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# Modified Tug-of-War Training as a Pedagogical Tool for Volleyball Serve Development in Secondary Physical Education

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**ABSTRACT**

The underhand serve is a foundational skill in volleyball, yet secondary school students frequently experience technical difficulties in regulating arm swing, body alignment, and force delivery due to traditional, repetitive drill-based instruction. This study evaluated the efficacy of modified tug-of-war training as an innovative pedagogical tool to enhance volleyball underhand serve proficiency in secondary physical education. Employing a two-cycle action research design, an intervention was conducted with 80 tenth-grade students ($M_{age} = 15.4$ years) at a public secondary school in Indonesia. The intervention integrated a modified tug-of-war activity designed to provide kinesthetically active resistance, facilitating proper body positioning and momentum transfer. Data were gathered through standardized psychomotor performance rubrics, cognitive assessments, and affective engagement observations, with success evaluated against a predetermined mastery threshold (score $\geq 80$). Baseline data revealed a 0% initial mastery rate. Following the intervention, classical mastery increased significantly to 28.75% ($M = 75.93$) in Cycle I and reached 98.75% ($M = 90.72$) in Cycle II, accompanied by notable improvements in cognitive understanding and affective participation. These findings demonstrate that utilizing modified tug-of-war activities as a task-based pedagogical tool effectively bridges the gap between mechanical force application and skill execution. This approach provides physical education teachers with a scalable, game-based alternative to conventional drills for motor skill acquisition in team sports.



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## 1. INTRODUCTION

Physical Education (PE) occupies a strategic position in fostering holistic student development across cognitive, affective, and psychomotor domains (Dong et al., 2026; Valle-Muñoz et al., 2025). Physical education teachers serve as primary instructional designers whose choice of pedagogical models, learning tasks, and media directly dictates classroom engagement and motor skill learning outcomes (Hodges-Kulinna et

al., 2024; Park et al., 2025; Youness et al., 2026). Within secondary education curricula, delivering effective team sport instruction demands innovative, student-centered approaches that move beyond traditional skill delivery (Silva et al., 2023). Specifically, teaching technical sport skills requires pedagogical frameworks that render technical execution relevant, engaging, and systematically structured to accommodate diverse motor learning capabilities in adolescent learners (Hardinoto et al., 2026; Khudolii et al., 2025).

In volleyball, the underhand serve is widely recognized as a foundational technical skill that serves as the primary offensive initiation and dictates the transition into structured play (Hudain et al., 2026; Sakhi, 2026). Mastering this skill requires a precise synthesis of kinetic chain sequencing, arm-swing velocity, shoulder stability, and body alignment at the point of ball contact (Nurrahman et al., 2026). However, secondary school students routinely demonstrate persistent technical errors, particularly regarding improper weight transfer, inconsistent contact force, and poor directional control (Astuti et al., 2025). These execution barriers are often exacerbated by conventional, teacher-centered drill paradigms that emphasize mechanical repetition, frequently resulting in student disinterest and diminished motor skill acquisition (Karisman & Supriadi, 2022; Kharisma et al., 2025).

Preliminary diagnostic observations at the secondary school level (involving tenth-grade PE cohorts, $N = 396$) confirmed these pervasive technical deficiencies. Initial performance screenings revealed that an overwhelming majority of students failed to meet established technical performance criteria for the underhand serve. Mechanically, learners exhibited restricted arm acceleration, unstable stance bases, and poor impact timing. Pedagogically, the reliance on static line drills led to rapid student disengagement and minimal active movement time. These empirical baseline findings align with contemporary PE literature indicating that unvaried instructional routines diminish student motivation and impede the neural and physical adaptation necessary for motor proficiency (Kharisma et al., 2025).

To overcome these instructional limitations, integrating game-based pedagogical tools provides an effective mechanism for enhancing motor engagement and skill comprehension. Modifying traditional, culturally familiar games offers a promising approach, as these activities combine high intrinsic motivation with functional physical demands (Aliriad et al., 2024; Septianto et al., 2024). Specifically, tug-of-war represents a resistance-based task that intrinsically demands upper-body force generation, core stability, balance, and synchronized physical effort—attributes that directly mirror the biomechanical requirements of the volleyball serve (Cayero et al., 2021). From a motor development perspective, structured resistance games act as kinesthetic feedback mechanisms, helping learners experience controlled force application and dynamic balance during skill movement (Barnett et al., 2019; Wick et al., 2017).

