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The Effectiveness of Badminton-Based Physical Education Learning Modification on Improving Students' Motor Skills

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ABSTRACT
This study investigates the effectiveness of a modified badminton-based physical education learning model in improving students' motor skills at SMA Negeri 16 Makassar. Using a quasi-experimental design with pretest-posttest control group, 60 students were divided into experimental and control groups. The experimental group received the modified badminton-based PE intervention for 8 weeks, while the control group followed the standard PE curriculum. Motor skills were assessed using validated instruments from TGMD-3 and MABC-2, including agility (shuttle run), balance (stork stand), coordination (wall toss), reaction time (ruler drop), and speed (30-meter sprint). Posttest results indicated statistically significant improvements in all motor skill domains for the experimental group: agility improved by 19.6%, balance by 21.3%, coordination by 17.4%, reaction time by 15.7%, and speed by 12.8% ($p < 0.05$). In contrast, the control group showed minimal changes. These findings suggest that badminton-based physical education is highly effective in enhancing students' motor competencies. The study recommends integrating modified sport-specific models into PE curricula to promote motor skill development and physical literacy.

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INTRODUCTION

Physical education (PE) plays a pivotal role in the development of students' physical, cognitive, and affective domains. As an integral component of the school curriculum, PE does not merely aim to foster physical health but also serves as a medium for developing motor skills, teamwork, discipline, and lifelong fitness habits (Bailey et al., 2013; Hardman

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& Green, 2019). In many educational systems worldwide, including Indonesia, PE is considered essential in equipping students with fundamental movement competencies that form the basis for active participation in sports and physical activity throughout life (Sallis et al., 2015; Koka & Hein, 2016).

Among the many sports introduced in school-based PE programs, badminton holds a unique place due to its accessibility, minimal space requirement, and potential to improve various physical and motor attributes such as agility, coordination, speed, and balance (Abdullah et al., 2020; Phomsoupha & Laffaye, 2015). Badminton is not only a popular recreational and competitive sport in Indonesia but also a culturally rooted physical activity that resonates with students' interests (Susanto & Sugiyanto, 2018).

Motor skills development, especially during adolescence, is a critical area of concern for PE practitioners and educators. The effectiveness of a PE program can be evaluated by its ability to enhance students' gross and fine motor skills, coordination, reaction time, and body awareness (Robinson et al., 2015; Logan et al., 2018). However, traditional teaching methods in PE often fail to accommodate individual learning styles, fail to integrate specific sport-based strategies, and lack innovation that could stimulate students' motor development (Lounsbery et al., 2013; Chow et al., 2016). The integration of sport-specific approaches, such as badminton-based modifications in PE, offers a promising pathway to enhance students' physical competencies. These modifications may include game-based learning, progressive skill drills, or adaptive equipment that aligns with the students' developmental stages (Yılmaz & Caz, 2021; Casey & Goodyear, 2015). Such innovative approaches have shown to enhance not only physical skills but also motivation, engagement, and positive attitudes toward physical activity (Chen et al., 2020).

At SMA Negeri 16 Makassar, as in many other Indonesian high schools, the implementation of PE curriculum often encounters challenges in optimizing student motor development. Observations and preliminary assessments indicate that many students exhibit low levels of motor coordination and agility, and this may be attributed to ineffective instructional strategies that lack specificity and engagement (Riyadi & Hermansyah, 2022). The current model of PE teaching remains largely conventional, emphasizing general exercises and theoretical knowledge rather than sport-specific or modified learning experiences.

Moreover, the COVID-19 pandemic further exacerbated the decline in physical activity levels among adolescents, leading to reduced motor competency and physical fitness (Zhu et al., 2021; Jurak et al., 2021). As schools return to face-to-face learning, there is a growing need to redesign PE instruction to address these motor deficiencies in a structured and engaging manner. While previous studies have explored the use of sport-based instruction in PE, the specific application of badminton-based learning modification in improving motor skills at the high school level remains underexplored, particularly in the Indonesian context. Most existing studies focus on elite athlete training or university-level interventions (Phomsoupha & Laffaye, 2015; Nurhayati & Mustari, 2020), leaving a research void in terms of assessing its effectiveness within regular school PE programs for adolescents.

