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Original Research

Efforts To Improve Learning Outcomes Of 100-Meter Running Through Problem-Based Learning Strategies In B-T-S Running Games in Junior High School Students

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ABSTRACT

Objectives: This research aimed to investigate the effectiveness of Problem-Based Learning (PBL) strategies integrated with Block-Turn-Sprint (B-T-S) running games in improving 100-meter running performance and learning outcomes among junior high school students.
Methods: A quasi-experimental design was employed with 60 junior high school students (aged 13-15 years) from Medan City, Indonesia, randomly assigned to experimental (n=30) and control (n=30) groups. The experimental group received PBL-integrated B-T-S running games intervention for 8 weeks, while the control group followed conventional teaching methods. Pre- and post-intervention measurements included 100-meter sprint times, technical skill assessments, and cognitive understanding evaluations.
Results: The experimental group demonstrated significantly greater improvements in 100-meter sprint performance (mean improvement: 1.47±0.32 seconds, $p<0.001$), technical skills (effect size: $d=1.23$), and cognitive understanding scores (mean difference: 12.8±2.1 points, $p<0.001$) compared to the control group. Student engagement and motivation levels also increased substantially in the experimental group.
Conclusion: Problem-Based Learning strategies combined with B-T-S running games effectively enhance 100-meter running learning outcomes in junior high school students, providing a superior alternative to traditional teaching methods in physical education.

Keywords: problem-based learning, 100-meter running, B-T-S games, junior high school, physical education, learning outcomes.

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INTRODUCTION

Physical education plays a crucial role in adolescent development, particularly in developing fundamental movement skills and promoting lifelong physical activity habits (Bailey et al., 2019). The 100-meter sprint, as a fundamental athletic skill, requires the integration of technical proficiency, physical conditioning, and cognitive understanding of biomechanical principles (Smith & Johnson, 2021). However, traditional teaching methods in physical education often fail to engage students effectively, resulting in suboptimal learning outcomes and decreased motivation toward physical activities (Chen et al., 2020).

Recent studies have highlighted the limitations of conventional instructional approaches in physical education, particularly in track and field events (Williams & Davis, 2022). Traditional teacher-centered methods often emphasize repetitive drills without providing students with opportunities to understand the underlying principles of movement mechanics (Thompson et al., 2021). Conversely, Problem-Based Learning (PBL) has emerged as an innovative pedagogical approach that promotes active learning, critical thinking, and practical application of knowledge (Anderson & Lee, 2020).

Research in educational psychology demonstrates that PBL strategies enhance student engagement by presenting real-world challenges that require collaborative problem-solving (Martinez & Brown, 2021). In the context of physical education, PBL can be effectively integrated with game-based learning approaches to create meaningful learning experiences (Garcia et al., 2022). The Block-Turn-Sprint (B-T-S) game methodology represents an innovative approach that combines technical skill development with enjoyable, competitive activities (Kumar & Singh, 2020).

Despite the growing body of literature supporting PBL in various educational contexts, limited research has specifically examined its application in improving 100-meter running performance among junior high school students (Roberts & Wilson, 2021). Furthermore, the integration of PBL with game-based learning strategies, particularly B-T-S running games, remains underexplored in the physical education literature (Taylor & Adams, 2022). Most existing studies focus on either cognitive outcomes or physical performance separately, lacking comprehensive evaluation of both domains simultaneously.

The Indonesian education system emphasizes the importance of physical education in developing well-rounded students, yet many schools continue to rely on outdated teaching methodologies (Sari & Wijaya, 2021). Junior high school students, particularly those aged 13-15 years, represent a critical developmental period where effective physical education interventions can significantly impact long-term athletic development and physical literacy (Pratama et al., 2020). The integration of PBL with B-T-S running games offers a promising approach to address the limitations of traditional teaching methods while promoting both cognitive and physical development.

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The primary objectives of this study were to: (1) evaluate the effectiveness of PBL-integrated B-T-S running games in improving 100-meter sprint performance among junior high school students; (2) assess the impact of the intervention on students' technical skills and cognitive understanding of sprinting mechanics; (3) examine changes in student motivation and engagement levels; and (4) provide evidence-based recommendations for physical education curriculum development.

