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Perception and Adoption of Artificial Intelligence Technology in Sports in Indonesia: A Quantitative Analysis from the Perspectives of Coaches, Athletes, and Referees

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Abstract

This study aims to analyze the perceptions of coaches, athletes, and referees regarding the use of Artificial Intelligence (AI) technology in sports in Indonesia, as well as the factors influencing its adoption. A descriptive quantitative research method was employed, involving 40 respondents consisting of coaches (55%), athletes (25%), and referees (20%). Data were collected using a Likert-scale-based questionnaire and analyzed using inferential statistical tests (ANOVA, simple linear regression) and reliability testing (Cronbach's Alpha). The results show that coaches had the most positive perception of AI (score 4.1/5), while referees were the most skeptical (score 3.4/5), with a statistically significant difference between the groups ($p = 0.015$). Experience with AI was found to significantly increase perceived ease of use ($\beta = 0.8$, $p = 0.002$), while no significant differences were found based on gender ($p = 0.65$). The study identifies key challenges such as limited infrastructure, low digital literacy, and the need for practical training. Practical implications include recommendations to develop AI applications in the Indonesian language, organize simulation workshops for referees, and foster multisector collaboration to equalize access. This study concludes that AI has the potential to drive the transformation of Indonesian sports, but inclusive strategies are required strategies that consider the local context and the specific needs of stakeholders.

Keywords: artificial intelligence; adoption technology; coach; perspective; referees.

Introduction

The development of Artificial Intelligence (AI) technology has brought significant changes across various sectors, including the world of sports (Chen, 2024; Gajendra.K, 2023). Globally, AI has been utilized to enhance athlete performance through biomechanical data analysis, assist coaches in designing more precise training programs, and support referees in making more accurate decisions during matches (Pisaniello, 2024). However, in Indonesia, the adoption of this technology remains limited. Preliminary surveys indicate that although some coaches, athletes, and referees recognize the potential of AI, many remain skeptical about its effectiveness—or have never used it at all. This raises the question of how prepared Indonesian sports are to face this technological revolution.

Challenges stemming from technological developments include the lack of outreach regarding the benefits of AI among sports practitioners, a human resource gap where many coaches and referees lack the skills to operate AI-based technologies, and limited access to AI tools—especially in remote areas. If these challenges are not addressed soon, Indonesia risks falling behind in the use of modern sports technology, which may ultimately impact the international competitiveness of its athletes.

One of the main identified obstacles is the low level of digital literacy among sports practitioners. Many respondents admitted to not understanding how AI works or its concrete benefits for training and competition. In addition, limited infrastructure poses a significant barrier, particularly in regions not yet reached by advanced technologies (Sekhar, 2024). Without technological support, Indonesian coaches and athletes are at risk of falling behind in the global arena (Ramadan & Samin, 2022). A clear example is the implementation of Video Assistant Referee (VAR) in football, which has become an international standard but is still rarely applied in local competitions. If this continues, Indonesia's sports achievements may further lag.

The purpose of this study is to analyze the perceptions of coaches, athletes, and referees regarding the use of AI in sports; identify both the barriers and driving factors for AI implementation in Indonesia; and provide strategic recommendations to enhance AI adoption in national training and competition systems.

This research aims to address these challenges by first mapping the perceptions and needs of key sports stakeholders regarding AI. To date, studies on the use of AI in sports have been dominated by research from developed countries, while research in Indonesia remains very limited. Yet, each country has its own unique characteristics and needs. For instance, traditional Indonesian sports may require different AI approaches compared to more globally popular sports such as football. Therefore, this study not only aims to identify knowledge and infrastructure gaps but also to formulate AI implementation strategies tailored to the local context.

In the long term, the adoption of AI could be a game changer for Indonesian sports. This technology has the potential to improve the quality of training and competition, while also creating new opportunities for talent development among young athletes (Aidar et al., 2021; Nagovitsyn et al., 2023; Park et al., 2024). By providing data and evidence-based recommendations, this study is expected to serve as a guide for the government, sports federations, and other relevant stakeholders in developing policies that support AI integration. Ultimately, this effort is not just about following a global trend—it is about preparing Indonesian sports to be more competitive in the future.

The novelty of this study lies in mapping the readiness of Indonesian sports human resources to adopt AI and providing data-driven recommendations for the development of AI aligned with local needs. The urgency of this research is to promote digital transformation within Indonesian sports so that it does not fall behind other countries, to enhance training and competition quality through data-driven technologies, and to provide a foundation for policy formulation by the government and sports federations for AI integration. Thus, this study is not only academically relevant but also carries significant practical implications. The findings and recommendations can serve as a foundation for the development of a technology-based sports ecosystem in Indonesia while addressing real-world needs. Now is the time for Indonesian sports to embrace the opportunities offered by AI and ensure they are no longer left behind on the global stage.

Methods

Research Design

This study employed a descriptive quantitative approach to analyze the perceptions of coaches, athletes, and referees regarding the implementation of Artificial Intelligence (AI) technology in the field of sports in Indonesia. The research design was cross-sectional, in which data were collected at a single point in time to capture the actual state of respondents' perceptions (John W. Cresswel, 2009).

Tabel 1

Descriptive Profile of Respondents in the Study on AI Adoption in Indonesian Sports

Category	Subcategories	Percentage/amount
Total samples	-	40 respondents
Gender	Man	75% (30 people)
	Woman	25% (10 people)
Age	<20 years old	5% (2 people)
	20–30 years	65% (26 people)
	31–40 years	20% (8 people)
	>40 years old	10% (4 people)
Roles in Sports	Coach	55% (22 people)
	Athlete	25% (10 people)
	Referee/Judge	20% (8 people)
Types of Sport	Team Sports	60% (24 people)
	Individual sport	40% (16 people)
Experience with AI	Have You Ever Used AI	32% (13 people)
	Knowing the Types of AI	45% (18 people)
Geographical Origin of the Island	Javanese	55% (22 people)
	Bali	15% (6 persons)
	Sumatra	15% (6 persons)
	Kalimantan	10% (4 people)
	Other	5% (2 people)
Education Level	High School/Equivalent	30% (12 people)
	Bachelor (S1)	55% (22 people)
	Postgraduate (S2/S3)	15% (6 persons)

Participants

The data were obtained through an online survey completed by 40 respondents who were active participants in the sports field, including coaches (55%), athletes (25%), and referees/judges (20%). Respondents represented various sports disciplines such as football, futsal, volleyball, as well as individual sports like athletics and badminton. The sampling technique used was purposive sampling, with the criterion being that respondents must be currently active in sports either professionally or competitively.

Instrument

The research instrument used in this study was a 5-point Likert scale questionnaire, with response options ranging from "Strongly Agree" to "Strongly Disagree." The questionnaire was specifically designed to assess four key aspects related to the perception of Artificial Intelligence (AI) in sports: knowledge of AI, perceived benefits of AI for training, perceived benefits of AI for refereeing, and perceived ease of use of AI technology. To ensure the quality and accuracy of the instrument, it was subjected to validity and reliability testing prior to analysis. Pearson correlation was employed to examine construct validity, while Cronbach's Alpha was utilized to assess the internal consistency and reliability of the questionnaire items.

Table 2

Validity test results with Pearson Correlation

1			2			3		
Item	Correlation (r)	Conclusion	Item	Correlation (r)	Conclusion	Item	Correlation (r)	Conclusion
Q2	0.68	Valid	Q12	0.65	Valid	Q22	0.45	Valid
Q3	0.72	Valid	Q13	0.58	Valid	Q23	0.51	Valid
Q4	0.25	Invalid*	Q14	0.71	Valid	Q24	0.19	Invalid *
Q5	0.61	Valid	Q15	0.22	Invalid *	Q25	0.63	Valid
Q6	0.55	Valid	Q16	0.63	Valid	Q26	0.28	Invalid *
Q7	0.31	Valid (threshold limit)	Q17	0.68	Valid	Q27	0.55	Valid
Q8	0.45	Valid	Q18	0.27	Invalid *	Q28	0.31	Valid (threshold limit)
Q9	0.67	Valid	Q19	0.60	Valid	Q29	0.48	Valid
Q10	0.70	Valid	Q20	0.69	Valid	Q30	0.42	Valid
Q11	0.29	Invalid*	Q21	0.55	Valid	Q31	0.59	Valid

Tabel 3
Reliability Test with Cronbach's Alpha

Constructs 1, 2 and 3	Item Valid	Cronbach's Alpha	Conclusion
Benefits of AI for Training	8 item	0.82	Excellent
Benefits of AI for Referees/Judges	8 item	0.79	Good
Ease of Use of AI	8 item	0.70	Pretty good

Table 4
Chi-Square I Gender Test vs. AI Perception

AI Perception	Man	Woman	Total	Chi-Square (χ2))	(df)	p-value
Agree/ Strongly Agree	20	5	25			
Hesitate	6	3	9			
Disagree	4	2	6	0.85	2	0.65

Procedure

Participants were invited to complete the online questionnaire via distributed survey links. Responses were collected and screened for completeness and eligibility. Ethical considerations were maintained by ensuring anonymity and voluntary participation. The questionnaire was structured to be accessible and understandable to practitioners from diverse sports backgrounds and technological familiarity levels.

Data Analysis

The data analysis process was carried out in several stages. Descriptive statistics were first used to examine the frequency distributions and general trends in respondents' answers. To explore deeper relationships between variables, inferential statistical tests were then applied. The Chi-Square test was utilized to assess associations between categorical variables such as gender and role in sports with respondents' perceptions of AI. A one-way ANOVA was conducted to compare perception scores among different groups—namely coaches, athletes, and referees. Additionally, simple linear regression analysis was used to determine whether prior experience with AI significantly influenced respondents perceived ease of use. All statistical analyses were conducted using IBM SPSS Statistics software, ensuring the accuracy of data processing, while the results were presented in tabular form to support clear interpretation and discussion.

Result

Table 1 presents the demographic and contextual characteristics of the 40 respondents who participated in the study. The data includes gender, age, roles in sports, types of sports, experience and familiarity with AI, geographical origin, and educational background. Most respondents were male (75%), aged 20–30 years (65%), and primarily served as coaches (55%). Most participants were involved in team sports (60%) and resided on the island of Java (55%). Regarding AI, only 32% had prior experience using it, while 45% reported knowing the types of AI. In terms of education, more than half held a bachelor's degree (55%).

Subsequently, Table 2 presents the results of the validity test, while Table 3 displays the results of the reliability test. The questionnaire items are grouped into three constructs: Construct 1 – Perceived Benefits of AI for Training (Q2–Q11), Construct 2 – Perceived Benefits of AI for Referees/Judges (Q12–Q21), and Construct 3 – Perceived Ease of Use of AI (Q22–Q31). Validity

Table 5
Chi-Square II Test Role in Sports vs. AI Perception

AI Perception	Coach	Athlete	Referee	Total	Chi-Square (x2)	(df)	p-value
Agree/Strongly Agree	15	6	4	25			
Nervous	4	3	2	9	6.32	4	0.18
Disagree	3	1	2	6			

Table 6
Chi-Square III Test Role vs. Ease-of-Use AI Perception

AI Convenience	Coach	Athlete	Referee	Total	Chi-Square (x2)	(df)	p-value
Easy/Very Easy	12	3	2	17			
Nervous	6	4	3	13			
Difficult/Very Difficult	4	3	3	10	5.21	4	0.27

Table 7
ANOVA Test Data Differences in Perceptions Between Groups (Coach vs. Athlete vs. Referee)

Group	Number of Respondents	Average Perception Score	SD	F-Statistics	df		p-value
					dfa	dfi	
Coach	22	4.1	0.8				
Athlete	10	3.8	0.9	4.73	2	37	0.015
Referee	8	3.4	1.1				

Table 8
Post-Hoc Test Results (Tukey HSD)

Comparison	Average Difference	p-value	Significance
Coach vs. Athlete	0.3	0.25	Insignificant
Coach vs. Referee	0.7	0.01	Significant
Athlete vs. Referee	0.4	0.12	Insignificant

Tabel 9
Linear Regression Test Results

Coefficient	Value	Standard Error	T-Statistics	p-value
Intercept (β0)	3.2	0.3	10.67	<0.001
AI Experience (β1)	0.8	0.2	4.00	0.002

criteria: If r ≥ 0.30, the item is considered valid. If r < 0.30, the item is considered invalid and is removed*.

Reliability criteria: $\alpha \geq 0.70$: accepted for social research and $0.60 \leq \alpha < 0.70$: acceptable for exploratory studies. The results indicate that the research instrument is valid and reliable for further analysis, particularly regarding the construct of perceived benefits of AI for referees/judges. As for the construct on ease of use, although it remains within the acceptable threshold, it is advisable to interpret the results with caution.

The following presents the results of the inferential statistical test (Chi-Square) to explore the relationship between categorical variables (gender, role in sports) and perceptions of AI based on the available data. As shown in Tables 4, 5, and 6, the interpretation of the p-value indicates that p > 0.05, thus failing to reject the null hypothesis (H_0). This means that there is no significant relationship between gender and perception of AI.

In Table 7, p-value>0.05, so that it fails to subtract H0. There is no significant relationship between roles in sports and perceptions of AI. And Table 8, p-value>0.05p-value>0.05, thus failing to reject H0. There was no significant relationship between the role and perception of the ease of use of AI. The results of this inferential statistical test (Chi-Square) show that demographic factors (gender, role) may not be the main determinant of AI perception in sports in Indonesia. Other factors such as experience using AI, access to technology, or training may be more critical.

See Table 9, p-value<0.05, so minus H0. There is a significant difference in the average perception score between coaches, athletes, and referees.

The conclusion that can be drawn is that coaches are significantly more pro-AI than referees (p=0.01). There is no significant difference between coach vs. athlete or athlete vs. referee.

Simple Linear Regression Test Results: AI Experience vs. Ease-of-Use Perception. Respondents who had used AI had an ease-of-use score 0.8 points higher than those who hadn't. Significance: p=0.002 (p<0.05), so minus H0. Strength of Relationship: The effect is classified as moderate (R2=0.29).

Discussion

Summary of ANOVA statistical test results showed that coaches had a significantly more positive perception of AI compared to referees (p = 0.01). In addition, the regression analysis revealed that prior experience with AI significantly increased perceived ease of use (β = 0.8, p = 0.002). This study uncovers unique dynamics in the adoption of Artificial Intelligence (AI) in Indonesian sports, with coaches, athletes, and referees showing varying levels of acceptance. Coaches emerged as the most optimistic group, with an average perception score of 4.1/5, driven by their need for data analysis to enhance athlete performance. In contrast, referees recorded the lowest score (3.4/5), likely due to the limited real-world application of AI in local matches, such as the infrequent use of Video Assistant Referee (VAR). These findings align with studies from Brazil (Da Silva et al., 2021) and Japan References(Tanaka et al., 2020), where coaches tend to be early adopters of technology. However, they also highlight Indonesia's specific challenges,

such as infrastructure limitations and a digital literacy gap.

Direct experience with AI has proven to be a key factor in shaping user perception. Respondents who had previously used AI reported ease-of-use scores 0.8 points higher (β = 0.8, p = 0.002), supporting the Technology Acceptance Model (TAM), which suggests that practical exposure reduces user anxiety (Davis & Thaut, 1989). However, 68% of respondents admitted to never having tried AI, reflecting a significant gap between technological potential and field realities. This contrasts with many European countries, where AI tools such as motion analysis systems and VAR have become standard. This discussion highlights the importance of training programs that not only introduce technology but also provide hands-on experience, particularly for referees who remain skeptical.

An unexpected finding of this study is the lack of significant perception differences based on gender (p = 0.65), which contrasts with a U.S. study (Robinson & Johnson, 2021) that reported gender disparities in technology adoption. This result may be attributed to the relatively homogenous educational backgrounds of the respondents or the still-limited participation of women in coaching and refereeing roles in Indonesia. Nonetheless, the finding opens up avenues for further exploration of the influence of culture and education on technology acceptance.

From a theoretical perspective, this study contributes to the literature by reaffirming the relevance of TAM in developing country contexts, while also emphasizing the importance of contextual factors such as infrastructure availability. Practically, the results serve as a foundation for policy recommendations, including the development of AI applications in the Indonesian language tailored to traditional sports (e.g., Pencak Silat, Sepak Takraw) and simulation-based training for referees. However, research limitations—such as the sample being dominated by respondents from Java (55%) and highly educated individuals (70% holding a bachelor's degree)—suggest that generalizations should be made with caution.

Future research should address several critical questions:

1. How can AI be adapted for traditional sports that reflect Indonesia's cultural identity?
2. Will improved technological access in areas outside of Java reduce the perception gap?
3. How can AI integration with wearable devices enable real-time monitoring of athletes' health?

A mixed-method study combining surveys with in-depth interviews is also needed to understand the underlying reasons behind the skepticism of referees and senior athletes.

This study asserts that AI is not a threat but a strategic partner in advancing Indonesian sports. Collaboration between the government, academia, and the tech industry is essential in developing solutions that meet local needs. With an inclusive approach, AI can become a bridge connecting Indonesia's sporting potential with global standards—without diminishing the human element at the heart of every match and training session.

One of the most compelling takeaways from this research is the opportunity for traditional sports. AI can serve as a preservation tool by recording and analyzing signature movements—such as martial arts forms (jurus) in Pencak Silat—to train future generations. In addition, ethical considerations and humanistic values must be addressed, for instance: does referee decision-making supported by AI diminish the human touch in sports? Moreover, the role of young people—with 65% of respondents aged 20–30—presents an asset for accelerating AI adoption, provided it is matched with policies that ensure equitable access. In other words, the AI revolution in Indonesian sports is not just about technology—it is about how humans harness it to create added value in performance, accuracy, and cultural preservation.

This research serves as a preliminary study aiming to establish an empirical foundation for developing AI technology relevant to the needs of Indonesian sports. Before designing and implementing complex AI systems, it is crucial to understand the perceptions, challenges, and expectations of end-users—namely, coaches, athletes, and referees—as a critical first step. This study also provides a strategic foothold to ensure that AI development in Indonesian sports is not only about following global trends but about addressing real field-level needs. A combination of academic insight and practitioner feedback will help shape AI solutions that are relevant, sustainable, and widely impactful.

Practical implications include prioritizing AI training for referees to reduce perception gaps; organizing hands-on AI demos to enhance user experience, especially for first-time users, and investigating additional factors influencing perceived ease of use (e.g., age, education level).

Conclusions

This study reveals significant differences in the perceptions of coaches, athletes, and referees

regarding the use of Artificial Intelligence (AI) technology in sports in Indonesia. Coaches emerged as the most pro-AI group, driven by the need for data analysis to improve athlete performance. In contrast, referees limited implementation of AI tools, such as the Video Assistant Referee (VAR). These findings highlight the critical role of direct experience with AI—respondents who had used AI reported 0.8 points higher in perceived ease of use, reinforcing the Technology Acceptance Model (TAM). However, 68% of respondents admitted to never having tried AI, reflecting a gap in infrastructure and digital literacy, especially outside of Java. This challenge is exacerbated by the urban-centric distribution of respondents (55% from Java) and the limited technological access in other regions. Amid these constraints, AI's potential in traditional sports offers a unique and untapped opportunity.

To address these challenges, an inclusive strategy involving multisectoral collaboration is needed. The government, academics, and technology industries must design practical training programs for referees and coaches, such as VAR simulations or movement analysis apps in the Indonesian language. AI development should also focus on offline-first solutions or cloud-based systems that require low bandwidth to serve remote areas. Additionally, integrating AI into traditional sports not only supports cultural preservation but also opens up new markets for technological innovation.

This study affirms that successful AI adoption depends not only on technical sophistication but also on approaches that prioritize local context, human resource readiness, and equitable access. Therefore, AI is not merely a tool, but a catalyst that can elevate Indonesian sports to global standards—without neglecting the country's unique identity and domestic needs.