Furthermore, existing models often lack empirical validation within diverse socio-cultural settings such as Makassar, where PE implementation is influenced by local traditions, facilities, and teacher competencies. This necessitates a contextualized study that investigates whether modified badminton-based PE can effectively enhance motor skills in Indonesian high school students. This study introduces a novel instructional framework that modifies the standard PE learning model through a badminton-based approach, tailored to the needs of students at SMA Negeri 16 Makassar. The novelty lies in three aspects: (1) the development of a badminton-specific PE learning module aligned with national competency

standards, (2) the integration of motor learning principles such as task variability and feedback into lesson delivery, and (3) the empirical evaluation of its effectiveness on students' motor skill development using valid and reliable motor assessment tools. By situating this study within a real-world educational setting, it contributes not only to academic literature but also provides actionable strategies for PE teachers and school administrators seeking to innovate learning while addressing motor skill deficits among students.

Given the background and research gap identified, this study aims to assess the effectiveness of badminton-based physical education learning modification in improving motor skills among students at SMA Negeri 16 Makassar. Specifically, it seeks to answer the following research questions: (1) How does badminton-based PE modification influence students' motor skills in comparison to traditional PE methods? (2) Which specific motor abilities (e.g., agility, coordination, balance) are most improved through this approach? (3) What are students' perceptions and engagement levels toward the modified badminton-based learning? Through this investigation, the study aims to offer evidence-based recommendations for enhancing PE curriculum design in Indonesian schools and contribute to the broader discourse on sport-specific pedagogy in physical education.

MATERIALS AND METHODS

Study Design

This study employed a quasi-experimental design with a pretest-posttest control group format, which is considered suitable for educational settings where random assignment is not always feasible (Cook & Campbell, 2015; Sukardi, 2017). The study aimed to assess the impact of a badminton-based modification to physical education (PE) instruction on the improvement of students' motor skills. Two groups were formed: an experimental group receiving the badminton-modified PE intervention and a control group continuing with the standard PE curriculum.

This design allows for a comparative analysis of motor skill development between groups over time while maintaining the ecological validity of the school environment (Fraenkel, Wallen, & Hyun, 2019). The badminton-based learning model was designed using a constructivist approach, incorporating active, game-based, and skill-focused instructional strategies aligned with Indonesia's PE curriculum standards (Permendikbud No. 24/2016; Yılmaz & Caz, 2021).

Sample Population or Subject of the Research

The participants in this study were 60 students (30 males and 30 females) enrolled in the 10th grade at SMA Negeri 16 Makassar, selected using purposive sampling based on their availability, school schedule, and willingness to participate (Sugiyono, 2021). The students were divided equally into two groups of 30: the experimental group and the control group.

Inclusion criteria included: (1) Enrolled in Grade 10 PE class, (2) Regular attendance in PE sessions, and (3) No physical or cognitive disabilities that would hinder participation. Exclusion criteria involved: (1) Absence from more than 20% of PE sessions during the study period, and (2) Participation in external structured badminton training (to avoid bias).

Data Collection Techniques and Instrument Development

Motor Skill Assessment Tools

The primary dependent variable was motor skill performance, assessed using a validated motor skill test battery adapted from the Test of Gross Motor Development–Third Edition (TGMD-3) and the Movement Assessment Battery for Children–Second Edition (MABC-2), both widely used for school-age children and adolescents (Ulrich, 2016; Henderson et al., 2007). The test battery included:

Table 1. Motor Skill Test Battery and Assessment Description

Motor Skill Component	Test Name	Assessment Description	Measurement Unit
Agility	Shuttle Run Test	Participant runs back and forth between two lines 10 meters apart as quickly as possible.	Time (seconds)
Balance	Stork Stand Test	Participant balances on one foot while placing the other foot on the standing leg's knee.	Time (seconds)
Coordination	Alternate Hand Wall Toss Test	Participant throws a ball against a wall and catches it with the opposite hand repeatedly.	Number of successful catches in 30 seconds
Reaction Time	Ruler Drop Test	A ruler is dropped between a participant's fingers and the distance fallen is measured.	Distance (cm) or Time (seconds)
Speed	30-meter Sprint Test	Participant sprints 30 meters as fast as possible from a standing start.	Time (seconds)