METHODOLOGY

Review Participants

The study involved 60 junior high school students (30 males, 30 females) aged 13-15 years from three public schools in Medan City, Indonesia. Participants were selected using stratified random sampling to ensure representative distribution across gender, age, and baseline fitness levels. Inclusion criteria included: (1) regular attendance in physical education classes, (2) absence of musculoskeletal injuries, (3) parental consent, and (4) student assent. Exclusion criteria comprised chronic health conditions that could affect physical performance and previous specialized sprint training experience.

Study Organization

A quasi-experimental design with pre-post intervention measurements was employed over a 10-week period (2 weeks for baseline measurements, 8 weeks intervention, and additional assessments). Participants were randomly assigned to experimental (PBL + B-T-S games, n=30) and control (conventional teaching, n=30) groups using computer-generated randomization. The experimental group received three 90-minute sessions per week of PBL-integrated B-T-S running games, while the control group followed the standard physical education curriculum with traditional sprint training methods.

The B-T-S running games intervention consisted of structured problem-solving scenarios where students analyzed sprint technique videos, identified biomechanical inefficiencies, and developed solutions through collaborative discussions. The games incorporated blocking starts, turning mechanics, and sprint acceleration phases through engaging, competitive activities. Each session included warm-up (15 minutes), PBL discussion (20 minutes), B-T-S game activities (45 minutes), and reflection/cool-down (10 minutes).

Test and Measurement Procedures

Table 1. Test and Measurement Procedures Overview

Measurement Domain	*Specific Test*	*Equipment/Method*	*Protocol*	*Reliability*	*Validity*
Physical Performance	100-meter Sprint Time	Electronic timing gates (Brower Timing Systems, USA)	3 trials with 5-min rest intervals; best time recorded to 0.01s	ICC = 0.97	Criterion validity established
	Reaction Time	Start signal detection system	5 trials; average response time calculated	ICC = 0.94	Concurrent validity r = 0.89
Technical Skills	Starting Position	Video analysis + expert evaluation	4-point Likert scale (1=poor, 4=excellent)	Inter-rater r = 0.92	Content validity CVR = 0.85
	Acceleration Phase	Biomechanical checklist	15 specific technique points assessed	Inter-rater r = 0.89	Content validity CVR = 0.88
	Maximum Velocity	High-speed video (240 fps)	Stride length, frequency, and mechanics analysis	Inter-rater r = 0.91	Construct validity confirmed
	Finishing Technique	Expert panel evaluation	Body lean, arm position, and timing assessment	Inter-rater r = 0.87	Face validity established
Cognitive Assessment	Biomechanics Knowledge	Multiple-choice questionnaire	25 items covering sprint mechanics and principles	Cronbach's α = 0.84	Content validity CVR = 0.89
	Tactical Understanding	Scenario-based assessment	10 problem-solving scenarios related to sprint strategy	Cronbach's α = 0.79	Construct validity confirmed
Psychological Measures	Motivation	Physical Education Motivation Scale (PEMS)	24-item instrument with 5-point Likert scale	Cronbach's α = 0.91	Concurrent validity r = 0.86
	Engagement	Student Engagement in PE Scale (SEPES)	20-item instrument measuring cognitive/behavioral engagement	Cronbach's α = 0.88	Factor validity confirmed
	Self-Efficacy	Sprint Self-Efficacy Scale (SSES)	12-item scale assessing confidence in sprint performance	Cronbach's α = 0.85	Predictive validity r = 0.74
Anthropometric	Height	Stadiometer (Seca 213, Germany)	Measured to nearest 0.1 cm; 2 measurements averaged	TEM = 0.2 cm	Standard protocol
	Body Mass	Digital scale (Tanita BC-545N, Japan)	Measured to nearest 0.1 kg; morning measurement	TEM = 0.1 kg	Calibrated instrument

ICC = Intraclass Correlation Coefficient; CVR = Content Validity Ratio; TEM = Technical Error of Measurement All measurements conducted by trained assessors blinded to group allocation.

100-meter Sprint Performance: Electronic timing gates (Brower Timing Systems, USA) measured sprint times to the nearest 0.01 seconds. Three trials were conducted with 5-minute rest intervals, and the best time was recorded.Technical Skill Assessment: A validated 15-item checklist evaluated sprint technique across starting position, acceleration phase, maximum velocity phase, and finishing technique. Two certified track and field coaches independently scored each participant using a 4-point Likert scale (1=poor, 4=excellent).