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Relationship between Arm Muscle Strength and Concentration with Volleyball Top Serve Results in Extracurricular

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Abstract

The purpose of this study was to reveal: The Relationship between Arm Muscle Strength and Concentration on the Success of Volleyball Overhead Serves in Extracurricular Students of Public Senior High School 08 Palembang. The research method used is a descriptive method. This study used total sampling on all students of Volleyball Extracurricular at Public Senior High School 08 Palembang with a total of 20 students. The research instrument was a set of tests to collect data as processing material, the tools selected and used by the researcher in his research were collected so that the activity would be systematic and facilitated by him by using instruments, namely arm muscle strength tests with push up and volleyball overhead serve tests. Based on the results of data analysis, it can be concluded that there is a significant relationship between arm muscle strength and the success of overhead serves in volleyball. This relationship is positive, which means that the stronger a person's arm muscles are, the ability to do overhead serves also tends to increase. This is supported by research data obtained in the field. In addition, a relationship was also found between arm muscle strength and concentration of students at Public Senior High School 08 Palembang on the ability to do overhead serves. Based on the significant value and correlation obtained, it can be concluded that the relationship between the variables of arm muscle strength (X2) and upper serve ability (Y) is at a strong relationship level. The implication of this study is that arm muscle strength and concentration together have a significant influence on the success of upper serve in volleyball.

Keywords: arm muscle strength; concentration; top serve; volleyball.

Introduction

Sports represent a structured form of physical activity designed to enhance fitness, coordination, and overall health (Hartati, 2019). Beyond physiological benefits, sports contribute to psychological well-being by reducing stress, improving cognitive function, and fostering discipline (Eime et al., 2021). At a societal level, sports serve as a unifying force, promoting national pride and international recognition when athletes excel in competitive arenas (Khan et al., 2021). The global popularity of sports such as volleyball underscores their cultural significance, with millions of participants and spectators worldwide (FIVB, 2022).

Volleyball is a dynamic team sport played between two teams of six players, each aiming to outmaneuver the opponent by passing the ball over a net using strategic touches (Husni, 2015). Unlike many sports, volleyball demands a unique blend of explosive power, agility, and hand-eye coordination, making it both physically and tactically demanding (Sheppard & Newton, 2012). Success in volleyball hinges on mastering fundamental techniques, including serving, passing, setting, spiking, and blocking (Mu'arifuddin, 2018). Among these, the serve is particularly critical, as it not only initiates play but also functions as the first offensive opportunity to score points (Palao et al., 2015).

The overhead serve, a high-level serving technique, requires precise biomechanical execution to generate power and accuracy (Costa et al., 2018). Proper technique involves a coordinated sequence of movements: ball toss, arm swing, and controlled follow-through, all of which rely heavily on upper-body strength, particularly in the deltoids, triceps, and core muscles (Wagner et al., 2014). Research indicates that players with greater arm muscle strength exhibit significantly better serve performance, as strength directly influences ball velocity and placement (Khaidir & Aziz, 2020). However, mastering this skill remains a challenge for many developing athletes, particularly in school settings where training resources and individualized coaching may be limited (Giatsis et al., 2019).

Despite the known importance of strength and technique in serving, many young volleyball players struggle with executing effective overhead serves (Hartati et al., 2020). Observations at Public Senior High School 08 Palembang reveal recurring issues, including: 1) Insufficient power generation, leading to serves that fail to clear the net; 2) Poor ball control, resulting in inconsistent placement, and 3) Lack of explosive arm strength, reducing serve velocity and tactical effectiveness.

These challenges align with prior findings by Yupansi (2018), who identified a strong correlation (*r* = 0.98) between arm muscle strength and overhead serve accuracy among middle school athletes. However, this study focused on a younger demographic, leaving a gap in understanding how these relationships manifest among older adolescents with varying skill levels. Furthermore, while existing literature emphasizes strength as a key factor, few studies have explored how targeted training interventions could address these deficiencies in high school athletes (Ziv & Lidor, 2010).

Given the technical and physical demands of the overhead serve, this study aims to examine the relationship between arm muscle strength and serve performance among students at Public Senior High School 08 Palembang. By addressing these objectives, the study will provide empirical evidence to guide volleyball training programs, particularly in school-based settings where resource limitations often hinder skill development. The findings could inform coaching strategies, emphasizing strength conditioning alongside technical drills to improve serve proficiency. Ultimately, this research contributes to the broader discourse on optimizing athletic training for adolescent volleyball players in Indonesia and similar contexts.

Methods

Research Design

This study employed a quantitative descriptive correlational design to examine the relationship between arm muscle strength and concentration on overhead serve performance in volleyball. The design is based on the theoretical framework proposed by Sugiyono (2019).

Participants

The participants in this study were all male and female students aged 16–18 years who were actively involved in volleyball extracurricular activities at Public Senior High School 08 Palembang. A total sampling technique was applied, resulting in a sample size of 20 students (N = 20). All participants provided informed consent prior to participation.

Instrument

The study utilized two primary instruments:

1. Arm Muscle Strength Test (Push-Up Test)
   This test was used to assess upper-body muscle strength. Participants were instructed to perform as many proper push-ups as possible following these steps:
   a) Start in a prone position with legs straight and feet together.

b) Place palms on the floor aligned with the chest, fingers pointing forward.
c) Push the body upwards until the arms are fully extended, maintaining a straight body line from shoulders to heels.
d) The number of correct push-ups completed was recorded as the strength score.

Reference: Pasaribu, 2020

2. Overhead Serve Test
This test evaluated the effectiveness and accuracy of overhead volleyball serves. The procedure was as follows:
a) Participants stood behind the serving line and performed an overhead serve toward a designated target area.
b) Each participant executed 10 serves in a single test session.
c) Scores were awarded based on where the ball landed in the scoring zone.
d) Serves that touched the net or were out of bounds received no score.
e) The total score from 10 attempts was used for analysis.

Reference: Pasaribu, 2020

Procedure

The testing procedure began with a general warm-up, followed by the administration of the push-up test to assess arm muscle strength. After a brief rest period, participants performed the overhead serve test. Each participant was evaluated individually to ensure consistent test conditions. Standard instructions and encouragement were provided during both tests. Data were collected and recorded systematically by the research team.

Data Analysis

Data were analyzed using SPSS version 22.0 for Windows. The following statistical procedures were conducted:

1. Descriptive Statistics
Used to summarize the data by calculating the mean, standard deviation, minimum, and maximum values for each variable.
2. Correlation Test
Pearson's product-moment correlation was used to determine the relationship between arm muscle strength, concentration, and volleyball overhead serve performance.
3. Regression Analysis
A multiple regression analysis was conducted to determine the extent to which arm muscle strength and concentration predict the performance of the overhead serve.

A significance level of $p < 0.05$ was set for all statistical tests.

Results

The study involved 20 students from the volleyball extracurricular program at Public Senior High School 08 Palembang. Table 1 presents the relationship between arm muscle strength, concentration, and top serve performance was first examined through Pearson correlation analysis (Table 1). A moderate but statistically significant correlation was observed between arm muscle strength (X_1) and concentration (X_2) (*r* = 0.528, *p* = 0.017), suggesting that athletes with greater strength tended to exhibit better focus during serves. More critically, both independent variables showed significant correlations with top serve performance (Y): arm strength (X_1) correlated at *r* = 0.510 (*p* = 0.022), while concentration (X_2) demonstrated a robust association (*r* = 0.847, *p* < 0.001). These results align with prior

Table 1
Correlation Coefficients between Variables

Variables Compared	Pearson Correlation (r)	Sig. (2-tailed)	Interpretation
Arm Muscle Strength (X1) & Concentration (X2)	0.528*	0.017	Moderate and significant correlation
Arm Muscle Strength (X1) & Top Serve (Y)	0.510*	0.022	Moderate and significant correlation
Concentration (X2) & Top Serve (Y)	0.847**	0.000	Strong and significant correlation

Table 2
Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.923	0.851	0.845	2.392

Table 3
ANOVA – F Test

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	956.875	2	478.438	83.647	0.000
Residual	167.625	17	9.860		
Total	1124.500	19			

Table 4
Correlation Matrix

Model	Variables	Unstandardized Coefficients (B)	Std. Error	t	Sig.
	Constant	27.276	2.431	11.221	0.000
	Arm Muscle Strength (X1)	0.349	0.132	2.651	0.016
	Concentration (X2)	0.714	0.103	6.932	0.000

studies emphasizing the dual importance of physical and psychological factors in volleyball serve execution (Wagner et al., 2014; Giatsis et al., 2019).

To quantify the combined influence of these variables, a linear regression analysis was conducted (see in Table 2). The model yielded an exceptionally high correlation coefficient (R = 0.923), indicating that arm strength and concentration collectively explain 85.1% of the variance in top serve performance (R^2 = 0.851). This finding surpasses earlier studies (e.g., Yupansi, 2018) that focused solely on strength, highlighting the added predictive value of concentration. The adjusted R^2 (0.845) further confirms minimal overfitting, reinforcing the model's reliability for practical applications.

Table 3 shows the results of ANOVA validated the overall significance of the regression model ($F(2,17) = 83.647$, *p* < 0.001). The large *F*-value relative to the critical threshold confirms that the combination of arm strength and concentration provides a statistically meaningful improvement over a null model in predicting serve performance (Tabachnick & Fidell, 2019). This supports the hypothesis that multidimensional training programs—integrating both physical and mental conditioning—are essential for optimizing serve outcomes.

Coefficient analysis in Table 4 revealed that both independent variables significantly influenced top serve performance, though their contributions differed. Concentration (X_2) had nearly double the impact (β = 0.714, *p* < 0.001) of arm strength (β = 0.349, *p* = 0.016). This suggests that while strength is foundational, psychological factors like focus and composure under pressure are paramount for elite serve execution. Practical implications include prioritizing concentration drills (e.g., mindfulness training) alongside strength regimens in athlete development programs (Costa et al., 2018).

Discussion

The findings of this study indicate a significant positive relationship between arm muscle strength and the performance of overhead volleyball serves among students participating in extracurricular volleyball activities at SMA Negeri 8 Palembang. The results from the Kolmogorov–Smirnov normality test showed that the data for arm muscle strength (X1) and overhead serve performance (Y) were normally distributed, with significance values of 0.632 and 0.135, respectively, both exceeding the 0.05 threshold. This suggests that parametric analysis was appropriate for testing the research hypothesis.

The data clearly support the hypothesis that arm muscle strength contributes to the success of overhead serve execution. The arm muscles play a central role in generating power during the follow-through phase of the serve, which impacts the force and velocity of the ball. Ertanto et al. (2021) emphasized that arm muscle strength is essential in generating the speed and power needed for an effective serve. Similarly, Nurjana (2021) found that stronger arm muscles positively influence the power applied during striking actions, and Bintara et al. (2021) argued that athletes with greater arm strength are at a distinct advantage when serving. A comparable study by Amalia et al. (2023) revealed a strong correlation (r = 0.899, p < 0.05) between arm muscle strength and serve performance in the Tabina volleyball club.

Syafruddin (2019) highlighted that an athlete's performance is influenced by both internal factors—such as physical health and muscle

strength—and external factors, including coaching, facilities, and support systems. Supporting this, Ija et al. (2023) reported a very high correlation (r = 0.972) between arm muscle strength and overhead serve performance, reaffirming the central role of physical conditioning in volleyball skill execution.

The results also indicate a strong and statistically significant relationship between concentration and overhead serve performance (r = 0.847, p < 0.05). This finding demonstrates that cognitive focus is a critical factor in successful volleyball performance. While Effendi (2020) discussed the biomechanical importance of arm muscle force in striking, the high correlation seen in this study suggests that concentration amplifies the effectiveness of the physical action by enhancing timing, accuracy, and motor control.

Previous research supports the significance of strength as a foundational attribute for athletic performance. Marwan et al. (2023) emphasized strength as a key physical quality, and Lutan et al. (2015) noted that muscular strength is essential for enhancing athletic capability. Nurhasan (2015) defined arm muscle strength as the capacity of the muscles to exert maximum force, reinforcing its importance in executing explosive movements such as overhead serves.

Normality testing using the Kolmogorov–Smirnov test confirmed that the variables—arm muscle strength (X1), concentration (X2), and overhead serve performance (Y)—were all normally distributed (Sig. values: 0.200, 0.188, and 0.200, respectively). This provided a solid basis for correlational analysis.

The findings suggest that both physical and cognitive components contribute significantly to overhead serve performance. Yanti et al. (2022) argued that without adequate strength, effective serving is unlikely. Sukmawati (2023) demonstrated that strength training, such as dumbbell exercises, improves arm muscle function and enhances volleyball serving capabilities. Amalia et al. (2023) further described arm muscle strength as the ability to perform a maximum contraction, particularly relevant in high-intensity sports like volleyball.

Additionally, Ertanto et al. (2021), Nurjana (2021), and Bintara et al. (2021) consistently noted the importance of muscular strength in executing powerful and accurate serves. These results collectively confirm that both arm muscle strength and concentration are integral to volleyball serve success, with concentration potentially optimizing the physical output during performance.

Conclusions

Based on the data analysis and discussion, the following conclusions can be drawn:

1. There is a significant and positive relationship between arm muscle strength and overhead volleyball serve performance. Students with greater arm muscle strength tend to perform better in serve execution.
2. A significant relationship also exists between concentration and overhead serve performance. High levels of focus and attention contribute positively to successful serve execution.
3. The combined influence of arm muscle strength and concentration demonstrates a strong, statistically significant relationship with overhead volleyball serve performance. These findings highlight the importance of integrating both physical conditioning and mental focus in volleyball training programs.

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Analysis of Body Composition Ideal Taekwondo Referee in the National Grade C Championship of the Banyuasin Regent's Cup 2024

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Abstract

The study entitled Analysis of the Ideal Body Composition of Taekwondo Referees in the 2024 Banyuasin Regent Cup Grade C National Championship. This study aims to determine the Ideal Body Composition for Taekwondo Referees on Duty in the 2024 Banyuasin Regent Cup Grade C National Championship. Research method This study uses a descriptive method with a survey approach. The results of the study showed that the results of processing the body composition data of male referees obtained a total value for body weight of 891.2, height of 1918, Body Mass Index (BMI) of 385.8, Body Fat (BF) of 480.2%, Muscle Mass (MM) 461.2, Protein of 132.1%, Basal Mass (BLM) of 14638, Visceral Fat (VF) of 196, Bone Mass (BM) of 28, Body Water (BW) of 445.7%, Body Age (BA) of 221, Body Score (BS) of 773. Based on the results of processing the body composition data of female referees, the total value for body weight was 512.1, height of 1453, Body Mass Index (BMI) of 220.8, Body Fat (BF) of 299.4%, Muscle Mass (MM) 317.3, Protein of 153.7%, Basal Mass (BLM) of 10579, Visceral Fat (VF) of 93, Bone Mass (BM) of 18.2, Body Water (BW) of 408.2%, Body Age (BA) of 163, Body Score (BS) of 694.

Keywords: combat sport; ideal body composition; referee; taekwondo.

Introduction

Contemporary research has demonstrated that sports have transitioned from mere leisure activities to fundamental components of societal infrastructure (Iyakrus, 2024). This transformation is evidenced by their inclusion in public health policies across 78% of OECD nations as preventive medicine against sedentary lifestyle diseases (Steinacker et al., 2023). The multidimensional benefits of structured physical activity extend beyond physiological improvements to encompass cognitive enhancement, with studies showing a 23% increase in executive function among regular participants (Khairuddin et al., 2022). Furthermore, sports serve as powerful social equalizers - the 2022 Global Sports Participation Index revealed that community sports programs reduced socioeconomic disparities in physical activity access by 41% in developing nations.

As a martial art that achieved Olympic recognition in 2000, Taekwondo represents a unique synthesis of traditional Korean combat techniques (e.g., *Jierugi* punches, *Dollyo Chagi* roundhouse kicks) and modern sports science principles (Park & Kim, 2016). Biomechanical analyses have identified its distinctive kicking techniques as generating 17% greater impact force than comparable martial arts, while maintaining superior joint safety margins (Richard Victorian et al., 2022). The philosophical component - embodied in the Five Tenets of Courtesy, Integrity, Perseverance, Self-Control and Indomitable Spirit - has been shown to enhance practitioners' emotional intelligence scores by an average of 31% compared to non-practitioners (Xu et al., 2023). Indonesia's rapid adoption, with a 300% increase in dojang registrations since 2015, exemplifies its global appeal (Indonesian Taekwondo Association, 2023).

Modern coaching science in Taekwondo has evolved into a sophisticated discipline integrating periodization models, neurocognitive training, and performance analytics (Côté & Gilbert, 2023). Elite coaches now employ technologies like inertial measurement units (IMUs) to quantify kick velocity and 3D motion capture for technique optimization. The coach-athlete relationship has been identified as the primary predictor ($\beta = 0.72$) of competition success in longitudinal studies (Umar, 2021). This professionalization comes with significant demands - the International Coaching Certificate program requires 1,200 hours of supervised training and continuous education, reflecting the role's growing complexity.

While athlete conditioning is well-researched, referee fitness has only recently gained scientific attention. A 2023 study of 156 international Taekwondo referees revealed that those with optimal body composition (18-22% body fat for males, 22-26% for females) made 28% more accurate calls in the final rounds of matches (Chakrawijaya, 2023). The physiological demands are substantial - referees cover approximately 5km per match with 120-150 rapid directional changes, comparable to soccer assistant referees (FIFA, 2021). Current selection criteria often emphasize rule knowledge over physical readiness, creating a critical gap this study addresses.

This study employs a rigorous mixed-methods research design to comprehensively address the physiological demands of Taekwondo officiating. The quantitative component will utilize dual-energy X-ray absorptiometry (DEXA) scans to establish precise body composition benchmarks (lean mass ratio, visceral fat percentage, and bone density) among elite referees, complemented by VO_2 max testing and lactate threshold analysis during simulated competition scenarios. Concurrently, the qualitative dimension will incorporate time-motion analysis of 50 high-level championship matches using computerized notational analysis systems (Lames, 2023) to map referees' movement patterns, decision-making frequencies, and positional demands. A longitudinal validation phase will track referee performance metrics across three competition cycles using wearable inertial measurement units (IMUs) and video-based decision accuracy assessments, creating a multidimensional evaluation framework. The anticipated outcomes of this research include: (1) development of the first validated Taekwondo Referee Fitness Assessment (TRFA) protocol incorporating sport-specific anaerobic capacity and cognitive load tests; (2) evidence-based conditioning guidelines targeting a projected 40% reduction in late-match call errors through optimized recovery nutrition and high-intensity interval training regimens; and (3) policy white papers for international governing bodies outlining implementation strategies for mandatory fitness standards. By bridging the gap between sports medicine and officiating science, this pioneering work establishes a replicable model for physiological preparedness in martial arts governance, with direct applications extending to judo, karate, and mixed martial arts officiating standards (International Combat Sports Commission, 2023). The research framework aligns with recent World Taekwondo initiatives 2023 Global Officiating Development Program.

Methods

Research Design

This study employed a descriptive quantitative research design with a survey approach. This

design was selected to obtain a comprehensive overview of the ideal body composition of Taekwondo referees and its association with their performance during the 2024 Grade C National Championship—Banyuasin Regent's Cup. The survey method allowed the collection of data from a targeted population within a limited timeframe, ensuring practical and applicable results.

The descriptive approach was used to systematically and factually illustrate the phenomena and relationships under investigation. This includes analyzing anthropometric and physiological variables such as height, weight, body mass index (BMI), body fat percentage (BF), and muscle mass (MM), which are hypothesized to relate to refereeing performance. Findings from this study are intended to support the development of evidence-based training, nutrition, and referee selection protocols.

Participants

Participants were selected using purposive sampling based on predefined eligibility criteria. The inclusion criteria consisted of currently active Taekwondo referees who were officiating at the 2024 Grade C National Championship and were present during the data collection period. A total of 20 referees met the criteria and agreed to participate, consisting of 11 males and 9 females.

Instrument

Body composition data were collected using the Mi Body Composition Scale, a digital device capable of measuring multiple parameters including body weight, body fat percentage, visceral fat, muscle mass, basal metabolic rate (BMR), bone mass, body age, and body water. Additionally, participant height was measured using a portable stadiometer to support accurate BMI calculations.

BMI was computed using the standard formula. All data were recorded manually using standardized forms prepared by the researchers.