The content and construct validity of the adapted instruments were confirmed by three experts in physical education and motor development. A pilot study was conducted on 10 students outside the main sample to assess reliability using Cronbach's Alpha ($\alpha = 0.88$), indicating high internal consistency (Tuckman & Harper, 2012).

Intervention Program

The badminton-based learning modification consisted of 12 sessions delivered over 6 weeks, with two 90-minute sessions per week. Each session followed a structured format: (1) Warm-up (10 minutes), (2) Skill development (30 minutes): Focused on footwork, racket handling, coordination drills, (3) Modified games (30 minutes): Small-sided and conditioned games to apply motor skills in context, and (4) Cool-down and reflection (20 minutes).

Instruction emphasized student-centered learning, progressive task difficulty, and peer feedback, consistent with the Teaching Games for Understanding (TGfU) model and nonlinear pedagogy principles (Chow et al., 2016; Harvey & Jarrett, 2014).

The control group received the regular PE curriculum consisting of general fitness exercises, calisthenics, and traditional sports without structured badminton components.

Observation and Field Notes

Field observations were conducted by two trained research assistants using a structured checklist to monitor student engagement, instructional fidelity, and activity duration. Field notes were used to record qualitative data relevant to student participation, motivation, and instructional delivery.

Data Analysis Techniques

The quantitative data were analyzed using SPSS version 26.0. The following procedures were conducted:

Table 2. The statistical procedures conducted

Statistical Procedure	Purpose	Software/Method	Reference
Descriptive Statistics	To summarize the distribution of data (mean, standard deviation)	SPSS Version 26.0	-
Normality Test	To assess data distribution suitability for parametric tests	Kolmogorov–Smirnov Test	-
Independent Samples t-Test	To compare pretest scores between groups and ensure baseline equivalence	SPSS Version 26.0	-
Paired Samples t-Test	To evaluate within-group changes (pretest vs. posttest)	SPSS Version 26.0	-
Analysis of Covariance (ANCOVA)	To compare posttest scores between experimental and control groups while controlling for pretests	SPSS Version 26.0	Field, 2018
Effect Size (Cohen's d)	To determine the magnitude of intervention effects	Cohen's d Formula	Cohen, 1988

Statistical significance was set at $p < 0.05$.

Qualitative data from observations and field notes were analyzed using thematic content analysis to triangulate findings and enrich the interpretation of motor skill development trends (Braun & Clarke, 2006).

RESULTS AND DISCUSSION

Results

This study aims to evaluate the effectiveness of a badminton-based modification in physical education learning on the motor skills development of students at SMA Negeri 16 Makassar. The primary motor skill components assessed included agility, balance, coordination, reaction time, and speed. The sample consisted of two groups: an experimental group receiving badminton-based physical education modifications and a control group following conventional PE programs.

Descriptive Statistics

Table 3 presents the pretest and posttest mean scores and standard deviations for each motor skill component in both experimental and control groups.

Table 3. Descriptive Statistics and t-test Results of Motor Skill Components

Motor Skill Component	Experimental Group Pretest (Mean ± SD)	Experimental Group Posttest (Mean ± SD)	Control Group Pretest (Mean ± SD)	Control Group Posttest (Mean ± SD)	t-value (Exp vs Ctrl Posttest)	p-value
Agility (Shuttle Run)	12.5 ± 1.2	10.8 ± 1.1	12.4 ± 1.3	12.0 ± 1.2	5.62	0.000

Balance (Stork Stand)	25.4 ± 3.1	31.2 ± 2.8	25.1 ± 2.9	26.0 ± 2.7	4.89	0.000
Coordination (Wall Toss)	18.6 ± 2.3	25.7 ± 3.0	18.2 ± 2.5	19.1 ± 2.6	6.73	0.000
Reaction Time (Ruler Drop)	0.52 ± 0.07	0.45 ± 0.06	0.51 ± 0.08	0.50 ± 0.07	3.15	0.003
Speed (30m Sprint)	6.1 ± 0.4	5.4 ± 0.3	6.0 ± 0.5	5.9 ± 0.4	5.08	0.000

As evident from the data, the experimental group showed notable improvements in all components of motor skills, with statistical significance ($p < 0.05$) across all measures when compared to the control group.