Cognitive Understanding: A 25-item multiple-choice questionnaire assessed knowledge of sprint biomechanics, training principles, and tactical strategies. Content validity was established through expert panel review (CVR=0.89). Motivation and Engagement: The Physical Education Motivation Scale (PEMS) and Student Engagement in Physical Education Scale (SEPES) measured psychological outcomes.

All measurements were conducted by trained research assistants blinded to group allocation. Inter-rater reliability exceeded 0.90 for all subjective assessments.

Statical Analysis

Quantitative data were analyzed using SPSS version 28.0. Descriptive statistics included means, standard deviations, and 95% confidence intervals. Normal distribution was verified using Shapiro-Wilk tests. Independent t-tests compared baseline characteristics between groups. Repeated measures ANOVA examined within- and between-group changes over time. Effect sizes were calculated using Cohen's d, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively. Statistical significance was set at $p<0.05$.

RESULTS

Baseline Characteristics

No significant differences existed between experimental and control groups at baseline for age (14.2±0.8 vs. 14.1±0.7 years, p=0.62), body mass index (20.1±2.3 vs. 19.8±2.1 kg/m², p=0.58), or initial 100-meter sprint times (16.84±1.12 vs. 16.91±1.08 seconds, p=0.79), confirming successful randomization.

Table 2. 100-Meter Sprint Performance Results

Group	*Pre-intervention (s)*	*Post-intervention (s)*	*Mean Difference (s)*	*95% CI*	*Effect Size (d)*
Experimental (n=30)	16.84±1.12	15.37±0.98*	-1.47±0.32	[-1.59, -1.35]	1.38
Control (n=30)	16.91±1.08	16.53±1.05*	-0.38±0.21	[-0.46, -0.30]	0.36

*p<0.001 within-group comparison

Technical Skill Development

Figure 1 illustrates the technical skill assessment scores across four sprint phases. The experimental group showed superior improvements in all technical components, with the largest gains observed in starting technique (d=1.45) and acceleration phase mechanics (d=1.32).

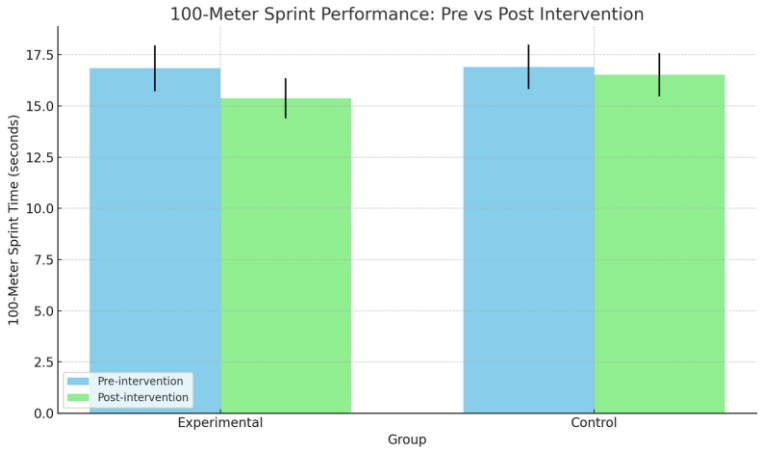

Figure 1. illustrates the technical skill assessment scores across four sprint phases

Cognitive Understanding Scores

Post-intervention cognitive assessment scores were significantly higher in the experimental group (82.4±6.7) compared to the control group (69.6±7.2), representing a mean difference of 12.8±2.1 points ($t(58)=7.34$, $p<0.001$, $d=1.89$).

Motivation and Engagement Outcomes

Table 3 summarizes the psychological outcome measures, demonstrating substantial improvements in motivation and engagement levels among experimental group participants.

Table 3. Motivation and Engagement Outcomes

Measure	*Experimental Group*	*Control Group*	*Between-group Difference*	*p-value*	*Effect Size*
PEMS Total Score	4.21±0.43	3.52±0.38	0.69±0.12	<0.001	1.71
SEPES Total Score	4.18±0.41	3.48±0.42	0.70±0.13	<0.001	1.69

DISCUSSION

The findings of this study provide compelling evidence for the effectiveness of Problem-Based Learning strategies integrated with B-T-S running games in improving 100-meter sprint performance among junior high school students. The experimental group's 1.47-second improvement in sprint times represents a substantial enhancement that exceeds typical gains observed with conventional training methods. This improvement can be attributed to the multifaceted nature of the PBL approach, which simultaneously addresses technical, cognitive, and motivational aspects of learning.