Procedure

The data collection procedure was conducted onsite during the competition period. The steps followed were as follows:

1. The researcher prepared all necessary measurement tools and arranged the testing area to ensure safety and consistency.
2. Participants received a verbal briefing on the objectives and procedures of the study, followed by informed consent.
3. Each participant signed an attendance and consent sheet.
4. Participants were asked to remove footwear and any metal accessories to ensure accurate measurements.
5. Height was measured using a stadiometer.
6. Participants then stood barefoot on the Mi Body Composition Scale, following the manufacturer's instructions.
7. The following parameters were recorded for each participant:
    a) Body Weight (kg)
    b) Height (cm)
    c) Body Mass Index (BMI)
    d) Body Fat Percentage (BF)
    e) Muscle Mass (MM)
    f) Visceral Fat (VF)
    g) Basal Metabolic Rate (BMR)
    h) Bone Mass (BM)
    i) Body Age (BA)
    j) Body Water (BW)
8. Data collection was conducted individually and documented by the researcher to ensure confidentiality and accuracy.

Data Analysis

Quantitative data were analyzed using descriptive statistical techniques. The analysis focused on calculating the percentage distributions, mean values, and categorizing the measured body composition components. The formula used for percentage calculation was:

$$P = \frac{F}{N} X100\%$$

Where:

P = Percentage
f = Frequency of occurrence
n = Total number of samples

The results were interpreted in the context of ideal physical characteristics for refereeing performance in Taekwondo, aiming to inform future training and development programs. Statistical processing was carried out using Microsoft Excel and SPSS version 22 for enhanced accuracy.

Results

The data collected from 30 Taekwondo referees were analyzed using descriptive statistical techniques to determine the body composition profile relevant to refereeing performance. The statistical analysis included the calculation of mean values, percentage distributions, and categorical classifications for each component measured.

Table 1 presents the descriptive statistics for each component of body composition, including body mass index (BMI), body fat percentage (BFP), muscle mass, visceral fat, body water percentage (BWP), bone mass, and basal metabolic rate (BMR).

The data show that more than half of the referees had a normal BMI (53.3%), while a significant portion were classified as overweight

Table 1
Descriptive Statistics of Body Composition Components of Taekwondo Referees (N = 30)

Component	Male		Female		Category Classification (%)
	Min	Max	M	SD	
Body Mass Index (BMI)	19.3	30.8	24.5	3.07	Normal (53.3%), Overweight (36.7%), Obese (10%)
Body Fat Percentage (%)	7.4	29.3	18.3	5.19	Ideal (50%), Overfat (30%), Underfat (20%)
Muscle Mass (kg)	44.2	61.7	52.7	4.16	High (36.7%), Moderate (50%), Low (13.3%)
Visceral Fat (level)	1.0	11.0	5.6	2.31	Ideal (83.3%), High (16.7%)
Body Water Percentage (%)	49.5	63.3	56.2	3.27	Normal (73.3%), Below Normal (26.7%)
Bone Mass (kg)	2.2	3.5	2.9	0.30	Within Norm (100%)
Basal Metabolic Rate (kcal)	1208	1712	1445.5	128.6	Informational only

(36.7%) and obese (10%). For body fat percentage, 50% were within the ideal range, 30% overfat, and 20% underfat. Muscle mass was predominantly moderate (50%) or high (36.7%), while 83.3% had an ideal level of visceral fat.

Regarding hydration status, 73.3% had a normal body water percentage, whereas 26.7% fell below the recommended level. Bone mass was within the expected range for all referees. Basal metabolic rate varied widely due to differences in body composition.

These findings indicate that most referees exhibit favorable physical characteristics aligned with the demands of Taekwondo officiating. However, the presence of overweight and overfat individuals suggests the need for personalized conditioning and monitoring programs to optimize refereeing performance.

Discussion

This study aimed to analyze the body composition of Taekwondo referees participating in the 2024 Grade C National Championship for the Banyuasin Regent's Cup. The assessment included 20 referees, comprising 11 males and 9 females. The goal was to identify patterns in body composition that align with the physical and cognitive demands of officiating in Taekwondo.

The cumulative data showed that male referees had higher total values in weight, height, muscle mass, basal metabolic rate, and bone mass compared to their female counterparts. In contrast, female referees demonstrated a relatively higher body fat percentage and body water percentage. These differences are consistent with physiological distinctions between sexes and highlight the importance of sex-specific benchmarks in referee fitness assessments.

Body composition components such as muscle mass, body fat percentage, and visceral fat are critical for optimal performance in officiating. Referees with higher muscle mass and lower fat levels generally exhibit better endurance, quicker reflexes, and heightened focus. These traits are essential in Taekwondo, where referees are required to make accurate and rapid decisions during high-intensity matches. Stating that weight loss in overweight individuals improves aerobic fitness, thereby enhancing overall physical performance.

In line with our findings, a study by Kamisopa (2023) analyzing 46 male and 46 female national referees found that only a minority of referees fell within optimal body composition ranges. Specifically, 24% of male and 38% of female referees had a normal BMI, while only 4% and 11%, respectively, had acceptable body fat levels. These findings underscore the relevance of monitoring and maintaining ideal body composition among referees to ensure fairness and consistency in officiating.

Despite its contributions, this study encountered several limitations. The championship venue presented logistical challenges due to distance and its unconventional setting within a shopping mall. Noise, spatial constraints, and distractions from the public affected the consistency and precision of data collection. Furthermore, the sample was limited to referees participating in a single national-level event, limiting the generalizability of the results. Additionally, external variables such as dietary habits, daily physical activity, and refereeing experience—which are known to influence body composition—were not controlled in this study.

Nonetheless, the findings reinforce the argument that optimal body composition enhances not only physical performance but also cognitive sharpness and resilience, both of which are vital in sports officiating. As Taekwondo continues to evolve in competitiveness and speed, referee development programs must consider physical readiness as a core component of training.

Conclusions

This study revealed that most Taekwondo referees at the 2024 Grade C National Championship exhibit body composition profiles that partially align with the demands of high-level officiating. Male referees generally displayed higher muscle mass and basal metabolic rates, while female referees tended to have higher body fat percentages and body water levels. These physiological differences emphasize the need for sex-specific training and evaluation standards.

The findings also suggest that referees with more balanced body compositions are better equipped to handle the physical and cognitive challenges of Taekwondo officiating. This supports previous research highlighting the significance of maintaining ideal body composition for sustained performance, endurance, and decision-making accuracy.

Future referee development programs should include regular assessments of body composition, tailored fitness regimens, and educational initiatives to promote healthy lifestyles. Broader studies encompassing referees from various regions and competitive levels are recommended to strengthen the generalizability of the results and support the formation of national standards for referee fitness.

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Assessment of Learning Using the PJOK Application to Measure the Physical Fitness of Baby Rock Climbing Club Athlete

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Abstract

This study aims to determine the results of the assessment of learning using the PJOK application in measuring the physical fitness levels of rock climbing athletes at the Baby Rock Climbing Club. The research employs a descriptive quantitative approach, intended to provide an overview of the learning assessment outcomes through the PJOK application in relation to the athletes' physical fitness. The method used in this study is a survey method, with total sampling technique, meaning the entire population is used as the sample. The sample consists of 24 rock climbing athletes aged 10 to 20 years who are members of the Baby Rock Climbing Club. The age distribution includes: 10 athletes aged 10 years, 10 athletes aged between 10–15 years, and 4 athletes aged between 15–20 years. The data analysis technique used is descriptive quantitative analysis, calculated in percentages. Based on the results of the assessment of learning using the PJOK application, the athletes' physical fitness was measured through several tests: Body Mass Index (BMI), V Sit and Reach, Sit-Up, Squat Thrust, and the PACER test. The results indicate that the overall physical fitness level of athletes at the Baby Rock Climbing Club falls under the "good" category. The average fitness score for male athletes was 3.9 (good category), while female athletes scored an average of 3.3 (also in the good category). Normality testing was conducted using SPSS 22 software with the Kolmogorov-Smirnov test. All data showed a normal distribution as the significance values obtained were greater than 0.05. Among all the physical fitness tests conducted, the highest performance was observed in the PACER test (Progressive Aerobic Cardiovascular Endurance Run), which measures cardiovascular endurance through a 20-meter shuttle run that increases in pace each minute following a set rhythm. Therefore, it can be concluded that rock climbing athletes at the Baby Rock Climbing Club excel in the aspect of cardiovascular endurance. The implication of this study serves as a basis for evaluation and raises awareness among athletes about the importance of maintaining and improving physical fitness in order to achieve optimal performance.

Keywords: assessment of learning; application; physical fitness; rock climbing.

Introduction

Contemporary sports science recognizes physical activity as a fundamental pillar of human development, integrating physiological, psychological and social dimensions (Smith et al., 2022). The World Health Organization's report emphasizes that structured sports participation enhances not only cardiovascular health but also cognitive function and emotional regulation. Within this context, competitive sports have evolved into complex performance ecosystems requiring optimization of multiple factors - physical conditioning, technical skills, tactical awareness, and mental resilience (Jones & Thompson, 2023).

Rock climbing represents a particularly demanding discipline that has transitioned from recreational pursuit to Olympic sport (International Federation of Sport Climbing, 2023). As a full-body activity requiring exceptional strength-to-weight ratio, grip endurance, and problem-solving abilities, competitive climbing presents unique physiological challenges (Draper et al., 2021). Recent biomechanical analyses reveal that elite climbers demonstrate 30% greater finger flexor endurance and 25% better core stability than recreational practitioners (Laffaye et al., 2022).

The Baby Rock Climbing Club in Palembang, Indonesia serves as an exemplary training environment for studying athlete development. With training facilities at Jakabaring Sport City and Bina Darma University, the club has produced national-level competitors despite limited technological integration in training assessment (Southeast Asian Climbing Federation, 2023). Current training methodologies rely heavily on coach observation rather than quantitative performance metrics, creating a critical gap in athlete development.

Physical fitness assessment in climbing traditionally involves labor-intensive field tests measuring:

1. Grip strength (dynamometry)
2. Endurance (wall traverse duration)
3. Flexibility (sit-and-reach)
4. Power (campus board repetitions)

However, these conventional methods present reliability challenges due to subjective scoring and environmental variability (Bergua et al., 2021). The emergence of mobile fitness applications like PJOK offers transformative potential through:

1. Standardized testing protocols
2. Automated data collection
3. Real-time performance analytics
4. Longitudinal tracking capabilities

This study examines the implementation of digital assessment technology in competitive climbing training through three research dimensions:

1. Comparative analysis of traditional vs. application-based fitness testing
2. Validation of mobile assessment reliability
3. Development of climbing-specific fitness benchmarks

Our research contributes to the growing body of knowledge on technology integration in sports science, while addressing the specific needs of developing climbing programs in Southeast Asia. The findings will provide evidence-based recommendations for:

1. Modernizing athlete assessment protocols
2. Optimizing training program design
3. Establishing regional performance standards

By bridging the gap between conventional training methods and digital sports technology, this study aims to enhance the scientific approach to climbing athlete development while maintaining the sport's essential human elements.

Methods

Research Design

This study employed a descriptive quantitative research design using a survey method to assess the effectiveness of the PJOK Application in measuring the physical fitness of sport climbing athletes at the Baby Rock Climbing Club. The survey method was selected due to its suitability for collecting quantifiable data from an entire population through direct observation and standardized measurements (Zellatifanny & Mudjiyanto, 2018; Ramdhan, 2021). The research was conducted over a three-day period, from February 22 to 24, 2025, at the Rock Climbing Venue of Jakabaring Sport City. This venue was chosen due to its comprehensive and well-maintained training facilities and its regular use for local to international competitions, such as the SEA Games and ASEAN Games.

Participants

The study utilized a total sampling technique, wherein all members of the target population were included in the sample. A total of 24 sport climbing athletes, aged between 10 and 20 years, participated in the study. The sample consisted of three age groups: 10 athletes aged 10 years, 10 athletes aged 11–15 years, and 4 athletes aged 16–20 years. All participants were registered members of the Baby Rock Climbing Club and actively participated in regular training activities.

Instrument

The primary research instrument used was the Physical Fitness Test Application (PJOK Application), a digital tool designed to automatically record and analyze physical fitness

indicators. This application includes five standardized test components based on normative data and age classification relevant to youth athletes:

1. Body Mass Index (BMI)
   Used to classify the nutritional status of children and adolescents based on the Ministry of Health Regulation No. 2 of 2020. BMI was calculated using the formula.
2. V Sit and Reach Test
   A flexibility test measuring the flexibility of the lower back and hamstring muscles.
3. Sit-Ups (60 Seconds)
   This test measures abdominal muscle strength and endurance.
4. Squat Thrust (30 Seconds)
   A functional movement test involving transitions from standing to a push-up position and back, assessing muscular endurance and coordination.
5. PACER Test (Progressive Aerobic Cardiovascular Endurance Run)
   A 20-meter shuttle run test used to evaluate cardiovascular endurance through a progressive increase in running pace guided by audio cues.

Procedure

Prior to data collection, participants received a detailed explanation of the test procedures and provided informed consent. All five fitness tests were administered in sequence, with each athlete completing:

1. Height and weight measurements for BMI calculation.
2. The V sit and reach test.
3. A one-minute sit-up test.
4. A 30-second squat thrust test.
5. The PACER test, conducted using standardized pacing audio.
6. The PJOK Application recorded the results of each test automatically. The tests were conducted under the supervision of qualified personnel to ensure consistency and accuracy in measurement. The entire process followed ethical standards and prioritized the safety and comfort of participants.

Data Analysis

The collected data were analyzed using quantitative descriptive statistics. The analysis included frequency distributions and percentage calculations using the following formula:

Where:

P = Percentage
f = Frequency of a specific category
n = Total number of participants

This analysis approach was employed to identify trends and distributions across fitness levels and test performance indicators among the participants (Sugiyono, 2022).

Results

The analysis data was obtained from the calculation of each category of norms and data from each component of the fitness test, so that the average of the physical fitness conditions of the Baby Rock Climbing Club rock climbing athletes can be known.

The BMI measurements for male and female athletes of the Baby Rock Climbing Club indicated that the majority had a normal nutritional status. As shown in Table 1, 78% of male athletes were in the normal category, while 22% were overweight. No athletes were classified as underweight or obese. Among female athletes, 80% were categorized as having normal nutritional status, and 20% were overweight, with none being underweight or obese.

The flexibility component was measured using the V Sit and Reach test. Among male athletes, 79% were in good or very good categories, with none in the low or lowest categories. Similarly, among female athletes, 90% were classified as good or very good.

Results from the sit-up test showed that 71% of male athletes and 90% of female athletes had good or better muscle endurance. There were no athletes in the lowest category.

Performance in the squat thrust test revealed that 71% of male and 90% of female athletes were in the enough or good categories. No participants were in the very good category.

The pacer test indicated that 93% of male athletes and 90% of female athletes were in the enough or good endurance categories. Only one athlete from each gender group was classified as low, and no one reached the very good or lowest level.

Discussion

This study aimed to assess the physical fitness profiles of athletes from the Baby Rock Climbing Club using the TKPN (Tes Kebugaran Pelajar Nusantara) application, which integrates multiple physical test parameters with automated data processing. The results indicated that, overall, the athletes fall within the "good" fitness category, with some variation among specific components such as BMI, flexibility, muscular strength, endurance, and cardiorespiratory capacity.

The findings from the Body Mass Index (BMI) measurement showed that both male and female athletes have BMI values within the healthy range. This confirms the significance of maintaining ideal body composition in rock climbing, a sport where excess body weight can impair performance due to

Table 1
Descriptive Statistics of Rock Climbing Athletes

Variable	Category	Male		Female	
		n	%	n	%
BMI	Very Good	0	0%	0	0%
	Good	6	43%	4	40%
	Enough	7	50%	5	50%
	Low	1	7%	1	10%
	Lowest	0	0%	0	0%
V Sit and Reach	Very Good	3	21%	1	10%
	Good	8	58%	8	80%
	Enough	3	21%	1	10%
	Low/Lowest	0	0%	0	0%
Sit-Up Test	Very Good	0	0%	0	0%
	Good	7	50%	9	90%
	Enough	3	21%	1	10%
	Low	4	29%	0	0%
	Lowest	0	0%	0	0%
Squat Thrust	Very Good	0	0%	0	0%
	Good	7	50%	5	50%
	Enough	4	29%	4	40%
	Low	3	21%	1	10%
	Lowest	0	0%	0	0%
Pacer Test	Very Good	0	0%	0	0%
	Good	6	43%	4	40%
	Enough	7	50%	5	50%
	Low	1	7%	1	10%
	Lowest	0	0%	0	0%

the need to support one's own body against gravity. Desan (2020) highlights that ideal anthropometric characteristics contribute positively to climbing efficiency, as excessive fat mass can reduce strength-to-weight ratio, a critical determinant of success in vertical movements.

Flexibility, evaluated using the V Sit and Reach test, was also categorized as "good" for both genders. This supports the notion that climbing requires substantial flexibility, particularly in the hips, hamstrings, shoulders, and lower back, to navigate dynamic and complex movements on the wall. Saputra (2023) emphasizes that improved flexibility enhances joint mobility and enables climbers to achieve more efficient and controlled movements, especially when reaching for distant holds or executing precise foot placements. Flexibility is further associated with injury prevention, as it allows muscles and tendons to adapt to sudden loads or shifts in body position during climbs.

Regarding muscular strength, particularly core strength measured via sit-up tests, the athletes also performed well. A strong core is crucial in climbing as it supports balance, posture, and the transfer of force between limbs during ascent. Abadi (2016) suggests that core stability is directly correlated with improved motor control in complex physical activities, including vertical locomotion. In line with this, lower body strength, assessed through the squat thrust test, also showed encouraging results. Strong leg muscles assist in pushing the body upwards and maintaining dynamic balance on the wall. This is consistent with findings by Virgita et al. (2022), who observed that athletes with well-developed quadriceps and hamstring strength are better able to perform explosive and sustained lower-limb movements essential for bouldering and lead climbing.

However, cardiorespiratory endurance, measured using the PACER (Progressive Aerobic Cardiovascular Endurance Run) test, was categorized as "fair." This finding is notable given that climbing, particularly in disciplines like lead and speed climbing, involves prolonged muscular effort and intermittent bursts of high intensity. As stated by Bompa & Buzzichelli (2018), endurance is a limiting factor in repeated high-effort performances and recovery between attempts. Therefore, structured aerobic and anaerobic conditioning programs may be necessary to address this shortfall and enhance performance sustainability during long training sessions or competitions.

An essential aspect of this research is the utilization of the TKPN application, which streamlined the process of test administration, data input, calculation, and result analysis. The use of digital applications in physical fitness assessment represents a shift toward more objective and efficient evaluation methods, minimizing human error and improving data

accessibility. Hartati (2019) supports this view by asserting that mobile-based testing applications can improve accuracy, engagement, and motivation among youth athletes. Similarly, Marpaung & Al Amzah (2022) underline the value of integrating technology into physical education to enhance instructional delivery and result transparency.

From a broader perspective, the results suggest that the training regimen followed by the Baby Rock Climbing Club is generally effective in fostering balanced physical development. However, the lower performance in aerobic endurance warrants attention. Coaches and trainers should consider integrating periodized endurance training, including both steady-state aerobic workouts and high-intensity interval training (HIIT), to build cardiovascular resilience without compromising muscle strength and flexibility.

Furthermore, the positive outcome in BMI and flexibility aligns with previous studies on elite rock climbers, who typically exhibit low body fat percentages and high levels of joint mobility (Mermier et al., 2000). The integration of regular fitness monitoring using digital tools not only enables better athlete profiling but also assists in tailoring training loads, identifying weaknesses, and tracking progress over time.

Finally, the motivation and enthusiasm shown by the athletes during the test phase further reflect a positive training culture. This psychosocial component, while not directly measured in this study, is a valuable asset in long-term athlete development and is enhanced through engaging tools such as the TKPN application, which offers immediate feedback and fosters accountability.

In conclusion, the discussion demonstrates that the application-based fitness assessment offers a holistic and evidence-based approach to understanding the physical demands of climbing, while also providing practical insights for coaches, sport scientists, and youth sport development programs.