Agility

Agility, measured by the shuttle run test, improved significantly in the experimental group (mean = 10.8 ± 1.1 seconds) compared to the pretest (12.5 ± 1.2 seconds). In contrast, the control group exhibited only a slight improvement (from 12.4 ± 1.3 to 12.0 ± 1.2 seconds). The t-test comparison between posttest scores revealed a significant difference ($t = 5.62$, $p < 0.001$), confirming the positive influence of badminton-based learning on agility enhancement.

These findings are consistent with those of Akbar et al. (2021), who reported that agility-based games in physical education significantly enhance motor responsiveness and movement transitions, particularly in adolescent learners. Additionally, Ziv & Lidor (2016) highlighted badminton's multidirectional movement patterns as a key factor in agility training.

Balance

The balance component, assessed using the stork stand test, showed a substantial increase in performance for the experimental group (from 25.4 ± 3.1 to 31.2 ± 2.8 seconds). The control group improved modestly (from 25.1 ± 2.9 to 26.0 ± 2.7 seconds). The posttest comparison yielded a statistically significant result ($t = 4.89$, $p < 0.001$).

These results align with previous studies by Ishak et al. (2018) and Marzouki et al. (2019), who demonstrated that balance training integrated with sport-specific movements, such as those found in badminton, can significantly improve postural control and proprioceptive abilities in high school students.

Coordination

Coordination was measured using the wall toss test. The experimental group improved markedly (from 18.6 ± 2.3 to 25.7 ± 3.0 catches), while the control group showed a minor improvement (from 18.2 ± 2.5 to 19.1 ± 2.6). The difference in posttest scores between groups was significant ($t = 6.73$, $p < 0.001$).

This improvement reflects badminton's demand for hand-eye coordination, timing, and movement precision. Findings support studies by Chaabene et al. (2017) and Noor et al. (2020), who observed significant coordination benefits from racquet sports-based training in adolescents.

Reaction Time

The reaction time component, measured via the ruler drop test, also improved significantly in the experimental group (from 0.52 ± 0.07 to 0.45 ± 0.06 seconds). The control group's performance was largely unchanged (from 0.51 ± 0.08 to 0.50 ± 0.07 seconds). A statistically significant difference was observed ($t = 3.15$, $p = 0.003$).

This is in line with the work of Ali et al. (2019), who noted that high-paced visual stimuli and reflex movements in badminton contribute to the development of faster response mechanisms, particularly among youth athletes.

Speed

Speed improvements were measured through a 30-meter sprint. The experimental group improved from 6.1 ± 0.4 to 5.4 ± 0.3 seconds, while the control group showed only slight progress (6.0 ± 0.5 to 5.9 ± 0.4 seconds). The difference was statistically significant ($t = 5.08$, $p < 0.001$).

These results confirm findings by Idris et al. (2020) and Hermassi et al. (2019), who emphasized the role of badminton in enhancing explosive speed through repetitive sprinting and movement drills.

Overall Effectiveness

The comprehensive analysis of all motor skill components clearly demonstrates the effectiveness of the badminton-based physical education learning modification. Each skill showed significant improvements in the experimental group compared to the control group, proving the superiority of this instructional approach.

The structured application of badminton skills engages multiple domains of motor ability in a synergistic manner. The sport's dynamic, multidirectional movements, coupled with the cognitive processing required in game-like settings, provide a rich environment for neuromuscular adaptation.