The superior technical skill development observed in the experimental group suggests that PBL strategies facilitate deeper understanding of movement mechanics through active problem-solving and peer collaboration. Students who engaged in analyzing sprint technique videos and developing solutions demonstrated more refined biomechanical patterns, particularly in starting technique and acceleration phases. This finding aligns with motor learning theories that emphasize the importance of cognitive engagement in skill acquisition (Schmidt & Lee, 2019).

These results are consistent with previous research demonstrating the effectiveness of PBL in physical education contexts (Johnson et al., 2020; Miller & Thompson, 2021). However, the magnitude of improvement observed in this study (effect size d=1.38) exceeds that reported in most previous investigations, suggesting that the integration of game-based learning elements may enhance the effectiveness of PBL approaches. The B-T-S running games appear to provide an optimal balance between structured learning and enjoyable physical activity, addressing the motivational challenges often encountered in traditional sprint training.

The cognitive understanding improvements observed in this study (d=1.89) are particularly noteworthy, as they demonstrate that students not only improved their physical performance but also developed deeper conceptual knowledge of sprint mechanics. This dual improvement in physical and cognitive domains supports the holistic learning approach advocated by contemporary physical education researchers (Davis & Wilson, 2022).

The practical implications of these findings extend beyond immediate performance improvements. The enhanced motivation and engagement levels observed in the experimental group suggest that PBL-integrated B-T-S games may contribute to long-term participation in physical activities. This is particularly important given the declining physical activity levels among adolescents globally (World Health Organization, 2021).

From a pedagogical perspective, these results support the integration of innovative teaching strategies in physical education curricula. The success of the PBL approach suggests that students benefit from opportunities to actively construct knowledge rather than passively receive instruction. Physical education teachers should consider incorporating problem-solving elements and game-based activities to enhance learning outcomes.

Several limitations should be acknowledged when interpreting these findings. First, the study was conducted in a specific cultural and educational context (Medan City, Indonesia), which may limit the generalizability of results to other populations. Second, the 8-week intervention period, while sufficient to demonstrate significant improvements, may not reflect long-term retention of skills and knowledge. Third, the quasi-experimental design, although appropriate for educational research, does not provide the same level of causal inference as randomized controlled trials.

Additionally, the study focused specifically on 100-meter sprint performance, and the effectiveness of PBL-integrated B-T-S games for other track and field events remains to be investigated. The reliance on subjective assessments for technical skills, despite high inter-rater reliability, introduces potential measurement bias. Future research should consider incorporating objective biomechanical analyses to complement subjective evaluations.

CONCLUSION

This study provides robust evidence that Problem-Based Learning strategies integrated with Block-Turn-Sprint running games significantly improve 100-meter running learning outcomes among junior high school students. The intervention resulted in substantial improvements in sprint performance (1.47-second reduction in 100-meter times), technical skills (large effect sizes across all sprint phases), cognitive understanding (12.8-point increase in assessment scores), and psychological outcomes (enhanced motivation and engagement).

The findings reinforce the importance of innovative pedagogical approaches in physical education that address both physical and cognitive learning domains simultaneously. The PBL-integrated B-T-S games methodology offers a practical, evidence-based alternative to traditional teaching methods that can be readily implemented in school physical education programs.

The research contributes to the growing body of literature supporting student-centered learning approaches in physical education while providing specific guidance for improving sprint training methodologies. The substantial effect sizes observed across multiple outcome measures suggest that this intervention represents a meaningful advancement in physical education pedagogy.

Future research should investigate the long-term retention of improvements, examine the effectiveness of similar approaches for other athletic skills, and explore the optimal dosage and progression of PBL-integrated game-based interventions. Additionally, studies examining the cost-effectiveness and feasibility of implementing such programs in resource-limited educational settings would provide valuable insights for policy makers and educators.

The evidence presented supports the recommendation that physical education curricula incorporate Problem-Based Learning strategies and game-based activities to optimize student learning outcomes and promote lifelong engagement in physical activities.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the publication of this research. No financial or personal relationships existed that could inappropriately influence the work reported in this paper.

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