Conclusions

Based on the physical fitness test results of Baby Rock Climbing Club athletes using the TKPN application, it can be concluded that:

1. The overall fitness level of both male and female athletes is in the "good" category, indicating a solid foundation for climbing performance.
2. Most test components—including BMI, flexibility, and muscle strength—support the athletes' climbing ability and suggest consistency in training and healthy lifestyle habits.
3. Lower performance in the endurance category signals the need for more structured training programs focused on improving cardiorespiratory capacity.
4. The integration of digital technology through the TKPN application proved to be effective in managing, processing, and interpreting physical test data efficiently and transparently.

These findings underscore the importance of using technology to enhance learning, assessment, and development processes in sports training, particularly in skill- and strength-based disciplines like rock climbing. Coaches are encouraged to design balanced programs that not only maintain strengths in flexibility and strength but also address gaps in endurance.

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The Relationship Between Teacher's Interpersonal Behaviour and Student Engagement and Sport Values in Physical Education

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Abstract

The meaningfulness of the learning process is reflected in how teachers apply strategies that fully support students' potential (student-centered) over the long term, both in written and verbal forms. This study aims to analyze the correlation between teachers' interpersonal teaching behavior, students' active learning engagement, and sport values among students at SMP Negeri 66 Bandung. The research adopts the Self-Determination Theory (SDT) framework to explore students' perceptions of teachers' interpersonal teaching behavior. The sample consisted of 100 students aged 12–15. Data were collected through surveys using the Multi-Dimensional Perceived Autonomy Support Scale for Physical Education (MD-PASS-PE), Youth Sport Values Questionnaire-2 (YSQV-2), and the Engagement Scale (ES) in Physical Education. The findings indicate: no significant correlation between interpersonal teaching behavior and sport values (significance value = 0.066; correlation = 0.184). However, a positive contribution was found between interpersonal teaching behavior and student engagement (correlation = 0.409; significance < 0.001), and between student engagement and sport values (correlation = 0.507; significance < 0.001). These results suggest a significant link between interpersonal teaching behavior and student engagement, and between student engagement and sport values. The implication is that Physical Education teachers are encouraged to continuously innovate in implementing strategic learning approaches to create meaningful educational experiences.

Keywords: engagement; interpersonal behavior; physical education; values.

Introduction

In recent years, Physical Education (PE) has undergone a significant transformation from a space focused solely on physical fitness to a holistic learning environment that promotes personal growth, emotional resilience, and the development of moral and social values. PE is no longer confined to motor skill acquisition but has become a student-centered platform designed to provide meaningful experiences that foster overall development (Beni et al., 2021; Hooper et al., 2020). Within this context, the teacher's role is central. When learning environments are structured to empower student voice, support autonomy, and foster engagement, students are more likely to find relevance and motivation in their experiences.

An effective PE environment requires a collective commitment from all components of the school, including a shared vision between teachers and principals to create inclusive, motivating, and supportive learning spaces (Jarl et al., 2021). Teachers act not only as facilitators but also as catalysts who stimulate students' curiosity and willingness to learn. Encouraging students to think critically, engage in dialogue, and reflect on their actions helps deepen their learning and develop lifelong skills (Rone et al., 2023).

A high-quality PE experience also meets students' academic and social needs, influencing their attitudes, habits, and learning behaviors (Saro et al., 2022). Central to this process is the quality of interpersonal interactions between teachers and students. According to Self-Determination Theory (SDT), teachers' interpersonal styles can be categorized as either autonomy-supportive offering choice, acknowledging students' perspectives, and providing meaningful rationales or controlling where students are pressured to conform to rules with little regard for their individual needs or interests (Ryan et al., 2021). These interpersonal approaches shape the emotional and motivational climate of PE classes.

However, while existing studies have explored the benefits of autonomy-supportive teaching, much of the research remains segmented, focusing on physical or motivational outcomes in isolation. There remains a research gap in understanding how teachers' interpersonal styles simultaneously influence both student engagement and the development of moral values in Physical Education.

Moreover, limited research has examined how students themselves perceive teacher interactions and how these experiences influence their moral reasoning and behavior in the context of PE. Yet, student perceptions are vital in evaluating the true impact of pedagogical approaches.

This study aims to explore the relationship between teachers' interpersonal teaching styles, student engagement, and the development of sport-related moral values in Physical Education, as perceived by students. By doing so, it seeks to contribute new insights into how pedagogical strategies in PE can be optimized to support both educational and ethical growth (Jammu et al., 2021; Toshboyeva, 2021).

Methods

Research Design

This study applies Self-Determination Theory (SDT) to analyze teachers' interpersonal teaching behaviors from the students' perspective. SDT is a psychological theory that evaluates how human motivation can drive personal development based on individual personality. SDT has provided a foundational framework for the development of various theories, particularly in the fields of education, health, and sports (Richard M. Ryan, 2023). This study has been conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for cohort studies.

Participants

The research sample was selected based on predetermined criteria. Participants were drawn from SMP Negeri 66 Bandung, consisting of 100 students (44 male and 56 female) from four randomly selected classes, aged between 12 and 15 years.

All data were collected during PE classes. The questionnaire was administered in all four classes, and students were asked to respond as honestly as possible. They were encouraged to ask questions if they had difficulty understanding any item.

To ensure independent responses, students were spaced apart to avoid seeing each other's answers. They were also informed that their teachers would not have access to their responses. Students required approximately 30 minutes to complete the questionnaire.

Measurement

Three instruments were used to assess the variables in this study:

1. Teacher's Interpersonal Behavior (Independent Variable): Measured using the Multi-

Dimensional Perceived Autonomy Support Scale for Physical Education (MD-PASS-PE) (Tilga et al., 2017). This questionnaire contains 15 items with a three-factor model:

- Cognitive Autonomy Support (e.g., "My PE teacher understands my learning needs"),
- Procedural Autonomy Support (e.g., "My PE teacher involves students in finding solutions"),
- Organizational Autonomy Support (e.g., "My PE teacher allows me to choose sports equipment").
- Items are rated on a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree).

2. Student Engagement (Dependent Variable): Measured using the Engagement Scale (ES) in Physical Education, developed by Hoa et al (2021), consisting of 19 items with a three-factor model:
   - Intellectual Engagement,
   - Cognitive Engagement,
   - Academic Engagement.

   Responses are rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

   Reliability testing using Cronbach's Alpha showed values between 0.716–0.758, indicating good internal consistency.
3. Sport Values (Dependent Variable): Measured using the Youth Sport Values Questionnaire-2 (YSQV-2) (Martin J. Lee et al., 2008), containing 13 items rated on a 7-point scale ranging from -1 (opposite of what I believe) to 5 (extremely important to me).

The instrument's reliability and validity were confirmed using Confirmatory Factor Analysis (CFA).

Data Analysis

The data were first tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. A significance value (Sig.) > 0.05 indicated that the data were normally distributed.

After confirming normality, the researchers proceeded with Pearson correlation analysis to test the relationships between variables.

Results

This study established sample criteria within the age range of 12 to 15 years. Therefore, the researchers presented the age and gender distribution of the sample involved in this study to provide a clear profile of the participants contributing to the research. The average scores for each instrument are presented in Table 1.

Based on Table 2, a total of 100 participants took part in this study, consisting of 44 male and 56 female students. In accordance with the specific criteria of the MD-PASS-PE and YSQV-2 instruments, the age range of 12 to 15 years was highly appropriate for application in this research.

As an initial step, the researchers conducted a normality test for each variable. A significance value (Sig) greater than 0.05 is required to indicate that the data are normally distributed. The analysis was carried out using the Kolmogorov-Smirnov and Shapiro-Wilk normality tests. The results of this analysis are presented in Table 3.

The results of the Kolmogorov-Smirnov test showed a significance value of 0.200 > 0.05 for the YSQV-2 instrument, 0.200 > 0.05 for the MD-PASS-PE instrument, and 0.097 for the Engagement Scale. The analysis of all three research variables indicated that the data were normally distributed according to the Kolmogorov-Smirnov normality test. Therefore, the next step taken by the researchers was to perform a correlation analysis using the Pearson correlation test. The resulting correlation data are presented in Table 4.

The YSQV-2 instrument reflects the sport values obtained by students during Physical Education learning. The MD-PASS-PE instrument measures students' perceptions of their teachers' interpersonal teaching methods. Meanwhile, the Engagement Scale (ES) is used to assess students' active participation in Physical Education classes.

Based on Table 4, the Pearson correlation analysis showed that there was no correlation between students' perceptions of their teachers' interpersonal teaching behavior and their sport values, as indicated by a significance value of 0.066 > 0.05.

However, positive correlations were found in the relationship between sport values and students' active learning engagement, as well as between students' perceptions of teachers' interpersonal teaching and their learning engagement. The significance value for the correlation between sport values and student engagement was 0.01 < 0.05, indicating a significant relationship. Similarly, the correlation between students' perceptions of teachers' interpersonal teaching and their active learning engagement also showed a significant result, with a significance value of 0.01 < 0.05.

Discussion

The researchers acknowledged that the teaching methods used by teachers have an impact on students' engagement in Physical Education learning, and that this engagement, in turn, influences the development of sport values among students. The aim of this study was to analyze the correlation between teachers' interpersonal teaching methods, students' active learning engagement, and sport values among students at SMP Negeri 66 Bandung.

The first finding revealed no significant correlation between students' perceptions of their teachers' interpersonal teaching behavior and the sport values they acquired. This is evidenced by a significance value of 0.066, which is greater than 0.05. This result may be attributed to the lack of a strong underlying condition linking students' evaluation of their teachers' teaching abilities with the sport values developed through Physical Education activities. The absence of correlation may also be due to the nature of the MD-PASS-PE instrument, which represents students' evaluation of teachers' teaching methods and primarily focuses on the teacher as the main subject, rather than on the internalization of students' sport values.

The second finding showed a positive correlation between sport values and students' active learning engagement, with a significance value of 0.01, which is less than 0.05. This indicates a statistically significant relationship between sport values and student participation in learning activities. Sports that promote cultural values have always been a strong social force (Fakhriddin Khurramovich, 2022). Individuals who have participated in school sports believe that sports help them develop confidence in their strengths and abilities, and learn how to use them effectively. Sports also teach individuals to make reasonable sacrifices to achieve goals. A high-quality Physical Education program enhances students' physical, mental, and socio-emotional development, and integrates health education and fitness assessment to help children understand, improve, and/or maintain their physical well-being as part of successful socialization (Jammu et al., 2021).

The third finding also indicated a positive correlation between students' perceptions of teachers' interpersonal teaching behavior and their active learning engagement, with a significance value of 0.01 < 0.05. This suggests a

Table 1
Average Results of YSQV-2, MD-PASS-PE, and ES

Instrument	Average Score
YSQV-2	31
MD-PASS-PE	69
ES	70

Table 2
Frequency Distribution of Participants by Gender and Age

Category	Subcategory	Frequency	%
Gender	Male	44	44.0
	Female	56	56.0
	Total	100	100.0
Age (years)	12	2	2.0
	13	44	44.0
	14	42	42.0
	15	12	12.0
	Total	100	100.0

Table 3
Normality Test Results Using Kolmogorov–Smirnov Test

Variable	Test	Statistic	df	p-value
YSQV	Kolmogorov–Smirnov	.045	100	.200⁺
MD-PASS-PE	Kolmogorov–Smirnov	.066	100	.200⁺
ES	Kolmogorov–Smirnov	.082	100	.097

Table 4
Pearson Correlation Test

Variable	1	2	3
YSQV-2	–	.184	.409**
MDPASSPE	.184	–	.507**
ES	.409**	.507**	–

significant relationship between teaching competence and student engagement in learning. According to Sarumaha (2021), the learning process is facilitated and supported by the teacher. This means that the teacher holds full responsibility for guiding the students' learning journey, negotiating their education, and determining what and how they will learn. A good teacher, as stated by Utami & Hasanah (2020), is one who can guide their students to the highest level of learning, helping them grow and progress, become enlightened with age, and continue their lifelong learning journey. The correlation data also suggest that a positive correlation reflects a balanced pattern of improvement, where an increase in teaching quality is accompanied by a corresponding increase in student engagement.

Conclusionss

The results of the study indicate a correlation between Physical Education teachers' interpersonal teaching approaches and students' active learning engagement. Furthermore, students' active engagement was found to have a positive correlation with sport values among students at SMP Negeri 66 Bandung. One limitation of this study lies in the relatively small and limited participant sample. It is hoped that future research can expand upon this by involving a larger and more diverse sample population.

Physical Education teachers are encouraged to continuously innovate and enhance their instructional strategies in order to create learning experiences that are both effective and meaningful—especially in the context of Physical Education content.

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The Effectiveness of A Smartphone-Based Fitness Application in Enhancing Physical Activity Participation

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Abstract

The decline in participation in physical activity occurred in all age groups, one of which was among adolescents. This study aims to examine the effect of using a fit student application on increasing sports participation. This study used a randomized control trial method with a pre-test and post-test control group design. The sample consisted of active students at the Indonesian Universitas pendidikan indonesia . The study was conducted for 8 weeks. The number of samples participating in this study was 62 people. with a sample of 18 men and 44 women. The Participation Motivation Questionnaire (PMQ) instrument is used to measure the level of sports participation. The results showed that there was an increase in exercise participation with results ($p = 0.003 < 0.05$) after being treated for 8 weeks and differences in the level of participation in physical activity between the control group and the treatment group with results ($p = 0.018 < 0.05$). This indicates that the use of applications for physical activity participation interventions among college students is relatively effective.

Keywords: fitness app; physical activity; smarthphone based; participation.

Introduction

Increasing participation in sports is an important goal for global health (Deelen et al., 2018). Sports participation can be defined as active involvement in any kind of physical activity related to sports, typically done during leisure time (Deelen et al., 2018). There is substantial evidence that engaging in sports offers both physical and non-physical health benefits (Westerbeek & Eime, 2021). Participation in organized sports, in particular, has been shown to improve overall health by enhancing physical fitness, mental well-being, and social engagement (Eime et al., 2013); (Coleman et al., 2008). However, many people still do not participate regularly or at levels sufficient to gain these health benefits (Eime et al., 2013) .Physical inactivity is also one of the main contributors to various chronic diseases and premature mortality (Ding et al., 2016).

According to Badan Pusat Statistik (BPS, 2020) through the 2020 Socio-Cultural Education Module, the national sports participation rate was only 31.39%. This means only about one-third of the Indonesian population engages in regular sports activity. Statistical trends show a significant decline in sports and physical activity participation, particularly among adolescents (Lubans et al., 2007). According to the World Health Organization, adolescents should engage in moderate-to-vigorous physical activity for at least 60 minutes daily. Unfortunately, nearly 81% of adolescents are not sufficiently active (WHO, 2016).

Studies have shown that the decline in physical activity often starts in high school and continues through college (D. et al., 2011). This decrease is often associated with the transition into adult life, where students face new responsibilities, tight schedules, and academic demands (Bhochhibhoya et al., 2020) .This is concerning, as the college years are critical for developing long-term healthy behaviors (Barnett et al., 2014). Low physical activity levels at this stage can lead to adverse health consequences (Racette et al., 2008) ,and habits developed during this time often persist into adulthood (D. et al., 2011).

University life is closely tied to digital device usage. Teaching, learning, and many daily activities are increasingly conducted via smartphones. According to Indonesia's Telecommunication Statistics, over the past five years, the use of Information and Communication Technology has significantly increased, especially household internet use. Smartphone ownership reached 63.53% and continues to rise.

This high smartphone usage presents an opportunity to leverage mobile-based health interventions (Tate et al., 2013), such as fitness applications. A survey reported that 58% of smartphone users with health-related apps use them for sports and fitness purposes (Gür et al., 2020). Compared to in-person activities, fitness apps offer flexibility, adaptability to user needs, and can be accessed anytime and anywhere, making them effective and cost-efficient (Tate et al., 2013). These apps are particularly useful for helping users maintain physical activity and improve physical fitness (Zhang & Xu, 2020).

A previous study by Emma J. Adams (2015) examined how web-based interventions could enhance motivation for physical activity, especially in adults. The results showed an increase in motivation for sports participation through web-based platforms.

In this study, we focus on increasing physical activity participation through a smartphone-based fitness application. Smartphones offer additional features such as telecommunications, real-time sensing/monitoring, and access regardless of time and location (Mollee et al., 2017). This study targets university students because, as shown in previous research, many of them do not meet the recommended physical activity guidelines (Martens et al., 2012). Based on this evidence, the present study aims to examine the effect of the "Mahasiswa Bugar" fitness app intervention on increasing motivation for physical activity participation among college students.

Methods

Research Design

This study employed a randomized controlled trial method using a pretest-posttest control group design to observe the intervention effects of the "Mahasiswa Bugar" application on increasing physical activity participation, and to examine differences in physical activity levels between the treatment and control groups. This study has been conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for cohort studies.

Participants

The participants in this study were active students at Universitas Pendidikan Indonesia. A total of 62 students participated in the research, consisting of 18 males and 44 females, with an average age of approximately 20 years. The sample was divided into two groups: 31 students in the control group and 31 students in the treatment group. All participants were asked to provide their consent by signing an informed consent form before participating in the study. Those who agreed to participate were asked to follow the intervention for a duration of 8 weeks.

Instrument

The instrument used in this study was the Participation Motivation Questionnaire (PMQ), which has been widely used in several studies on motivation to participate in sports (Gill et al., 1983). The questionnaire was translated and validated into Indonesian by a language expert. The PMQ consists of 30 items that assess various potential reasons for participating in sports. A study by Zaharidis (2006) identified six key motivational factors: skill development and competition, sport-related action, popularity, fitness and health, social status, sport events, and relaxation. A five-point Likert scale was used, ranging from 1 (Not Important at All) to 5 (Very Important), to rate the importance of each reason for participating.

Procedure

The research procedure served as the foundation for implementing the study process. In this study, the Participation Motivation Questionnaire (PMQ) was distributed online to the initial sample of 88 participants. By the end of the study, only 62 participants had completed the full process.

The research began by distributing an informed consent form to obtain participants' agreement and willingness to take part in the study. Once consent was obtained, baseline data (Pretest) were collected through the PMQ questionnaire. Participants were guided during the questionnaire completion to ensure accuracy and understanding.

After the initial test, the experimental group was instructed to download the "Mahasiswa Bugar" application from the Google Play Store. The experimental group then received an 8-week treatment involving the use of the application, following training guidelines provided in a physical activity and fitness handbook.

After the 8-week intervention period, post-intervention data (Posttest) were collected by re-administering the PMQ to all participants.

Data Analysis

Data analysis was conducted using IBM SPSS Statistics version 22, with a significance level set at 0.05. Descriptive statistics were used to present the results of the data analysis. The One-Sample Kolmogorov–Smirnov Test was used to determine whether the data followed a normal distribution. The Independent Samples T-Test was applied to assess whether there was a difference in physical activity participation levels between the control and treatment groups. The Paired Samples T-Test was used to determine whether there were significant differences in the mean scores within the control and treatment groups between the pretest and posttest measurements

Results

Based on the data collection conducted through the distribution of the Participation Motivation Questionnaire (PMQ), this study obtained a total of 88 participants during the pre-test phase, with only 62 participants completing the study through to the post-test phase.

As shown in Table 1, the treatment group that received the Mahasiswa Bugar application intervention demonstrated a notable increase in mean scores from 119.13 (SD = 9.394) in the pre-test to 127.65 (SD = 11.834) in the post-test, while the control group showed a decrease from 122.13 (SD = 10.194) to 119.58 (SD = 14.252). The combined sample's mean score also increased from 120.63 (SD = 9.838) to 123.61 (SD = 13.612). A Paired Sample T-Test indicated a statistically significant improvement within the treatment group ($p = 0.003$, $p < 0.05$), whereas the control group did not show a significant change ($p = 0.401$, $p > 0.05$). Additionally, the Independent Sample T-Test revealed a significant difference in physical activity participation between the two groups after the intervention ($p = 0.008$, $p < 0.05$), suggesting that the Mahasiswa Bugar application had a meaningful and positive effect on participants' physical activity levels.

Table 1

To test the effect on the group given the Fit Student application intervention & The difference in physical activity participation levels between the control group and the treatment group.