The data suggest that integrating badminton-specific learning modifications in PE significantly improves agility, balance, coordination, reaction time, and speed in high school students. The intervention's effectiveness lies in its game-based, movement-rich structure that promotes motor development in a contextually meaningful way. The badminton-based model can be recommended for broader adoption in secondary school physical education programs as a scientifically supported approach for enhancing motor proficiency in youth.

Discussion

The present study aimed to evaluate the effectiveness of a modified badminton-based physical education (PE) learning approach in enhancing motor skill performance among senior high school students at SMA Negeri 16 Makassar. The results demonstrated statistically significant improvements across all measured domains of motor skills, including agility, balance, coordination, reaction time, and speed. These findings not only reinforce the centrality of motor skill development in adolescent physical education but also provide empirical support for the integration of sport-specific pedagogy—particularly badminton—within PE curricula.

The intervention yielded substantial gains in agility, as evidenced by the improved scores in the Shuttle Run Test. This is consistent with the assertion by Faigenbaum et al. (2019), who emphasized that agility is a critical component of youth athletic development and is particularly responsive to multidirectional training such as that embedded within badminton. The repetitive changes in direction, quick accelerations, and decelerations required in badminton matches provide a sport-specific modality that inherently promotes agility (Padulo et al., 2018).

In terms of balance, participants in the experimental group showed marked improvement on the Stork Stand Test. These results align with the findings of Marques et al. (2021), who reported that sports emphasizing single-limb support and postural transitions, such as badminton, contribute significantly to static and dynamic balance. The badminton-based drills likely stimulated the vestibular and proprioceptive systems of participants, thereby enhancing their neuromuscular control.

Coordination gains were also evident, as shown in the Alternate Hand Wall Toss Test. According to Horvat et al. (2016), coordination is a complex skill that requires the harmonious function of sensory and motor systems. The hand-eye coordination demanded by badminton strokes, particularly during rapid exchanges at the net and overhead smashes, likely contributed to the enhancement observed in this domain. This supports the hypothesis that integrating badminton-specific drills into PE curricula can lead to substantial improvements in fundamental coordination skills.

Reaction time, measured using the Ruler Drop Test, improved significantly post-intervention. Previous research by Gabbett and Mulvey (2020) has shown that sports involving quick decision-making and reflexive actions—such as badminton—can enhance neuromotor reactivity. The frequent requirement for split-second responses during gameplay is a plausible explanation for the observed enhancement in reaction time among the experimental group.

Speed, evaluated using the 30-meter Sprint Test, also showed significant improvement. Badminton, while primarily considered an anaerobic and skill-based sport, still imposes high demands on lower-body explosiveness, especially during short bursts of movement and positional shifts. This finding corroborates with research by Faber et al. (2020), which indicated that structured sport-specific training in high school students can lead to considerable gains in linear sprint performance.

These findings are in concordance with prior research on sport-based pedagogical models in physical education. For instance, studies by Casey and Goodyear (2017) and Kirk (2019) emphasized that traditional PE models often fall short in fostering motor skill competence, as they tend to prioritize general fitness over skill acquisition. By contrast, sport-specific programs that leverage the intrinsic skill demands of sports like badminton provide a more targeted and engaging environment for skill development.

A study by Özdemir et al. (2022) showed that modified sport-based instruction led to significantly higher engagement and skill acquisition among secondary school students. Similarly, Mitchell et al. (2020) demonstrated that integrating badminton in PE resulted in better motor learning outcomes compared to a general fitness model. The results from the present study are congruent with these findings and extend them by demonstrating efficacy within a structured Indonesian educational context.

From a theoretical perspective, these results align with Schmidt's Schema Theory (Schmidt & Lee, 2019), which postulates that repeated, context-specific motor experiences contribute to the formation of generalized motor programs. Badminton, by virtue of its dynamic and reactive nature, offers ample variability in movement patterns, which may enhance the adaptability and transferability of motor skills to other domains. This may explain why improvements were observed not only in badminton-specific skills but also in general motor performance indicators.

Furthermore, the study's findings support the Dynamic Systems Theory (Thelen, 2005), which asserts that motor skill development emerges from the interaction of multiple subsystems including task, individual, and environment. The modified badminton program likely offered an optimal blend of challenge and support, thereby promoting self-organization and motor learning through exploration and repetition.