While prior scholarship has explored game-centered frameworks in volleyball—such as Teaching Games for Understanding (Stolz & Pill, 2014), problem-based learning (Awaluddin et al., 2025), and general task constraints (Moy et al., 2024)—the functional application of modified tug-of-war training as a specific pedagogical tool for serve

development remains unexamined. Current literature lacks empirical evidence demonstrating how resistance-based game modifications, when embedded within a progressive pedagogical design, systematically bridge the gap between gross strength exertion and fine motor skill accuracy in secondary physical education settings.

To address this empirical and instructional gap, this study evaluated the implementation of modified tug-of-war training as a pedagogical tool to improve volleyball underhand serve performance among secondary school students. Utilizing an action research framework, this investigation examined the progressive impact of this game-based intervention on students' cognitive understanding, affective engagement, and psychomotor skill execution, providing PE practitioners with an evidence-based, scalable alternative to conventional drill instruction.

## 2. METHOD

This study adopted an Action Research (AR) design, a reflective practitioner-led inquiry framework widely recognized for systematically evaluating pedagogical interventions and optimizing motor skill acquisition in educational settings (Lizandra et al., 2025; Robinson et al., 2023). The intervention was structured across two iterative cycles, each encompassing four interconnected phases: planning, action, observation, and reflection. This cyclic approach enabled continuous monitoring of student motor responses and pedagogical adaptations, ensuring that task constraints and resistance intensity were progressively calibrated based on empirical observations from preceding lessons.

Participants comprised 80 tenth-grade students ($M_{age} = 15.4$ years, $SD = 0.6$) sampled from an accessible secondary school population ($N = 396$) in Indonesia. A stratified purposive sampling technique was employed to target physical education classes exhibiting critical technical deficits in the volleyball underhand serve during preliminary diagnostic screenings. Prior to data collection, institutional clearance and informed consent were obtained from school administrators, physical education teachers, and students' legal guardians. All participants were free from acute musculoskeletal injuries and presented baseline physical capabilities suitable for moderate-to-vigorous physical activity.

The instructional intervention integrated modified tug-of-war training as a primary pedagogical tool across a six-week instructional unit. Prior to Cycle I, a baseline (pre-cycle) assessment was administered to establish pre-intervention skill levels. In Cycle I, students engaged in a progressive instructional sequence where modified tug-of-war games were implemented as resistance-based task constraints, designed to enhance core stability, upper-body force transfer, and directional awareness during the serve motion. Following Cycle I reflections, Cycle II incorporated differentiated pedagogical modifications, including targeted kinesthetic feedback, individualized error correction, and variable resistance games to address persistent mechanical and motivational bottlenecks.

Data were collected using a multi-domain assessment battery targeting cognitive, affective, and psychomotor learning dimensions. Psychomotor execution was evaluated

using a validated volleyball underhand serve performance rubric assessing technical sub-components: stance/base of support, arm swing trajectory, ball-impact accuracy, and follow-through. Cognitive understanding was measured via a standardized motor-knowledge questionnaire focusing on mechanical principles, while affective engagement was recorded using a structured observational checklist evaluating task participation, cooperation, and persistence during practice.

Data were analyzed using descriptive quantitative statistics to evaluate individual and group progression. Psychomotor, cognitive, and affective scores were benchmarked against a predetermined mastery threshold ($\geq 80\%$ performance accuracy), reflecting established physical education proficiency standards. Classical mastery was calculated as the proportion of students achieving or exceeding this performance criterion. In accordance with action research standards for secondary physical education, the pedagogical intervention was deemed successful when overall classical mastery reached a target benchmark of $\geq 80\%$ across the participant cohort.

## 3. RESULTS AND DISCUSSION

### Results

### Baseline Performance (Pre-Cycle)

Baseline assessments conducted prior to the intervention confirmed severe technical deficits in underhand serve execution among participants. As detailed in Table 1, none of the 80 students (0.00%) achieved the predetermined mastery threshold ($\geq 80$). All participants were classified in the non-mastery category, demonstrating consistent mechanical errors such as insufficient arm acceleration, off-center ball impact, and improper weight distribution. These findings underscored the insufficiency of conventional instruction and established the empirical justification for implementing the game-based action research intervention.

**Table 1**. Baseline Distribution of Volleyball Underhand Serve Performance Scores ($N = 80$)

| Score Range | Performance Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 93–100 | Excellent | 0 | 0.00 |
| 86–92 | Good | 0 | 0.00 |
| 80–85 | Satisfactory | 0 | 0.00 |
| <80 | Needs Improvement | 80 | 100.00 |
| Total | | 80 | 100.00 |

### Cycle I Intervention Outcomes

Following the introduction of modified tug-of-war training in Cycle I, student performance demonstrated noticeable positive shifts. As shown in Table 2, classical learning mastery reached 28.75% ($n = 23$), with the overall cohort mean increasing to 75.93. Although cognitive understanding and affective engagement improved rapidly, psychomotor execution lagged the target benchmark of 80% classical mastery. Qualitative reflections following Cycle I revealed persistent kinetic errors, specifically

incomplete forward lean, inconsistent contact timing, and restricted follow-through momentum.