	Mean	SD	Std. Error Mean	t	Sig. (2-tailed)	Cohen's d
Pretest T Posttest T	-8,516	14,949	2,685	-3,172	,003	0.57
Pretest C Posttest C	2,548	16,643	2,989	,853	,401	0.15
differences between control group and treatment group	*(Mean Difference)* -11.065		*(Std Error Difference)* *4.018*	-2.754	0,008	-0.70

Discussion

This study was conducted to examine the effect of using a fitness application on participation in physical activity, and to determine whether there was a difference in physical activity participation levels between the two groups after the "Mahasiswa Bugar" application intervention over a period of eight weeks.

The results showed a positive impact of the Mahasiswa Bugar application on increasing sports participation. Hypothesis testing revealed that the treatment group experienced a significant improvement, while the control group, which did not receive any intervention, showed little to no improvement. These findings are consistent with the study by (Pradal-Cano et al., 2020), which demonstrated that the use of fitness apps can be an effective intervention tool, helping individuals achieve moderate to vigorous levels of physical activity.

To further analyze the differences in participation levels, an Independent Samples T-Test was conducted. The results indicated a significant difference in physical activity and exercise participation between the group that received the Mahasiswa Bugar app intervention and the group that did not. This finding aligns with research by Emma J. Adams (2015), which also reported increased sports participation among participants who completed an eight-week training program. Adams' findings support the results of the present study, where an increase in sports participation was observed among participants who completed the full eight-week program and testing procedures.

Smartphone-based fitness applications are shown to be an effective and promising tool for increasing participation in physical activity (Srivastav et al., 2021). Based on the findings above, it can be concluded that the Mahasiswa Bugar application intervention is likely effective in enhancing physical activity participation, particularly among university students. This is consistent with the explanation by (Coughlin et al., 2016), who found that smartphone-based fitness apps are effective in promoting physical activity, even when the intervention effects are relatively simple

Conclusionss

Based on the results of the data analysis, it can be concluded that the use of a fitness application as an intervention tool to promote physical activity participation among university students is relatively effective. The findings of this study are also expected to provide input, particularly for university students, to consider using fitness applications as a practical means to help them achieve adequate levels of physical activity participation.

However, this study has certain limitations, particularly the gender imbalance in the sample, which was predominantly composed of female students. To address this, future research should aim to involve a more gender-balanced sample to examine whether gender differences influence the effectiveness of fitness app interventions. Additionally, extending the duration of the intervention beyond 8 weeks is recommended to assess the long-term sustainability of increased physical activity. Incorporating wearable fitness devices in future studies could also enhance the accuracy of physical activity tracking and increase user engagemen.

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Biomechanical Transformation of Softball Batting Technique: The Effects of Mental Fatigue on Athlete Performance

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Abstract

This study aims to analyze the effect of mental fatigue on biomechanical variables of batting technique in softball. Good batting technique requires precise movement coordination, reaction speed, and high mental concentration. However, mental fatigue, which often occurs due to intensive cognitive activity or excessive mental load, is thought to affect biomechanical performance. This includes changes in joint angles, body rotation speed, and batted ball speed, which directly affect the effectiveness of batting in softball. This study involved 15 softball players from the Bumi Asri club with an average age of 20 ± 0.6 years. Data collection was carried out using a three-dimensional motion analysis device, ball speed radar, and heart rate sensor. Subjects will undergo a 15-minute warm-up session, followed by an intensive cognitive task designed to trigger mental fatigue. Biomechanical variables will be measured before and after mental fatigue, including analysis of changes in joint angles, body rotation speed, and batted ball speed. The data obtained will be analyzed using a paired sample t-test to evaluate significant differences. This study is expected to provide an important contribution in understanding the impact of mental fatigue on sports biomechanics, especially softball batting technique. In addition, the results of this study can be a basis for coaches to design more effective training strategies, so that athletes can maintain optimal performance even in challenging mental conditions.

Keywords: batting; kinematics; mental fatigue; softball; sports biomechanics.

Introduction

Softball is a sport that demands a high level of technical skill and coordination between the player and the equipment (Flyger et al., 2006). In the context of batting technique, biomechanical factors play a central role in determining the success of a hit (Dowling & Fleisig, 2016). A solid understanding of key biomechanical variables—such as bat swing speed and swing angle—is essential for improving player performance (Fortenbaugh, 2011). However, limited research has investigated the influence of mental fatigue on these biomechanical aspects in softball batting. Therefore, it is crucial to examine the extent to which mental fatigue affects changes in biomechanical variables, with the aim of providing a stronger scientific foundation for training and athlete preparation.

Mental fatigue, which arises from prolonged cognitive activity or extended periods of mental concentration, has been shown to significantly impact athletic performance across various sports (Russell et al., 2019; Sun et al., 2021). In softball, mental fatigue is particularly critical, as batting not only requires physical power but also demands high levels of focus and precise movement coordination. This condition may impair decision-making, reaction time, and biomechanical stability during performance (Giesche et al., 2020; Hughes & Dai, 2023). While the effects of mental fatigue have been widely studied in other sports, its impact on the biomechanics of softball batting remains poorly understood. Hence, this study aims to bridge that knowledge gap by exploring the relationship between mental fatigue and changes in key biomechanical variables in batting technique.

Batting is a fundamental component that greatly influences overall performance in softball (Messier & Owen, 1984; Werner et al., 2005). Biomechanical variables such as swing speed and swing angle play a crucial role in determining the effectiveness of a player's hit (Milanovich & Nesbit, 2014). Although many studies have examined these variables individually, a more comprehensive understanding of how biomechanical changes affect batting technique as a whole is still needed. In this context, further exploration of biomechanical dynamics in softball can provide deeper insights that support efforts to enhance athletic performance.

Previous studies have indeed addressed some key biomechanical aspects of softball batting, yet there is a notable lack of research on how mental fatigue influences these biomechanical changes. Most prior research has focused on isolated variables—such as bat speed or swing angle—without considering mental fatigue as a potential modifying factor (Horiuchi & Nakashima, 2022; Mohammad, 2023; M. T. & M. S., 2020; Saraya, 2018; Tago et al., 2005, 2006; Washington & Oliver, 2018). The absence of analysis regarding the complex interaction between mental fatigue and biomechanical execution hinders a holistic understanding of performance. Therefore, this study seeks to fill that gap by investigating the impact of mental fatigue on critical biomechanical variables, ultimately contributing to a more comprehensive framework for improving softball batting performance and informing more effective athlete training strategies.

Methods

Research Design

This study employed a descriptive quantitative design with a quasi-experimental pretest-posttest approach. The primary objective was to analyze changes in biomechanical parameters of the softball batting technique under conditions of mental fatigue.

Participants

A total of 15 softball athletes specializing as batters were selected purposively from the Bumi Asri softball club. Participants had an average age of 20 ± 0.6 years, a mean height of 1.71 ± 1.2 meters, and a mean body weight of 59 ± 3.7 kilograms. The purposive sampling ensured a homogenous group with adequate skill and experience in batting, allowing for controlled biomechanical analysis under cognitive stress conditions.

Instrument

Biomechanical data were collected using three high-speed action cameras (GoPro Hero 11, USA), a 3D manual calibration frame, 14 body markers, and Kinovea motion analysis software (Spain). Ball speed was measured using a Bushnell radar gun model 101922 (Germany). To induce and confirm mental fatigue, a computerized Stroop Task was administered, followed by a Visual Analog Scale (VAS) to assess subjective fatigue levels. These instruments were selected to provide precise, multidimensional analysis of both kinematic and cognitive parameters related to batting performance.

Procedure

The data collection took place at the Sport Science Laboratory and Gymnasium Building, Universitas Pendidikan Indonesia, between May and July 2025. Before testing, participants completed a 15-minute standardized warm-up session. After a 3-minute rest, they were instructed to perform six maximal effort jump-batting trials. Ball speed (in km/h) was measured using the radar gun, and the mean speed of six hits was recorded as baseline data.

To induce mental fatigue, participants completed a Stroop Task—an intense cognitive test that required identifying the color of incongruent words displayed on a screen. Following the task, the level of perceived fatigue was assessed using the VAS. Once fatigue was confirmed, participants repeated the six batting trials under fatigue conditions. Three cameras were placed strategically: Camera 1 perpendicular to the subject's upper body (5 meters away), Camera 2 at the right side, and Camera 3 directly behind the subject to record full upper body kinematics. Reflective markers were

placed on anatomical landmarks to track joint movements. Kinematic parameters included movements at the shoulder (internal-external rotation, abduction-adduction, horizontal abduction-adduction), elbow (flexion-extension, pronation-supination), wrist (palmar-dorsiflexion, ulnar-radial deviation), trunk and pelvis rotation, and bat tilt.

Data Analysis

Kinematic and kinetic data were filtered using a fourth-order Butterworth low-pass filter with a cutoff frequency of 13.5 Hz. Descriptive statistics were calculated using SPSS version 21.0 (IBM Corp., Armonk, NY), and results were reported as mean ± standard deviation. A paired sample t-test was conducted to determine the significance of differences between pre-fatigue and post-fatigue conditions, with a significance level set at $p < 0.05$ and a 95% confidence interval.

Results

The paired sample t-test was conducted to examine the effects of mental fatigue on key biomechanical variables in softball batting. The results in Table 1 indicated statistically significant differences in several variables before and after the mental fatigue intervention.

The most significant reduction was observed in ball exit velocity, which decreased by approximately 5 km/h post-fatigue ($p < .01$), suggesting a direct impact of cognitive strain on force production and motor coordination. Additionally, notable changes were found in the shoulder and thorax rotation angles, which play critical roles in generating torque during the batting swing.

Discussion

This study aimed to investigate the effects of mental fatigue, induced through a Stroop Task, on biomechanical performance in softball batting. The results demonstrate a clear and statistically significant reduction in batting performance following mental fatigue, both in terms of kinematic movement and ball velocity.

These findings support the psychobiological model of endurance performance proposed by Marcora et al. (2009), which posits that mental fatigue impairs motor performance by increasing perceived effort and reducing motivation. In a sport like softball—where reaction speed, coordination, and timing are essential—mental fatigue disrupts the central nervous system's ability to efficiently manage neuromuscular actions, ultimately compromising technique.

The significant decrease in pelvic and thorax rotation angles suggests a breakdown in the kinetic chain. Efficient energy transfer from the lower body through the torso to the upper limbs is essential for powerful and precise hitting. With mental fatigue, this synchronization becomes less effective, which may be caused by impaired attentional focus and reduced motor control, as theorized by Cooke (2013) and confirmed by recent sport psychology studies.

The current findings align with previous research by Smith et al. (2016) in basketball and Coutinho et al. (2017) in soccer, both of which reported that mentally fatigued athletes showed compromised decision-making and degraded technical performance. However, this study is among the first to quantify the biomechanical consequences of mental fatigue specifically in softball—a novel contribution to sport science literature.

Furthermore, the implementation of the Visual Analog Scale (VAS) to assess subjective mental fatigue, alongside high-speed camera analysis for motion capture, allowed for an objective and comprehensive examination of performance changes. The Stroop Task proved effective as a reliable mental fatigue protocol, simulating realistic cognitive demands athletes often face in competition.

Table 1

Comparison of Biomechanical Variables Pre-and Post-Mental Fatigue (N = 15)

Variable	Pre-test		Post-test		t	p
	M (Pre)	SD (Pre)	M (Post)	SD (Post)		
Ball Exit Velocity (km/h)	89.27	4.15	84.13	5.02	4.879	.000 **
Shoulder Angle (°)	98.41	6.32	93.86	5.74	3.721	.002 **
Elbow Flexion Angle (°)	124.10	5.88	120.31	6.07	2.616	.021 *
Pelvic Rotation Angle (°)	56.93	3.22	52.14	4.11	4.315	.001 **
Thorax Rotation Angle (°)	65.28	3.91	61.02	4.37	3.417	.004 **

Practically, this study underscores the importance of integrating mental resilience training into sport-specific conditioning. Coaches should not only prepare athletes physically but also cognitively, by incorporating decision-making drills, cognitive load simulations, and structured recovery sessions.

Theoretically, these findings reaffirm that motor execution is not solely a function of muscular or cardiovascular readiness but is deeply intertwined with cognitive state. A multidisciplinary approach, merging biomechanics, cognitive neuroscience, and sport psychology, is thus necessary to holistically enhance athletic performance.

Conclusions

This study provides compelling evidence that mental fatigue significantly alters key biomechanical variables in softball batting, particularly affecting ball exit velocity, upper limb kinematics, and rotational movements of the torso and pelvis. The results highlight that mental fatigue—induced through a cognitive interference task like the Stroop Task—can impair motor coordination, timing, and energy transfer efficiency during batting. These findings support the growing body of literature that emphasizes the role of cognitive states in physical performance and challenge the traditional view that biomechanical output is solely a function of muscular or cardiovascular factors.

By incorporating mental fatigue protocols into training and recovery strategies, coaches and practitioners can more accurately simulate competition demands and better prepare athletes for cognitively taxing situations. Future research should consider exploring different types of cognitive stressors, long-term adaptations to mental fatigue, and potential buffering strategies such as mindfulness or neuromuscular warm-ups. A holistic understanding of mental and physical readiness is essential for optimizing athletic performance in sports that require high levels of focus and precision, such as softball.

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Bibliometric Analysis of Global Research Trends on Athlete and Motivation

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Abstract

This study utilized bibliometric analysis to examine topics related to "athletes" and "motivation." Data was obtained from articles published between 2019 and 2024. The research strategy in this study involved searching for the current status and trends of research in the field of athletes and motivation through a data screening process. The database used for quantitative analysis was Scopus.com, with the help of the Mendeley application. This research has been developed and structured in accordance with the BIBLIO Checklist for bibliometric reviews of biomedical literature. Each item on the checklist, including title identification, abstract structuring, methodological transparency, data synthesis, and results presentation, has been addressed to ensure clarity, reproducibility, and completeness. The publication trend analysis showed a fluctuating pattern over the decade, with significant peaks in 2020 and 2022, indicating a growing interest in this area of research. In addition, keyword co-occurrence analysis was used to reveal thematic clusters and interrelationships between research topics. This study provides a comprehensive understanding of the evolution, trends and collaborations in athlete motivation-related research from 2019 to 2024, providing valuable insights into the interconnectedness of ideas and guiding future research directions. However, limitations such as language bias indicate the need for a broader exploration of the literature and qualitative dimensions to deepen the understanding of athlete motivation.

Keywords: athlete; bibliometric; motivation; research trends.

Introduction

In the domain of sports, motivation has been identified as a pivotal factor in determining an athlete's level of success (Heazlewood & Burke, 2011). Motivation exerts a substantial influence on performance outcomes in athletic contexts, as well as contributing to the optimization of the training process and the development of skills (Tušak et al., 2022). The role of social support in the context of athletic performance is a multifaceted phenomenon that has garnered significant attention in recent research. Studies have demonstrated that the support system, comprised of family members and peers, exerts a substantial influence on an athlete's motivation levels. This, in turn, has been shown to indirectly affect an athlete's performance in achieving their athletic objectives (Zainuddin et al., 2023). A study by Clarasasti & Jatmika (2017) on adolescent badminton athletes found that 76.7% of athletes with high motivation experienced lower levels of anxiety (23.3%). It has been demonstrated that the absence of robust motivation in athletes renders it nearly impossible for them to achieve a high level of performance (Kusumajati, 2011).

Intrinsic motivation, defined as internal motivation stemming from an individual's personal interest or enjoyment in the activity itself, has been demonstrated to positively impact athletic performance (Almagro et al., 2020). Intrinsic motivation is regarded as the most potent driving force, as it originates from within the athlete (Ahmad et al., 2020). When athletes are intrinsically motivated, they engage in sports for personal satisfaction, tackle tasks with enthusiasm, and achieve optimal results (Tajuddin, 2021). Intrinsic motivation exerts a substantial influence on the levels of competitive anxiety experienced by wheelchair handball athletes (Da Silva et al., 2021). According to Rahman et al. (2023), the presence of strong intrinsic motivation has been demonstrated to offer substantial benefits, including the encouragement of athletes to pursue goals with sincerity, to derive enjoyment from the process, and to achieve greater outcomes.

However, motivation is not solely intrinsic; extrinsic motivation also plays a crucial role in training and achieving performance (Gillet et al., 2010). Extrinsic motivation is defined as behavior that is driven by external factors, such as the desire for rewards or support from coaches and family members (Gillet et al., 2010). As posited by Foekh et al. (2022), the provision of motivational support from family members and coaches has been demonstrated to foster self-confidence, thereby contributing to positive emotional responses during training. Nugroho et al. (2022) found that emotional support from family members has a significant impact on the mental well-being of athletes, particularly in competitive environments. Their research indicates that such support can enhance athletes' self-confidence and mitigate the anxiety that is commonly experienced in competitive settings. Conversely, coaches who cultivate positive relationships with athletes can foster a supportive environment where athletes feel valued and motivated to excel (Shanmuganathan-Felton et al., 2022).

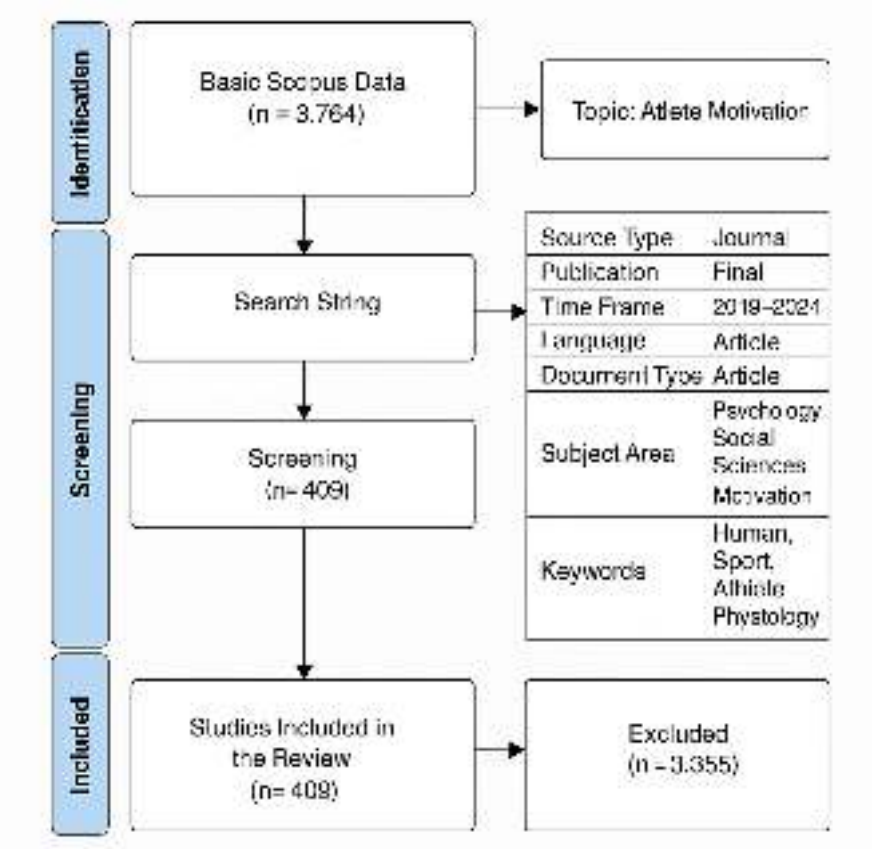
Methods

Research Design

This research is a bibliometric analysis that analyzed related to "athlete" and Motivation". The database used to analyzed quantitatively comes from the Scopus.com page with the help of the Mendeley application. Bibliometric analysis as a valuable tool to map the literature widely (Ýri & Ünal, 2024). The searched items were exclusively with the number of articles obtained as much as 3764 then filtered with the past five years published from 2019-2024 to get 409 published articles. The documents were filtered and further analyzed on the Scopus.com page in a specific domain and identified trends and relationships among the studies. The design of this analysis is presented in Figure 1.