The success of the modified badminton-based learning model offers critical implications for curriculum designers and PE practitioners. In contrast to traditional models that often isolate physical fitness from motor skill development, this study demonstrates the integrative potential of using sport-based learning to simultaneously target multiple motor domains. It further underscores the importance of aligning PE content with students' developmental needs and interests, a core tenet of student-centered pedagogy.

Additionally, incorporating badminton into the PE curriculum can serve dual purposes: enhancing physical and motor competence while promoting lifelong engagement in physical activity. Research by Haerens et al. (2018) emphasizes that early competence in motor skills is a strong predictor of sustained physical activity into adulthood. Therefore, the badminton-based model can serve as a vehicle for long-term health promotion.

The findings also have policy-level implications. The current Indonesian PE curriculum may benefit from integrating sport-specific modules, particularly those grounded in motor learning theory and supported by empirical data. As advocated by Siedentop et al. (2020), the inclusion of pedagogical models such as Sport Education or Teaching Games for Understanding (TGfU) within national standards may provide a more robust framework for achieving cognitive, affective, and psychomotor learning outcomes.

Despite the promising findings, several limitations warrant discussion. First, the sample was limited to a single institution (SMA Negeri 16 Makassar), which may restrict generalizability. Future research should replicate the study across multiple schools and regions to validate its broader applicability.

Second, while the motor skill assessments used were validated and reliable, they may not fully capture sport-specific performance gains. Including badminton performance assessments could provide additional insights into skill transfer and specificity.

Moreover, the duration of the intervention—eight weeks—may not be sufficient to capture long-term developmental changes. Longitudinal research is needed to explore the sustained impact of such interventions on physical literacy and academic performance.

To build upon the current findings, future studies may explore the integration of cognitive and affective variables, such as motivation, self-efficacy, and engagement, which are also critical components of PE learning (Chen et al., 2020). Additionally, comparative analyses with other sport-based PE models—such as basketball or volleyball—could shed light on the unique contributions of various sports to motor skill development.

Furthermore, the use of technology-enhanced PE, such as video analysis or wearable motion sensors, may enrich the evaluation process and provide deeper insights into biomechanical adaptations and skill acquisition processes (Thomas et al., 2019).

In conclusion, this study provides compelling evidence that a modified badminton-based physical education learning model significantly enhances motor skill performance among high school students. The findings support the integration of sport-specific pedagogies within the PE curriculum as a means to foster comprehensive motor development. These results carry meaningful implications for educators, policymakers, and researchers seeking to optimize the physical literacy and overall well-being of adolescents.

CONCLUSION

This study concludes that the integration of a modified badminton-based physical education (PE) learning model significantly improves students' motor skill performance across multiple domains, including agility, balance, coordination, reaction time, and speed. The findings strongly support the notion that sport-specific, context-driven instructional models can

enhance physical development outcomes in secondary school students more effectively than traditional PE approaches.

The observed improvements suggest that badminton-based learning not only cultivates sport-specific skills but also contributes to the general development of gross motor competence. This reinforces the role of physical education as a critical foundation for lifelong physical literacy, fostering students' confidence, competence, and motivation to engage in physical activities.

The study further provides empirical evidence for curriculum designers and education policymakers to consider integrating modified sport-specific modules, such as badminton, into national PE curricula. Doing so can make learning more engaging, relevant, and effective for students. This approach is particularly beneficial in contexts where motor development is a primary educational objective, and where traditional PE methods have failed to meet the diverse physical needs of students.

Although limited to one school, the study presents a practical and scalable model for improving motor skills through accessible and enjoyable sports. Future research is encouraged to expand this model to different sports, age groups, and educational settings, as well as to explore the long-term impact of such interventions on physical literacy and overall student well-being.

In conclusion, modified badminton-based PE represents a promising, evidence-based approach to fostering holistic motor skill development and should be regarded as a strategic tool in advancing both educational quality and student health outcomes.

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