**Table 2**. Post-Cycle I Distribution of Volleyball Underhand Serve Performance Scores (N = 80)

| Score Range | Performance Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 93–100 | Excellent | 3 | 3.75 |
| 86–92 | Good | 5 | 6.25 |
| 80–85 | Satisfactory | 15 | 18.75 |
| <80 | Needs Improvement | 57 | 71.25 |
| Total | | 80 | 100.00 |

**Cycle II Intervention Outcomes**

To resolve the motor execution bottlenecks identified in Cycle I, Cycle II incorporated task-differentiated variations, individual kinesthetic feedback, and targeted resistance adjustments. As illustrated in Table 3, classical mastery surged to 98.75% ($n = 79$), with 31.25% of students achieving the "Excellent" category and 65.00% attaining the "Good" category. Only a single student (1.25%) remained slightly below the proficiency threshold. The overall class mean increased substantially to 90.72, significantly surpassing the targeted 80% benchmark.

**Table 3**. Post-Cycle II Distribution of Volleyball Underhand Serve Performance Scores (N = 80)

| Score Range | Performance Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 93–100 | Excellent | 25 | 31.25 |
| 86–92 | Good | 52 | 65.00 |
| 80–85 | Satisfactory | 2 | 2.50 |
| <80 | Needs Improvement | 1 | 1.25 |
| Total | | 80 | 100.00 |

**Longitudinal Progression Across Cycles**

The progressive trajectory of classical learning mastery across the intervention phases highlights the developmental efficacy of the modified tug-of-war pedagogical tool. Starting from a 0.00% baseline, classical mastery advanced to 28.75% in Cycle I before reaching 98.75% in Cycle II. This linear progression confirms that combining task-based resistance games with progressive instructional refinement effectively facilitates kinesthetic learning and motor skill mastery in secondary physical education settings.

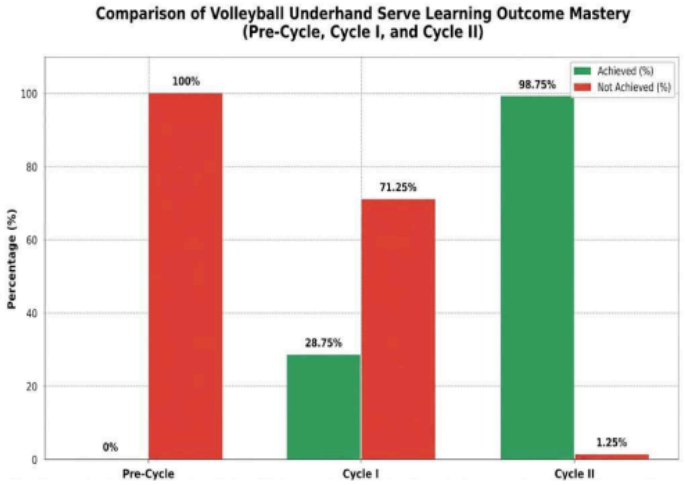


**Figure 1**. Progressive Trajectory of Classical Learning Mastery Across Intervention Cycles

## Discussion

The findings of this action research study demonstrate that integrating modified tug-of-war training as a pedagogical tool significantly improves secondary school students' performance in the volleyball underhand serve. Moving from a baseline mastery of 0.00% to 28.75% in Cycle I and ultimately reaching 98.75% in Cycle II, the intervention highlights the efficacy of game-based resistance training in overcoming persistent technical execution barriers. Rather than relying on traditional, repetitive drill-based instruction, the modified tug-of-war framework provided dynamic, task-based constraints that facilitated motor skill acquisition across psychomotor, cognitive, and affective domains.

### Kinesthetic Feedback and Task Constraints in Motor Skill Acquisition

The dramatic gain in underhand serve performance can be explained through the theoretical lens of the Constraints-Led Approach (CLA) derived from ecological dynamics (Orth et al., 2019; Pinder & Renshaw, 2019; Renshaw et al., 2016). In traditional PE settings, the underhand serve is often taught as an isolated, static technique, which deprives learners of functional environmental and task information. In this study, the modified tug-of-war activity acted as a powerful task constraint (specifically altering task mechanics and resistance). Pulling against controlled resistance forced learners to engage their lower-body kinetic chain, establish a stable base of support, and generate force through coordinated core stability and arm extension.