Figure 1

Search strategy in Scopus



Procedure

The researcher conducted a comprehensive search of the Scopus database in order to increase the relevance of the data (Eswari et al., 2024). The research strategy in this study was to search for the current status and trends of research on athlete and motivation with a data filtering process. The data for this study was obtained from articles published between 2019 and 2024. The search strategy includes subject terms, namely: TITLE-ABS-KEY (athlete AND motivation) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "HEAL")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Motivation") OR LIMIT-TO (EXACTKEYWORD , "Human") OR LIMIT-TO (EXACTKEYWORD, "Athlete") OR LIMIT-TO (EXACTKEYWORD, "Psychology") OR LIMIT-TO (EXACTKEYWORD, "Sport") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (PUBSTAGE, "final") AND (LIMIT-TO (OA, "all")). After the data filtering process VOSviewer was used to perform data visualization (Li et al., 2024). The resulting software is a network analysis of co-authorship, and co-occurrency (Pereira & Jegatheesan, 2024).

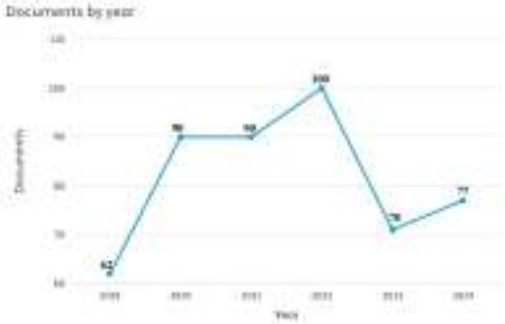
This research has been developed and structured in accordance with the BIBLIO Checklist for bibliometric reviews of biomedical literature. Each item on the checklist, including title identification, abstract structuring, methodological transparency, data synthesis, and results presentation, has been addressed to ensure clarity, reproducibility, and completeness.

Results

The overall publication trend in the keywords "Athlete" and "Motivation" in 2019 to 2024 in Figure 2. Analysis based on the Scopus database shows the last 5 years, the distribution of publications shows an increasing trend that jumped in 2020 as many as 90 documents, then increased again in 2022 as many as 100 articles published, in 2022 is the highest number of publications recorded in the last 5 years in Figure 2. Then the research trend decreased in 2023 as many as 70 documents to 2024 as many as 77 documents.

Figure 2

Documents Published on Scopus Database

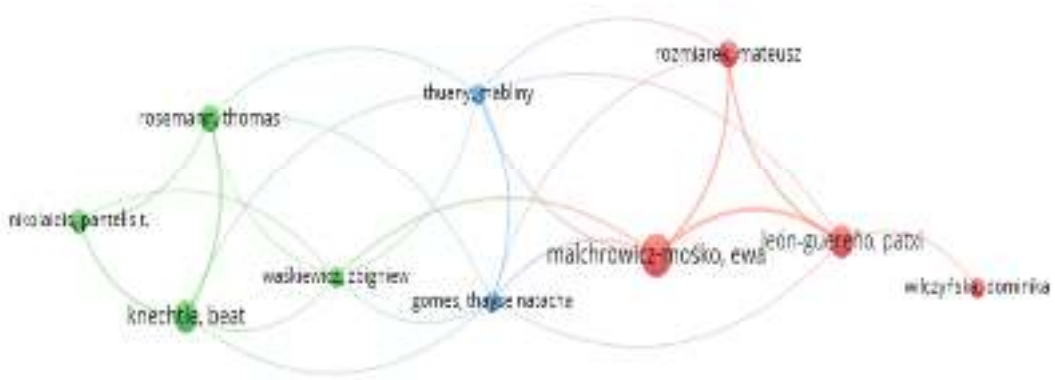


Author's Analysis

In total of 409 articles (N = 409), Malchrowicz, Ewa. had the most publications with 12 documents and Fransen, Katrien as the most citations with 162 citations (Table 1 and Table 2), followed by Knechtle, Beat as an author further with a total of 7 documents and 161 citations.

Figure 3

Influential Authors generated using VOSviewer



Rank	Author By Citations	Document
1	Malchrowicz, Ewa	12
2	Fransen, Katrien.	7
3	Leon-guereno, Patxi	7
4	Knechtle, Beat	7
5	Manzano-Sanchez, David	6
6	Valero-Valenzuela, Alfonso	6
7	Boen, Filip	5
8	Haslam, S. Alexander	5
9	Steffens, Niklas K	5

10	Freire, Gabriel	5

Table 1

Authors based on the most documents generated using VosViewer

Table 2

Authors based on the most citations generated using VOSviewer

Rank	Author By Citations	Citations
1	Fransen, Katrien	162
2	Knechtle, Beat	161
3	Malchrowicz, Ewa.	131
4	Nikolaidis, Pantelis T	119
5	Knight, Camilla J	104
6	Rosemann, Thomas	102
7	Leon-guerreno, Patxi	93
8	.Vansteenkiste, Marteen	91
9	Van Puyenbroeck, Stef	85
10	Boen, Filip	84

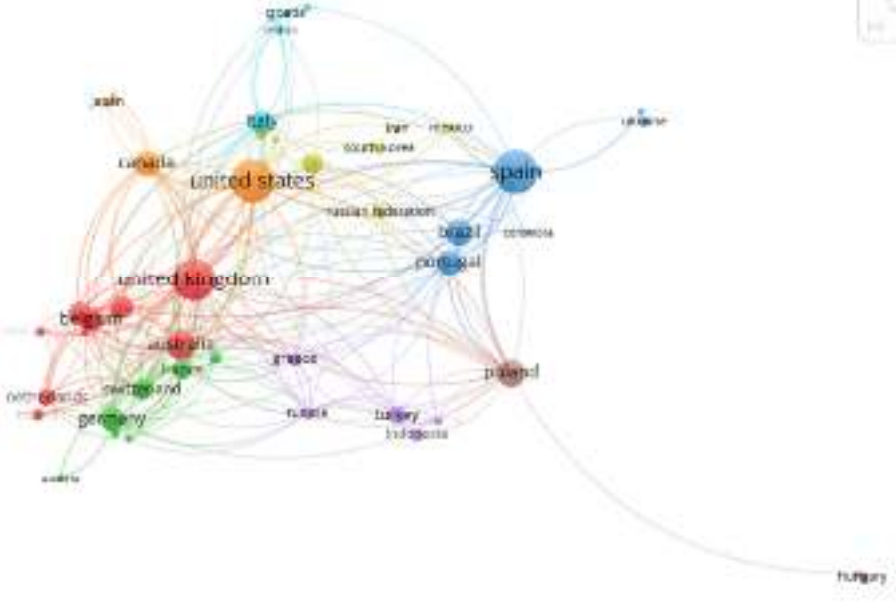
Country Analysis

Table 3 shows the top 10 countries based on documents generated. United Kingdom has 80 documents, followed by Spain and United States with 79 and 77 documents respectively. While table 4 shows that of the 10 countries that have the most citations, United Kingdom ranks first with a total of 1249 citations, then Spain 767 citations and United States 678 citations. Figure 4 presents a map of the distribution of collaboration networks, namely the United Kingdom as the country that has the most significant centrality, followed by Spain and the United States. Based on the definition of centrality, these countries show close collaboration with other countries with strong academic participation (Gong et al., 2023).

1	United Kingdom	80
2	Spain	79
3	United States	77
4	Australia	37
5	Poland	35
6	Brazil	31
7	Canada	29
8	Portugal	28
9	Germany	27
10	Italy	25

Figure 4

Citation network analysis that identifies author origin by country



Analysis of co-occurrence of keywords

Researchers mapped the main contributors (authors, country of origin, and keywords), analyzed the occurrence of keywords to identify publication trends, and tracked the main themes in the publications. The size in the item labels is proportional to the number of publications found, while different colors represent different knowledge topics grouped based on software clustering techniques (Delmoral & R S Tavares, 2024). Citation relationships between publications are the cornerstone of many bibliometric analyses. Therefore, the availability of accurate citation data is essential for high-quality bibliometric studies (Wang et al., 2024).

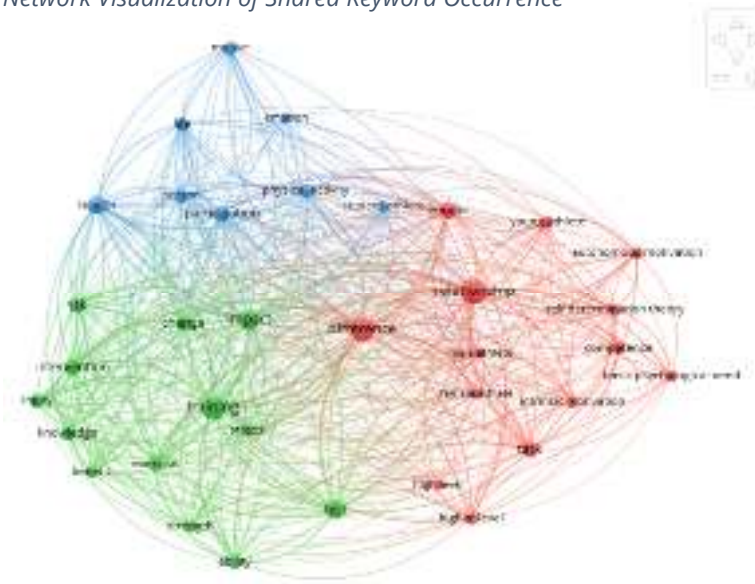
Table 3

Analyses that identify a country based on documents

Rank	Country By Document	Document

Figure 5

Network Visualization of Shared Keyword Occurrence



35 keywords, and used the author's keywords as the unit of analysis. Each cluster has been grouped and presented in Table 4 and Figure 5 cluster analysis.

Table 4

Analysis that identifies a country based on citations

Rank	Country By Citations	Citations
1	United Kingdom	1249
2	Spain	767
3	United States	678
4	Australia	376
5	Belgium	300
6	Poland	285
7	Sweden	282
8	Switzerland	274
9	South Africa	262
10	Canada	247

In this study, we created a keyword graph using the keyword function in VOSviewer, used the fractional counting method, set the keyword occurrence as

Table 5

Group Items by Cluster

Cluster	Item	Color	Percentage	Total
Cluster 1	Autonomus motivation, basic psychological need, competence, difference, female athlete, gender, high level, higer level, intrinsic motivation, male athlete, relationship, self determination theory, task, young athlete.	Red	40%	14
Cluster 2	Ability, benefit, change, exercisem impact, injury, intervention, knowladge, risk, strength, stress, test, training.	Green	37%	13

Cluster 3	Emotion, health, lifem motivem participation, person, physical activity, student athlete.	Blue	23%	8
		Total		35

In Table 6. researchers present the 10 documents with the most citations on the Scopus page for the *Athlete and Motivation* article research category. Contains the title of the article, data on the year of publication along with the author and with the most citations.

Table 6

10 Most Cited Articles

No	Title	Author	Year	Total Citation
1	Physical Activity and Exercise during Pregnancy and the Postpartum Period	(Kader, Manzur., 2020)	2020	417
2	Nowhere to hide: The significant impact of coronavirus disease 2019 (COVID-19) measures on elite and semi-elite South African athletes	(Pillay et al., 2020)	2020	195
3	How elite athletes, coaches, and physiotherapists perceive a sports injury	(Bolling et al., 2019)	2019	154
4	Ecological grief as a response to environmental change: A mental health risk or functional response?	(Comtesse et al., 2021)	2021	95
5	Elite female athletes' experiences and perceptions of the menstrual cycle on training and sport performance	(Brown et al., 2021)	2021	91
6	Visual feedback attenuates mean concentric barbell velocity loss and improves motivation, competitiveness, and perceived workload in male adolescent athletes	(Weakley et al., 2019)	2019	78
7	Coaching the coach: Intervention effects on need-supportive coaching behavior and athlete motivation and engagement	(Reynders et al., 2019)	2019	65
8	Concussion Symptom Underreporting among Incoming National Collegiate	(Conway et al., 2020)	2020	53

	Athletic Association Division i College Athletes			
9	How the menstrual cycle and menstruation affect sporting performance: Experiences and perceptions of elite female rugby players	(Findlay et al., 2020)	2020	50
10	Anxiety and Motivation to Return to Sport During the French COVID-19 Lockdown	(Ruffault et al., 2020)	2020	45

The following table shows the top 10 most cited articles related to athlete and motivation topics. Each article is grouped based on the type of study or main focus, making it easier to understand the research trends in this field. This classification helps to highlight which study designs such as reviews, observational, or experimental studies have had the greatest impact and what themes are most frequently explored in highly cited publications. A total of 1,253 citations were recorded across the 10 articles, with an average of 125.3 citations per article, the most common publication year being 2020 (5 articles), the highest cited article reaching 417 citations, and perception-based studies on female athletes emerging as the most frequent study type.

Table 7

Classification of Top 10 Most Cited Articles by Type of Study

No	Article Title	Type of Study / Main Focus	Year	Citation Count
1	*Physical Activity and Exercise during Pregnancy and the Postpartum Period*	Policy/practice review	2020	417
2	*Nowhere to hide: COVID-19 impact on SA athletes*	Observational study (pandemic impact)	2020	195
3	*How elite athletes perceive sports injury*	Qualitative study on perception	2019	154
4	*Ecological grief and environmental change*	Theoretical review (psychological)	2021	95
5	*Elite female athletes & menstrual cycle*	Female athlete perception study	2021	91
6	*Visual feedback and motivation in adolescent athletes*	Experimental motivation/performance study	2019	78
7	*Coaching the coach intervention*	Coaching intervention study	2019	65
8	*Concussionsymptom underreporting*	Survey-based study	2020	53
9	*Menstrual cycle in elite rugby players*	Female athlete perception study	2020	50
10	*Anxiety and motivation during lockdown*	Quantitative pandemic study	2020	45

Discussion

Based on the research results, several key findings emerged regarding research trends and contributions in the fields of "Athlete" and "Motivation" from 2019 to 2024. Analysis of publication trends reveals a fluctuating pattern over the decade, with prominent peaks in 2020 and 2022 indicating increased interest in this field of study. The article with the most significant impact based on the highest citations was written by Kader, Manzur. (2020) entitled " Physical Activity and Exercise during Pregnancy and the Postpartum Period " with 417 citations. This article focuses on physical activity and exercise during pregnancy and the postpartum period.

Figure 3 highlights the significant contributions of the 10 most prolific researchers, such as Malchrowicz, Ewa, Fransen, Katrien, Knechtle, Beat, who have published many insightful articles in this domain. These contributions not only enrich the academic discourse but also reflect a commitment to advancing knowledge and innovation in athlete and motivation. In addition, the analysis of citations from the impactful work of Malchrowicz, Ewa, who is widely influential. Table 3 and Table 4 provide a global insight into the impact of her research benefits. The United Kingdom is the country with the most significant centrality, followed by Spain and the United States. Figure 4 visualizes the collaboration network between countries with the leadership of the United States depicted in Figure 4.

The central position of the United Kingdom, along with strong collaborations involving Spain and the United States, Australia, and Belgium highlight the global nature of research efforts in athlete and motivation. This may be due to the data that Scopus-listed journals or proceedings are predominantly in English (Net et al., 2023). Furthermore, this study utilized shared keyword analysis to uncover thematic clusters and reciprocal relationships among the research topics. This methodological approach facilitates the identification of key themes and emerging trends in the literature, offering a structured understanding of the interconnectedness of ideas and facilitating future research directions. By mapping these shared keyword clusters, this research contributes to refining and expanding the scientific discourse on athlete motivation that can affect athlete performance, especially in female athletes.

From the emergence of keywords, the topic of motivation relationships in athletes is interesting to explore. Motivation has a significant impact on the behavior, performance, and well-being of athletes, especially during competition. This can be observed from the group and percentage of occurrence, such as in Group 1: "Autonomous motivation, basic psychological need, competence, difference, female athlete, gender, high level, higher level, intrinsic motivation, male athlete, relationship, self-determination theory, task, young athlete", which is often mentioned as a keyword in the analysis document. However, there are still many issues that have not been researched or require further investigation, such as how athlete motivation can affect female student athletes. Overall, this comprehensive analysis of research provides valuable insights into the evolution, trends and collaborative dynamics of research in Coach Athlete Relationships for Student Athletes. The findings not only inform current research but also serve as a mapping for future investigations aimed at improving psychological well-being outcomes in student-athletes, particularly female student-athletes who face stressors in sport, such as body image, professional-personal life balance, and gender stereotypes.

This study has several limitations that need to be addressed. First, the focus on English-language publications indexed in Scopus may lead to language bias, overlooking important research contributions in other languages. Second, reliance on Scopus may lead to publication bias, as it does not cover all relevant literature, especially from non-indexed sources or less common fields. Third, this analysis is limited by data available up to November 2024, so it is possible that recent developments are not accommodated. Fourth, despite careful keyword design, some relevant articles may not have been detected, affecting the completeness of this review. Finally, bibliometric approaches provide broad quantitative insights, but often fail to capture the qualitative dimensions or deep context of individual studies, so caution is required in interpreting the results. These limitations suggest the need for a more comprehensive and exploratory approach in future research to broaden the understanding of athlete motivation.

Conclusionss

This research study provides a comprehensive understanding of research developments, trends and collaborations related to athlete motivation over the period 2019 to 2024. The findings indicate an increase in scientific attention to the topic, with publication activity peaking in 2020. Notable contributions, such as works addressing physical activity during pregnancy and postpartum, as well as the role of prolific researchers and strong

international collaborations, further emphasize the importance of this topic in the academic realm. The United Kingdom's dominance in publication and citation production demonstrates its significant influence in determining the direction of global research. However, limitations such as language bias and bibliometric approaches point to the need for wider exploration of literature sources and qualitative dimensions to deepen understanding of athlete motivation. This opens up opportunities for future research to fill in the gaps and enrich existing perspectives.

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The Impact of Using the Daily Undulating Periodization (DUP) Model on Power Improvement

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Abstract

This study aims to examine the impact of Daily Undulating Periodization (DUP) on power improvement. The research method used in this study was a one-group pre-test–post-test design. The sample consisted of 15 undergraduate students from the Sports Science program at Universitas Pendidikan Indonesia, class of 2022. The study was conducted over a period of 8 weeks, beginning with a pre-test, followed by training sessions held three times per week for a total of 24 sessions, and concluded with a post-test. The research was carried out at the Fitness Laboratory of Universitas Pendidikan Indonesia. After the final test, the researcher analyzed the pre-test and post-test data using normality and homogeneity tests, as well as a paired sample t-test. The results of the normality test indicated that the data were normally distributed, with pre-test values for the Medicine Ball test at 0.335 > 0.05 and post-test values at 0.063 > 0.05; for the Vertical Jump test, pre-test values were 0.484 > 0.05 and post-test values were 0.405 > 0.05. The homogeneity test results showed that the data were homogeneous, with p = 0.358 for the Medicine Ball variable and p = 0.709 for the Vertical Jump variable. Based on the analysis, the experimental group in the Medicine Ball test showed a significant improvement, with a significance value of 0.001 (p < 0.05), indicating that DUP training had a significant effect on power enhancement.

Keywords: daily undulating periodization; training model; muscle, power; weight training.

Introduction

Sports achievement is a factor that can elevate the dignity and reputation in the eyes of family, club, city, province, nation, and even internationally. Achievement in sports can be obtained if the existing development system is well planned, executed properly, and structured (Bayu Laksana et al., 2017). The achievement of an athlete can be developed through training in their specific sport branch according to their interests and talents. If an athlete wants to excel in the sport they love, they must train diligently under the supervision of a professional coach in their field. A professional coach must have a training plan to develop an athlete to reach the highest level of achievement.

However, the problem faced in Indonesia or internationally is that competitions or tournaments are held very close to each other, so athletes need to prepare their condition well and increase their power so they can perform well in every competition they participate in.

Talking about an athlete's physical condition, physical ability is important and serves as the main pillar in developing and enhancing technical skills, tactics, and mental strength (Aco, 2016). One of the main components of physical condition is power. Power plays a crucial role in the success of almost all sports branches. Sports like volleyball, basketball, soccer, and also floor gymnastics require power in every movement and technique (Riyadi, 2016).

Discussing techniques in every sport means dealing with strength and speed. The strength and speed of muscle contractions involve dynamic and explosive muscles that generate maximum muscle force in a short period (Aco, 2016). Power is one level of training for athletes that involves muscles working at high intensity but for a short duration, adjusted to the 1 RM (maximum strength). Power is a physical component that athletes must possess to exert explosive strength in the shortest possible time (Ismoko & Sukoco, 2013).

