurance and 50-meter backstroke speed in athletes of Tirta Sriwijaya Aquatic Club. This is shown through regression testing with a significance value of 0.00 < 0.05, also indicating a strong correlation (R = 0.798).
3. There is a significant relationship between both arm muscle strength and arm muscle endurance and the 50-meter backstroke speed in athletes of Tirta Sriwijaya Aquatic Club. This is supported by multiple correlation testing with a significance value of 0.00 < 0.05, indicating a very strong or near-perfect correlation (R = 0.876).

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