From a motor learning perspective, this dynamic resistance serves as an immediate, intrinsic kinesthetic feedback mechanism (Renshaw and Chow 2019). Secondary school students frequently struggle with feeling the timing of force generation and directional balance. By experiencing the directional vector forces during the tug-of-war modification, students developed an intuitive sensory understanding (*proprioceptive awareness*) of how to transfer weight from the rear foot to the front foot—a mechanical

movement directly transferable to the momentum needed for an accurate volleyball serve.

**Bridging Gross Force Application and Fine Motor Control**

A key challenge identified in Cycle I was the transition from gross muscular exertion (pulling) to fine motor accuracy (striking the ball). While Cycle I yielded initial progress (28.75% mastery), many students still exhibited restricted follow-through and unstable contact timing. According to Dynamic Systems Theory by Kelso, motor behavior emerges from self-organization among physical, environmental, and task subsystems (Kulman, 2026). When task constraints are too rigid or uncalibrated, movement patterns temporarily lose stability before reorganizing into more proficient coordination states.

To address this, Cycle II introduced differentiated task variations and individualized kinesthetic cues, optimizing the "challenge point" by Guadagnoli and Lee (Thomas et al., 2025). By adjusting resistance levels and integrating target-zone scoring, the intervention guided learners to refine their motor programs, transforming raw force generation into controlled, precise arm acceleration and follow-through trajectory. This shift explains the substantial surge to 98.75% mastery in Cycle II, proving that resistance games—when systematically scaffolded—do not disrupt motor control but rather accelerate the emergence of stable, functional movement solutions.

**Affective Engagement, Motivation, and Cognitive Comprehension**

Beyond mechanical execution, the modified tug-of-war tool produced notable shifts in student motivation and active participation. Traditional drill practices often induce cognitive overload and boredom, particularly among lower-ability learners who experience frequent failure. In contrast, embedding skill acquisition within a modified traditional game leverages the motivational benefits of Self-Determination Theory (Ryan & Deci, 2022) by fostering competence, autonomy, and relatedness through collaborative physical play (Aliriad et al., 2024).

The game-based structure transformed abstract mechanical principles (e.g., angle of release, force application, balance) into tangible, experiential tasks. Students developed a stronger cognitive grasp of *why* specific body alignments were necessary, as they could directly feel the biomechanical advantage during the tug-of-war interactions. Consequently, heightened affective engagement directly reinforced psychomotor persistence, creating a positive feedback loop that sustained high-level practice behaviors throughout both intervention cycles.

**Implications for Secondary Physical Education Practice**

These results offer important practical implications for physical education pedagogy. First, they demonstrate that modified traditional games are not merely recreational filler activities, but highly functional pedagogical tools capable of targeted biomechanical and skill development. Second, physical education practitioners can implement low-cost, scalable resistance tasks—such as modified ropes or resistance bands—to teach

complex team sport skills in resource-constrained secondary school environments without sacrificing instructional rigor or empirical efficacy.

## 4. CONCLUSION

This action research study demonstrates that modified tug-of-war training serves as an effective, scalable pedagogical tool for enhancing volleyball underhand serve proficiency among secondary school students. By integrating controlled resistance-based games into a progressive instructional design, the intervention successfully bridged the gap between gross force generation and fine motor skill accuracy. The longitudinal progression—advancing from a baseline classical mastery of 0.00% to 28.75% in Cycle I and culminating in 98.75% in Cycle II ($M = 90.72$)—confirms that task-based game modifications accelerate motor skill acquisition, deepen cognitive comprehension, and foster sustained affective engagement far more effectively than traditional, repetitive drill instruction.

From a pedagogical perspective, these findings demonstrate that physical education practitioners can strategically deploy modified resistance games as functional task constraints that provide immediate proprioceptive feedback, enabling learners to naturally experience weight transfer, core stabilization, and momentum release rather than relying solely on abstract verbal cues. Reimagining culturally familiar traditional games beyond recreational warm-ups allows educators to align game-based mechanics with explicit biomechanical objectives, thereby simultaneously enhancing student intrinsic motivation and technical motor competence. Furthermore, the successful integration of modified tug-of-war highlights a low-cost, high-impact instructional framework that enables secondary schools operating in resource-constrained environments to deliver rigorous, evidence-based physical education without requiring expensive equipment.

Although this action research framework confirms immediate skill acquisition, the study is constrained by a single-site sample ($N = 80$) and the absence of a delayed retention test to evaluate long-term motor skill permanence. To build upon these preliminary insights, future scholarship should adopt quasi-experimental or randomized controlled trial (RCT) designs across diverse demographic cohorts, incorporate objective biomechanical motion analysis—such as 3D kinematic tracking of arm swing velocity and impact angles—and systematically measure skill retention and transferability to dynamic game contexts over extended post-intervention periods.

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