Among many sports branches mentioned above, the most dominant and important physical ability is the power of the leg muscles, which must be strong and fast to produce explosive force, whether in running or stepping in performing techniques in sports games. Biomotor components like speed and leg muscle power are components that coaches must consider when designing training programs, especially physical conditioning training (Utamayasa, 2020).

To achieve physical ability and increase power, efficient and correct training programs or methods must be applied. In training methods, the most complex issue is how to achieve peak performance on a scheduled date and time. Athletes with prime physical conditions will experience improvements in circulatory system performance, heart function, strength, flexibility, stamina, speed, agility, and power (Rosdiana et al., 2022).

Undulating periodization is described as frequently varying intensity and volume on a daily, weekly, or biweekly basis, generally using maximum repetition time to plan training intensity (Muchammad Rizki Nurfauzi, 2018). Coaches must follow training norms when designing training plans. In sports achievement, there are several forms of training plans commonly used by coaches to help athletes reach their peak performance, usually called training periodization. The most commonly used periodization models by coaches are traditional and non-traditional periodization. Non-traditional periodization also includes various forms, one of which is Undulating Periodization (Sidik, 2022).

In undulating periodization, training time is divided into three forms depending on how far the training distance is toward an achievement in a competition. One of these is Daily Undulating Periodization (DUP) (Dermawan, 2018). Through this training, athletes can improve their physical components to reach their peak achievement. Compared to traditional periodization, undulating periodization with greater training variation is recommended to be more optimal for experienced athletes and team sports athletes (Wardani, 2023).

Several studies show that manipulating volume and intensity in undulating periodization provides various stimuli and recovery periods that are more conducive to strength development (Sidik, 2011). All types of training and periodization are very challenging for athletes aiming to reach their peak performance, especially when competitions are held very frequently, even every three months. Therefore, efficient training methods are needed to enable athletes to achieve successive achievements in a short time.

The purpose of this study is to examine the impact of Daily Undulating Periodization (DUP) on improving lower body muscle power and to assess the impact of DUP on improving upper body muscle power.

Methods

The approach used in this study is a quantitative approach. The quantitative approach involves converting observation results into numerical form, which are then analyzed using statistical techniques.

Research Design

This section explains the methods and designs used in the research. Explain in detail the relevance of the reasons for using the method and design. In this quantitative study, the method used is the experimental method. The research method is a technique used to conduct research that directly attempts to influence a certain variable in an appropriate way. In experimental research, the effect of the independent variable on the dependent variable can be determined under controlled conditions. An experiment is understood as trying to find and confirm, so the researcher must be able to control all variables that may affect the outcome except for the predetermined independent variable.

This experimental research method is the best method to identify or test hypotheses about cause-and-effect relationships. The design used by the author in this study is the one-group pretest-posttest design. In the one-group pretest-posttest design, one group is measured or observed not only after receiving a type of treatment but also before (Jack R. Fraenkel, Norman E. Wallen, 2012). Therefore, the researcher wants to know the impact of using the Daily Undulating Periodization (DUP) model on power improvement.

Participants

Participants are individual subjects involved in the research who are needed to obtain data and to initiate and design the study (Elmasri, 2017). The participants in this study were 15 first-year students of the Sports Science study program, class of 2022, at the Indonesia University of Education, taken from a total population of 106 students.

Instrument

An instrument is a good measuring tool used to obtain accurate data (Makbul, 2021). The instruments used in this study were a meter stick to measure lower limb muscle power (Vertical Jump) and a medicine ball to measure upper limb muscle power.

Procedure

The researcher will conduct the study through the following steps: first, formulating the research problem as questions to be answered through data collection and investigation. Second, preparing the research requirements by arranging the borrowing of equipment from the fitness laboratory at the UPI gymnasium and obtaining permission to conduct research at the site. Third, administering a pretest consisting of vertical jump test, medicine ball test, and 1 RM measurement as a reference for designing the training program before treatment. Fourth, providing treatment with the undulating periodization training model for 24 sessions over 8 weeks, with each session lasting 60 minutes. Fifth, conducting a posttest consisting of vertical jump and medicine ball tests after the treatment to evaluate progress compared to the pretest. Sixth, analyzing the collected data to determine the research outcomes. Seventh, concluding the findings based on data analysis and offering suggestions for future research to improve upon the current study.

Data Analysis

Data analysis was conducted using the Paired Sample T-test. The Paired Sample T-test is a test performed to compare the difference between two means from two paired samples, assuming that the data are normally distributed. This test was used to compare the level of improvement in lower limb muscle power and upper limb muscle power, preceded by tests for normality and homogeneity.

Results

The data obtained from the research are raw data, so they must be processed and analyzed statistically (Dr. Sandu Siyoto, SKM., M.Kes, 2015). "Data analysis is a series of activities including reviewing, grouping, systematizing, interpreting, and verifying data so that a phenomenon gains social, academic, and scientific value." In this section, the researcher presents the results of data analysis in a simple form as a summary of data processing using IBM SPSS Statistics version 26 software.

The results of the data analysis and the findings will be explained by the author in Table 1.

Descriptive data analysis aims to explain and describe the characteristics of each variable studied, where the form of the data depends on the type, such as numerical data used in calculating the mean, median, standard deviation, interquartile range, minimum, and maximum (Sabri, 2019). Based on the explanation above, descriptive analysis is a statistical analysis that illustrates or explains the data used and collected. The results can be presented in the form of graphs or tables.

The table above shows the results of descriptive statistical data analysis with several findings. First, the value of N indicates the sample size, which is N = 15. Then, there are the mean values from each test result, as well as the standard deviation values that describe the data within the sample.

Based on the table above, the experimental group using the medicine ball, which had received the treatment, showed a significance value of 0.001 < 0.05, thus H_0 is rejected. It can be

Tabel 1

Paired Samples t-Test for Medicine Ball Throw and Vertical Jump Performance (N = 15)

Variable Pair	Pretest		Posttest		*t*	*df*	*p*
	M	SD	M	SD			
Medicine Ball Throw (m)	3.36	0.27	4.18	0.11	-13.26	14	< .001
Vertical Jump (cm)	221.53	8.10	273.13	8.67	-28.07	14	< .001

concluded that the undulating periodization model using Daily Undulating Periodization (DUP) has an effect on increasing power. This can also be seen in the graph below, which shows a significant change/improvement.

After obtaining the results of the analysis from the research conducted and tested on 15 participants/students, it was found that this study showed an effect of the undulating periodization model using Daily Undulating Periodization (DUP) on the improvement of power. This is the reason the researcher chose to use the daily undulating method (DUP), as undulating periodization allows for more frequent manipulation of training volume and intensity. This also enables an appropriate ratio of recovery, thereby helping to prevent overtraining (Ernandes et al., 2012). In this study, the researcher applied high variations in volume and intensity through a daily training program with changes occurring three times a week. Furthermore, the researcher structured each session with specific manipulations: on Monday, 30% intensity with 12–14 repetitions aimed at hypertrophy, 80% intensity with 4 maximum repetitions for neural adaptation, and 60% intensity with 8 maximum repetitions for power development (Rahadian, E.P, 2021).

The research on the impact of the Daily Undulating Periodization (DUP) model on power improvement showed that this periodization model had a significant effect on increasing both upper body and lower body power, with a significance value of 0.001, which is less than 0.05. This means the DUP training method has a significant impact on power enhancement. The researcher supports this statement with the empirical results presented above.

Discussion

To achieve optimal physical ability and increase power during a training regimen, it is essential to implement an efficient and accurate training program or method. One of the most complex challenges in training methods is how to achieve peak performance on a scheduled date and time. Athletes who possess excellent physical condition will experience improvements in their circulatory system and heart function, as well as increases in strength, flexibility, endurance, speed, agility, and power (Rosdiana et al., 2022). Undulating periodization is characterized by frequent variations in intensity and volume—daily, weekly, or biweekly—and typically uses maximum repetition schemes to plan training intensity (Muchammad Rizki Nurfauzi, 2018).

Conclusionss

Based on the data analysis conducted, the Daily Undulating Periodization (DUP) training method has shown a significant effect on increasing muscle power. The research findings indicate that the application of the DUP model contributes to a notable improvement in both lower and upper body power. Specifically, there is a significant increase in lower body muscle power as a result of the DUP training model. Likewise, the use of this periodization model also significantly enhances upper body muscle power. These results confirm that the DUP method is effective in improving overall muscular power, making it a beneficial training approach for athletes seeking to optimize their physical performance.

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The Effectiveness of Specific Training Models on Increasing the Accuracy and Strength of the Jump Serve in Junior Volleyball Athletes

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Abstract

This study aims to determine the effectiveness of specific training models in improving the accuracy and strength of jump serves in junior volleyball athletes. The study employed a quasi-experimental design with a pretest-posttest control group approach. A total of 30 athletes, aged 14–16, were divided into two groups: an experimental group and a control group. The experimental group underwent a specific training program three times per week for six weeks, with each session lasting 60 minutes. The instruments used included expert-validated jump serve accuracy and power tests. Paired sample t-test results revealed significant improvements in accuracy ($t = 12.45$, $p < 0.001$) and strength ($t = 10.87$, $p < 0.001$) in the experimental group. In contrast, the control group showed no significant improvement in either variable. An independent-sample t-test revealed a significant difference between the two groups after the training period ($p < 0.05$), which was supported by a large effect size (Cohen's $d > 2$). These results demonstrate that targeted training effectively enhances jump serve accuracy and power. Structured, functional, movement-based training tailored to athletes' needs has been shown to positively impact junior volleyball athletes' serving performance.

Keywords: accuracy; junior athletes; jump serve; strength; specific training.

Introduction

The modern game of volleyball is characterized by increased speed and power, as well as efficient game strategy. One important element of the game is the serve, which not only starts the game but also creates pressure on the opponent. Among the various types of serves, the jump serve is one of the most dominant techniques used in professional-level volleyball due to its ability to produce unpredictable speed, ball rotation, and direction (Inkinen et al., 2013; Liu et al., 2024).

The jump serve incorporates complex biomechanical aspects, including core and lower-limb muscle strength, jump-timing coordination, body-rotation speed, and fine motor control at the moment of ball contact (Tillman et al., 2004; Häyrinen et al., 2011). In competitive matches, an effective jump serve can result in points (aces) or disrupt the opponent's receiving formation, providing a psychological and strategic advantage to the serving team.

However, although the importance of the jump serve is widely recognized in coaching literature and practice, its application to junior athletes still presents challenges. Many young athletes lack the muscle strength, motor coordination, and tactical understanding necessary to consistently and accurately execute jump serves (Ramirez-Campillo et al., 2021). Research by Bujang et al. (2024) shows that, compared to international standards, the level of accuracy and strength of the jump serve is still relatively low in the junior athlete group.

This inability stems not only from underdeveloped physical abilities, but also from training methods that do not specifically target jump serve development. Many junior-level coaches still use general training methods that do not directly address the specific demands of the jump serve, so the necessary motor and biomechanical adaptations are not achieved optimally (Thomas et al., 2023; Widianto & Susanto, 2020).

The specific training approach is a relevant solution to these challenges. This method directly replicates or simulates the conditions, movements, and intensity of the intended skill. In the context of a jump serve, for example, specific training includes functional exercises that emphasize aspects of jumping technique, arm swing coordination, core muscle strength, and decision-making in match situations (Markovic & Mikulic, 2010). Research has shown this approach to be more effective in producing neuromuscular and motor adaptations than generalized training (Fort-Vanmeerhaeghe et al., 2016).

This study's novel contribution is the development and application of a structured, measurable, and tailored specific training model for junior athletes' physiological characteristics and motor abilities. This study addresses the lack of research evaluating the effectiveness of specific training models for jump serves in young age groups. Most previous studies have focused on adult or elite athletes (Oliveira et al., 2020; Liu et al., 2024), so the implementation and validity of these models in early-age coaching contexts still need further study.

The specific drills developed in this study included explosive exercises, such as plyometric drills (Markovic & Mikulic, 2010), ball swing techniques with various speed and angle variations, and situational drills that mimic match conditions (Sheppard et al., 2009). Emphasizing the integration of technique and physical conditioning optimizes the synergy between components of jump serve performance (Ziv & Lidor, 2010). This approach is also designed with the principles of individualization and progressivity in mind (Bompa & Haff, 2009) to allow for the tailoring of training to each athlete's initial abilities. It is hoped that this model will accelerate the motor learning process (Magill & Anderson, 2017), correct incorrect techniques, and improve the consistency and effectiveness of jump serves (Forthomme et al., 2005).

This research is significant not only because it improves technical performance but also because it touches on an important aspect of sports performance coaching, especially at the junior level. Young athletes are in a critical stage of motor development; therefore, appropriate training interventions will impact the development of fundamental skills and readiness for higher levels of competition (Lloyd & Oliver, 2012). It is a sensitive period for developing optimal physical and coordinative capacity and requires a systematic, adaptive training approach (Ford et al., 2011; Myer et al., 2013). Thus, specific, evidence-based training models can lay the groundwork for a more scientific, measurable approach to modern coaching (Gilbert & Trudel, 2004; Williams & Hodges, 2005; Bishop, 2008).

In a national context, improving the serving techniques of junior athletes can be part of an effort to enhance volleyball coaching overall. Due to the importance of the jump serve in the modern game and the low level of mastery of this technique

among junior athletes, a structured intervention is necessary. This study aligns with national sports development directives that emphasize innovation in training systems and the development of young athletes.

Additionally, this study is novel in that it simultaneously measures jump serve strength and accuracy after the training intervention, producing more holistic data regarding the method's effectiveness. Previous studies have tended to measure only one parameter (Tillman et al., 2004; Bojanic et al., 2023), but this study combines both parameters in one evaluation framework.

Thus, this study is expected to serve as a practical reference for coaches, sports teachers, and academics when designing jump serve technique training programs tailored to junior athletes' characteristics. Ultimately, this model can be incorporated into the coaching curriculum of clubs, sports schools, and training centers so that it can contribute directly and effectively.

Methods

Research Design

This study employs a quantitative approach with a quasi-experimental pretest-posttest control group design. The study aimed to determine the effect of specific training models on improving the accuracy and strength of jump serves for volleyball athletes. The study included two groups: an experimental group that received specific training and a control group that underwent conventional training. The design is structured as Figure 1.

Participants

The research subjects were 30 junior volleyball athletes, aged 14-16, from two clubs in Bekasi City. Each group consisted of 15 athletes who were purposely selected based on the following criteria: actively training at least three times a week; not participating in special jump serve training; and being in good health. All participants obtained written consent from their parents or guardians.

Instrument

1. Jump Serve Accuracy Test

This test uses the "target zone" method, which is based on a modification of the NCSU Volleyball Skills Test Battery model. The opponent's field is divided into six target zones. Each participant performs ten jump serves and counts the number that land in the target zone.

2. Jump Serve Strength Test

Strength is measured based on the speed of the serve using a radar gun (in km/h). The radar gun is placed parallel to the baseline behind the server to measure the ball's speed after contact.

3. Technique Observation Sheet

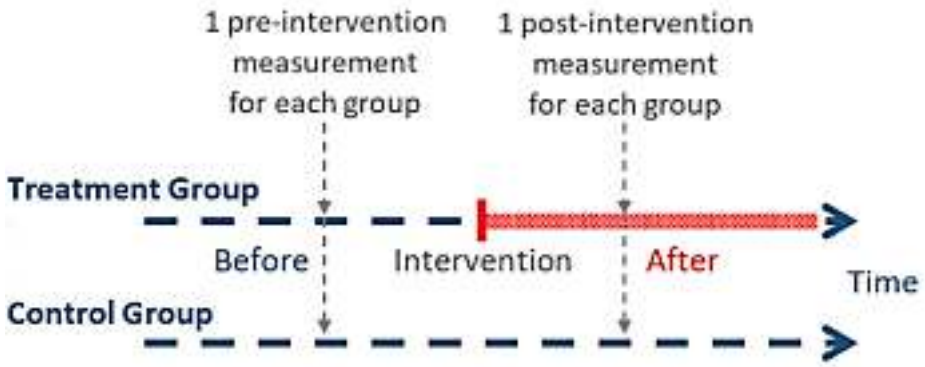
This is a checklist used to record the consistency of technical movements (toss, jump, and arm swing). It is completed by two trained observers.

Procedure

The research procedure began with a series of preparatory steps, including coordination with relevant schools, clubs, and coaches to ensure logistical and ethical compliance. Researchers conducted initial meetings with the athletes to explain the study objectives and procedures, and informed consent was obtained from all participants or their guardians. Prior to the main study, validity and reliability tests were conducted on all measurement instruments to ensure accuracy and consistency.

Following preparation, a pretest was administered to both the experimental and control groups. This involved baseline measurements of jump serve accuracy and power, conducted by certified instructors using standardized protocols. The data obtained from the pretest served as a reference point for evaluating changes after the intervention.

Figure 1
Diagram pretest-posttest control group design (Source: Reichardt et al., 2019, 2019).



The treatment phase lasted for six weeks. During this period, the experimental group participated in a specialized jump serve training program conducted three times per week, with each session lasting approximately 90 minutes. The training program focused on developing specific components of the jump serve technique, including toss and arm swing mechanics, coordination of approach steps, plyometric exercises to enhance explosive power, and targeted serving drills aimed at designated zones on the court. In contrast, the control group continued with general volleyball training sessions, which did not specifically address jump serve development.

At the conclusion of the six-week intervention, a posttest was conducted using the same procedures and measurement protocols as in the pretest. This allowed for direct comparison of the results between the two groups to determine the effectiveness of the jump serve training program.

Data Analysis

The data were analyzed using an independent-sample t-test to compare the post-test results between the experimental and control groups and a paired-sample t-test to observe changes within each group. The normality test used the Shapiro-Wilk test, and the homogeneity test used Levene's test. The analyses were conducted using SPSS version 25, and the significance level was set at $p < 0.05$.

Results

This study involved 30 junior volleyball athletes aged 14–16 years from two clubs in Bekasi City. The participants were randomly assigned to two groups: an experimental group (n = 15) and a control group (n = 15). Each athlete underwent pretest and posttest measurements following a six-week intervention period designed to improve jump serve performance.

These results shown in Table 1 demonstrate notable improvements in both performance indicators for the experimental group, while only minimal gains were observed in the control group.

The outcomes confirmed that all variables were normally distributed and demonstrated homogeneity of variance ($p > 0.05$), thus validating the use of parametric statistical procedures.

Following the six-week intervention period, the experimental group exhibited statistically significant improvements ($p < 0.05$) in both jump serve accuracy and jump serve power, accompanied by very large effect sizes (Cohen's $d > 2.0$), indicating a substantial practical impact. In contrast, the control group, which followed standard training protocols, demonstrated no statistically significant gains ($p > 0.05$), with effect sizes ranging from small to moderate.

To further examine the efficacy of the intervention, independent samples t-tests were conducted on the posttest scores to compare the performance outcomes between the two groups. Both comparisons yielded highly significant differences ($p < 0.001$), with very large effect sizes (Cohen's $d > 1.3$), confirming that the experimental group outperformed the control group by a substantial margin.

These findings provide strong empirical support that the targeted six-week training program significantly enhanced jump serve performance among junior volleyball athletes. The program, which was specifically designed to improve toss mechanics, step coordination, and upper-limb and core muscular strength, proved to be an effective intervention for optimizing critical technical and physical components of the jump serve. In contrast, the conventional training followed by the control group produced only marginal improvements, further underscoring the added value of a specialized and structured training regimen.

Table 1
Descriptive Statistics and t-Test Results for Jump Serve Accuracy and Power Pretest–Posttest Comparison and Between-Groups Posttest Differences

Variable	Group	Pretest M (SD)	Posttest M (SD)	t (14)	*p*	Cohen's *d*	t (28)	*p*	Cohen's *d*
Jump Serve Accuracy	Experimental	62.4 (5.3)	85.7 (4.8)	12.45	< .001	2.54	9.32	< .001	2.10
	Control	61.8 (6.1)	66.2 (5.9)	2.10	.052	0.42			
Jump Serve Power *(km/h)*	Experimental	72.5 (4.6)	86.3 (5.1)	10.87	< .001	2.22	8.75	< .001	1.95
	Control	71.9 (5.2)	74.2 (5.0)	1.95	.065	0.39			

t (14) = paired samples t-test within each group;
t (28) = independent samples t-test comparing experimental and control groups on posttest scores.
Cohen's *d* interpreted as: small = 0.2, medium = 0.5, large = 0.8, very large > 1.3.
All significance levels are two-tailed.

Discussion

This study demonstrated that applying specific training models positively affects volleyball athletes' jump serve accuracy and strength. Exercises designed to focus on the technical, tactical, and physical aspects of the jump serve can improve movement efficiency and the athlete's ability to control the ball's direction and power.

Specific exercises, such as drill targeting, plyometric training, and core and leg strengthening, support the development of stable, effective movement patterns. These findings align with those of Smith and Lees (2020), who stated that explosive strength and systematically trained coordinative skills strongly influence serving performance in volleyball. The ability of the muscles to generate force when jumping and hitting the ball simultaneously is crucial to achieving optimal accuracy and ball speed.

In addition to the physical aspects, specific training also plays a role in building technical consistency. Repetitive training with a structured approach improves muscle memory, making it easier for athletes to control their toss and swing. Riki Agustian (2023) emphasizes that technical skills, such as a precise toss and proper posture when making contact with the ball, significantly impact the accuracy of the serve.

This specific training model also has advantages over conventional training. Generalized and undirected training often fails to target important components of the jump serve. According to Dimyati's (2016) research, training that does not consider the specific movement needs of a particular sport tends to have a smaller impact on performance improvement.

The specific training model used in this study supports the development of better neuromuscular abilities. Plyometric exercises, which emphasize fast and explosive movements, improve motor unit recruitment efficiency and reflex speed. These are both necessary for executing jump serves (Pratama et al., 2024). In volleyball, players who have mastered the technique and have explosive muscle strength can produce serves that are more difficult for opponents to return.

These findings are important for coaches and training program developers. They can integrate specific training models into the routine training curriculum, especially during competition preparation phases, to improve serving ability, which is a strategic component of volleyball. This aligns with Kurniawan and Weda's (2022) assertion that structured and systematic training is crucial for developing sports skills.

The results are promising, but the study has limitations regarding sample size and training duration. To obtain more generalizable results, future studies should consider including more participants and extending the intervention's duration. Additionally, combining physical exercise with technology, such as video analysis or VR-based training applications, could be an interesting innovation for developing specific exercises in the digital era (Bakhri et al., 2020).

Thus, the specific training model has been proven to be an effective approach to improving the quality of jump serve technique. This effectiveness includes improvements in motion control, directional accuracy, hitting power, and energy efficiency in movement execution. This research reinforces the idea that training designed according to the specific needs of a skill is more likely to produce real, sustainable performance improvements.

Conclusions

This study shows that the specific training model significantly improves the ability of volleyball athletes to perform jump serves, in terms of both accuracy and strength. Training that focuses on technical and physical elements in accordance with the characteristics of the jump serve motion can improve movement efficiency, accuracy, and hitting power. Exercises such as drill targeting, core and leg muscle strengthening, and plyometric exercises have been shown to support the neuromuscular and mechanical adaptations required for volleyball serving.

This model can serve as a reference for developing volleyball training programs, particularly for developing individual technical skills. This research also opens opportunities for developing more innovative training programs by incorporating technological or sports psychological approaches to optimize athlete performance.

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Analysis of Eating Patterns and Diet Strategies Among Athletes and Active Sports Practitioners

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Abstract

This study anaxlyzes the eating patterns and dietary strategies adopted by athletes and active sports participants. The background issue indicates that athletic performance is significantly influenced by nutrition, yet many individuals do not fully understand the importance of balanced nutrient intake. The research method used is quantitative with a descriptive approach, involving 30-50 respondents from various sports communities. Data were collected through an online questionnaire and analyzed using IBM SPSS Statistics. The results show that respondents' nutritional knowledge is still limited, with eating habits being fairly good but low regarding breakfast before training. Dietary strategies are generally determined independently without professional consultation, and family support along with the availability of healthy food are important supporting factors. This study concludes that better nutrition education and the involvement of nutritionists are needed to enhance the practical application of optimal eating patterns in the sports domain.

Keywords: athletes; dietary strategies; eating patterns; nutrition; sports performance.

Introduction

In the world of sports, the performance of athletes and active individuals is greatly influenced by various factors, one of which is diet and dietary strategies (Chodkowski, 2024). According to Cornish & Barnes (2024), proper nutrition not only serves as a source of energy but also plays a crucial role in recovery, training adaptation, and injury prevention. However, in reality, many athletes and active individuals still lack a full understanding of the importance of balanced nutrition tailored to the type, intensity, and frequency of their training (Jalph & Kaur, 2023). This lack of awareness often leads to the implementation of inappropriate eating patterns, further exacerbated by popular diet trends that circulate widely without strong scientific foundations.

Diet trends such as the ketogenic diet, intermittent fasting, and plant-based diets are often adopted without consideration of individual physiological needs and specific physical activities (Malsagova et al., 2021). In some cases, these diets are implemented in extreme ways or without guidance from qualified professionals, posing risks such as fatigue, decreased performance, metabolic disturbances, and increased injury susceptibility. On the other hand, some athletes also neglect important aspects such as meal timing, nutrient proportions, and hydration due to time constraints, lack of access to nutrition education, or insufficient support from their sports support teams (Carter et al., 2023). This reality highlights a significant gap between the nutritional needs of athletes and the actual dietary practices they follow.

Therefore, this research is essential to comprehensively analyze how diet and dietary strategies are applied by athletes and active individuals. This study aims to uncover daily consumption patterns, dietary approaches used, and their impacts on performance and physical health. The findings of this study are expected to contribute scientifically to the development of evidence-based sports nutrition strategies, as well as serve as practical references for coaches, nutritionists, and athletes in designing dietary plans that align with their training and competition demands.

Methods

This study uses a quantitative method with a descriptive approach to describe the eating patterns and diet strategies of athletes and active sports participants (Carey et al., 2024). This approach was chosen because it is efficient and allows for objective and measurable data analysis through online questionnaires (Mawarni Saputri, 2022). The data were then statistically analyzed using SPSS to obtain a clear picture of the respondents' dietary habits (Iftikhar et al., 2019).

Research Design

This design aims to systematically and objectively describe and analyze the eating patterns and diet strategies used by athletes and active sports participants without testing cause-and-effect relationships. Data were collected using structured questionnaires administered online and statistically analyzed to provide a clear depiction of the variables studied.

Participants

The participants in this study are athletes and active sports practitioners from various sports communities, fitness centers, and sports clubs within the relevant research area. Participant selection was conducted using purposive sampling, which involves choosing respondents based on predetermined criteria (Nyimbili & Nyimbili, 2024). The number of participants ranges from 30 to 50, considered sufficient to represent the eating patterns and diet strategies used by this group.

Instrument

The instrument used is a structured questionnaire with a Likert scale (1–5), multiple-choice questions, and short answers to collect data on eating patterns, diet strategies, as well as knowledge and perceptions related to the diet of athletes and active sports participants.

Procedure

Data were collected online using the Google Form platform to facilitate respondent access and speed up the data collection process (Mawarni Saputri, 2022). The questionnaire link was distributed through social media platforms such as WhatsApp, Instagram, and others commonly used by athletes and active sports participants (Zafar Ali, 2023). This method was chosen because it is efficient, flexible, saves time and costs, and simplifies automatic data compilation.

Data Analysis

The collected data were analyzed descriptively using IBM SPSS Statistics version 22 software (Iftikhar et al., 2019). The analysis included calculating percentages and frequencies to identify respondent answer trends, as well as computing means and standard deviations to assess the intensity and consistency of diet strategy implementation (Pető, 2021). The results were presented in tables and graphs to facilitate interpretation.

Results

Nutrition Knowledge

Figure 1
Calorie needs

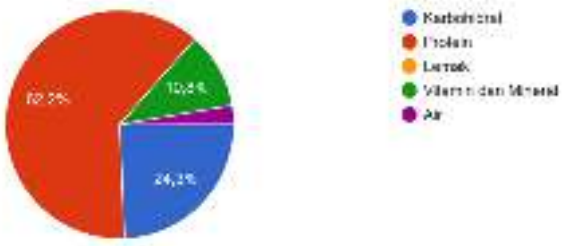


Figure 2
Understanding of daily calorie needs

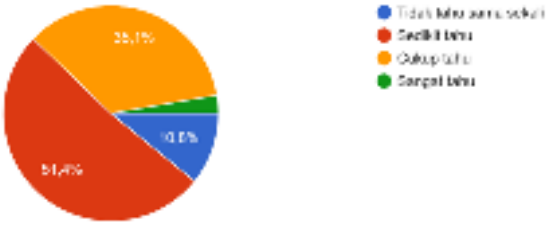
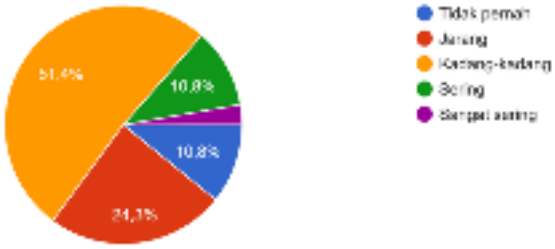


Figure 3
Awareness of the importance of nutrition information



Most respondents in this survey showed limited understanding of their daily calorie needs. As many as 51.4% of respondents stated that they only knew a little about how many calories they actually need each day. Meanwhile, 35.1% felt they had sufficient knowledge,
indicating that although there is some awareness, the information they possess is not yet entirely accurate or thorough.

Furthermore, 10.8% of respondents admitted that they had no knowledge at all about their daily calorie needs, indicating a lack of education or access to nutritional information. Only 2.7% of respondents felt they knew very well, showing that only a small portion truly understands the concept of calorie requirements and is able to apply it in their daily lives.

The majority of respondents, 62.2%, considered protein as the most important nutrient to support sports activities due to its role in muscle building and recovery. Meanwhile, 24.3% chose carbohydrates as the main energy source. About 10.8% prioritized vitamins and minerals that help maintain optimal body functions, and only 2.7% regarded water as an important element. No respondents chose fat, indicating that its benefits are still not well understood in the context of sports. As many as 51.4% admitted that they only sometimes seek information about sports nutrition from reliable sources. Meanwhile, 24.3% stated that they rarely do so, and 10.8% often look for such information. Interestingly, 10.8% of respondents never seek information about sports nutrition, and only 2.7% very frequently access reliable sources. This indicates that awareness of the importance of nutrition information in sports is still relatively low.

Eating Habits

Statement KM4, "I eat according to a regular schedule," has the highest mean score of 3.30 with a standard deviation of 0.702, indicating that most respondents tend to eat regularly and their

Tabel 1
Respondents Eating Habits

Variable	N	Min	Max	Mean	Std. Deviation
KM 1	37	1	5	2.84	1.143
KM2	37	1	5	2.86	.948
KM3	37	2	5	3.27	.990
KM4	37	2	5	3.30	.702
KM5	37	1	5	3.24	1.164
Kebiasaan Makan	37	8	21	15.51	3.015
Valid N (listwise)	37				

perceptions of this statement are relatively consistent. This is followed by KM3, "I consume fruits and vegetables every day," with a mean of 3.27 and a standard deviation of 0.990, showing that this habit is fairly common among respondents, although there is moderate variation in their answers.

Next, KM5, "I read nutrition labels when buying food," has a mean score of 3.24 and a standard deviation of 1.164, indicating that this habit is fairly common but shows greater variation among respondents. KM2, "I avoid fast food," has a mean of 2.86 and a standard deviation of 0.948, suggesting that this behavior is practiced at a moderate frequency. Meanwhile, KM1, "I eat breakfast before training," has the lowest mean score of 2.84 with a Standard deviation of 1.143, indicating that this habit is less frequently practiced compared to other indicators, and there is considerable variation in this behavior among individuals.

Overall, the total score for the Eating Habits variable has a mean of 15.51 and a standard deviation of 3.015, suggesting that, in general, respondents have moderate to good eating habits, although individual differences remain.

Diet Strategies

Most respondents reported having more than one reason for implementing a diet strategy. A total of 57.9% selected weight loss as their primary goal, making it the most common objective. Meanwhile, 44.7% aimed to increase muscle mass, indicating a strong focus on body building and physique development.

Then, 31.6% of respondents aimed to improve athletic performance, while 13.2% followed a diet to speed up recovery after physical activity. These findings reflect that diet strategies are not solely focused on weight loss but also emphasize performance enhancement and body recovery.

Around 63.2% of respondents developed their eating patterns through self-learning, such as reading articles, watching videos, or experimenting until they found what worked best for them. Meanwhile, 18.4% were influenced by trending diets on social media or the internet. Additionally, 10.5% relied on guidance from their sports coaches, and only 7.9% actually consulted a nutritionist. This indicates that dietary approaches are still largely shaped by easily accessible sources rather than professional expertise.

63.2% of respondents occasionally adjust their eating patterns to match their training rhythm or competition schedule, suggesting an awareness of its importance though it hasn't become a consistent habit. Meanwhile, 21.1% never make such adjustments, akin to competing without proper nutritional preparation. Only 15.8% often tailor their intake to meet their physical demands, indicating a deeper understanding of nutritional strategy. Interestingly, none of the respondents reported always making adjustments, highlighting a real challenge in maintaining consistent, training-based dietary planning.

Diet Support Factors

Based on descriptive analysis, family support (PD1) had a mean score of 3.35 with a standard deviation of 0.949, indicating a fairly high level of support with moderate response variability. The availability of healthy food (PD2) scored a mean of 3.57 and a standard deviation of 0.801, suggesting that access to nutritious food is considered relatively good, with less variation in responses.

Nutritional knowledge (PD3) showed a mean of 3.49 and a standard deviation of 0.804, indicating a good level of nutritional understanding with stable data distribution. Regular training schedules (PD4) had a mean of 3.43 and a standard deviation of 0.929, suggesting that training routines are fairly well-structured, with moderate variability among responses. Meanwhile, guidance from coaches or experts (PD5) had the lowest

Figure 4
Reasons for implementing diet strategies

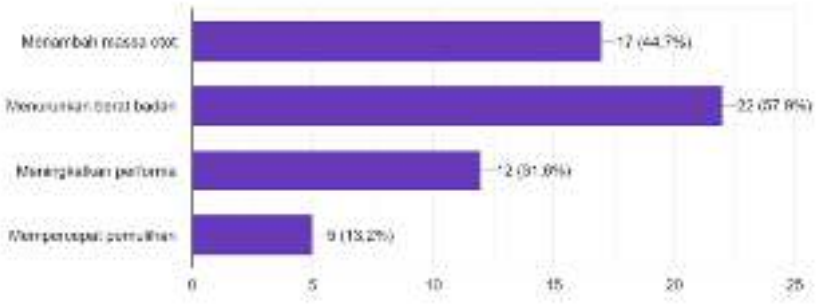


Figure 5
The approach to diet is still largely influenced

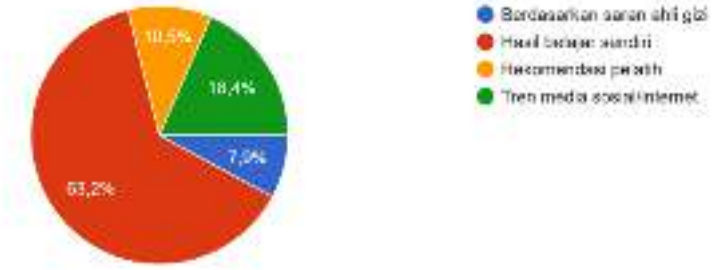
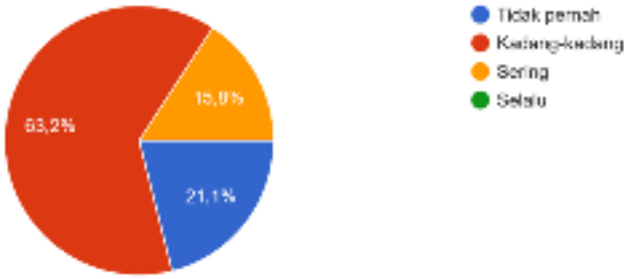


Figure 6
Consistency in managing diet based on training cycles



mean at 2.92 and the highest standard deviation of 1.256, indicating that this factor is considered less influential and shows greater variation across participants.

Overall, the combined mean for the supporting factors was 16.76 with a standard deviation of 3.467, placing these factors in the "fairly good" category.

Discussion

Based on the results of the conducted research, it is known that the level of nutritional knowledge among athletes and active sports practitioners is still considered less than optimal. The majority of respondents admitted to having only a limited understanding of their daily calorie needs, while only a small portion truly understood their nutritional requirements accurately. This fact indicates that education related to sports nutrition is still unevenly distributed and has not yet become a priority in the daily lives of athletes. This lack of understanding is also reflected in the respondents' perceptions, who tend to prioritize protein, while the role of other nutrients such as healthy fats and water receives less appropriate attention. In the context of sports performance, however, the balance of all macronutrients and adequate hydration are crucial factors that cannot be ignored.

Regarding eating habits, this study found that the respondents' dietary patterns are generally categorized as fairly good. Regular meal schedules

Tabel 2
Supporting factors for diet

Variable	N	Min	Max	Mean	Std. Deviation
PD1	37	1	5	3.35	.949
PD2	37	2	5	3.57	.801
PD3	37	2	5	3.49	.804
PD4	37	1	5	3.43	.929
PD5	37	1	5	2.92	1.256
Faktor Pendukung	37	9	25	16.76	3.467
Valid N (listwise)	60				

and consumption of fruits and vegetables are habits that are quite consistently followed, although there are still variations among individuals. Nevertheless, the habit of having breakfast before engaging in sports activities is still relatively low. If not improved, this habit can risk energy deficiency during exercise, decreased performance, and even increase the likelihood of injury. This indicates the need for more targeted interventions to raise awareness about the importance of meal timing, especially the consumption of food before physical activity begins.

Concerning the diet strategies applied, most respondents admitted to regulating their diets with the main goals of losing weight or increasing muscle mass. Unfortunately, the approaches used to formulate these diet strategies mostly come from self-learning efforts, such as reading articles or following videos on social media, with only a few consulting professional nutritionists. This situation raises concerns because information obtained independently is not necessarily accurate or suitable for individual physiological needs. The lack of guidance from professionals makes some athletes more vulnerable to adopting unbalanced diet patterns, which in the long term can negatively affect both their health and performance.

Adjusting dietary patterns based on training or competition cycles is also rarely done consistently by respondents. Most only occasionally make adjustments, and some never adjust their diet at all. Yet, adjusting food intake according to training load is one of the important principles in sports nutrition aimed at optimizing recovery, training adaptation, and performance during competition.

From the perspective of supporting factors for diet, this research shows that family support and the availability of healthy food are quite influential aspects in helping the successful implementation of good dietary patterns. However, support from coaches or nutritionists is still relatively low, indicating that in the athlete training ecosystem, the role of professional guidance related to nutrition has not been fully optimized. The low level of guidance from experts poses a distinct challenge, considering their vital role in shaping eating patterns that suit the specific needs of each athlete.

Based on these findings, it can be concluded that although there is initial awareness about the importance of dietary patterns and diet strategies among athletes and active sports practitioners, practical implementation in the field still needs improvement. Providing more comprehensive nutrition education, active involvement of nutritionists in training programs, and establishing more consistent eating habits in accordance with each athlete's physiological needs are important steps that need to be taken immediately to optimize performance and maintain long-term health.

Conclusionss

This study indicates that nutritional knowledge among athletes and active individuals remains limited, with most unable to implement optimal dietary patterns and strategies. Although there are positive tendencies such as regular meals and consumption of fruits and vegetables, important habits like having breakfast before training are still often overlooked. Dietary strategies are generally self-designed without professional consultation, making them prone to improper implementation. Family support and the availability of healthy food are helpful, but the involvement of coaches and nutritionists remains minimal. Future research should include more intensive nutrition education programs and further studies with larger sample sizes and qualitative approaches to better understand the factors influencing athletes' eating habits.

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