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Development and Validation of an Adaptive Game-Based Underhand Passing Training Model Integrated with Video Feedback for ³⁵ Youth Volleyball Athletes Aged 13–15 Years

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Abstract

Study purpose. This study aimed to: ⁴ develop an effective underhand passing training model for volleyball athletes aged 13-15 years, ² test the feasibility of the model, and ³ measure its effectiveness in improving underhand passing skills.

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Material and methods. This study used the Research and Development (R&D) method from Borg & Gall, involving 30 male athletes (13-15 years) from five clubs in Ponorogo. The development stages included needs analysis, product design, expert validation, small-scale trials (n=10), and large-scale trials (n=30). Data were collected through observation, questionnaires, and passing skill tests. The small-scale trial (n=10) showed an increase in the mean passing score from 66.8 to 75.9, indicating preliminary effectiveness of the developed model. Effectiveness was analyzed using paired-sample t-test and N-Gain.

Results. The final model integrated basic training with small-team play (2v2, 3v3) and passing-to-setup transitions. Expert validation obtained a score of 85% (feasible). The large-scale trial showed a significant improvement in passing skills (mean pre-test=67.4, post-test=79.2, $p<0.001$). The N-Gain score was 0.36 (moderate category).

Conclusion. The developed underhand passing model is feasible and effective in improving the underhand passing skills of volleyball athletes aged 13-15 years.

Keywords: Underhand Passing, Training Model, R&D, Volleyball, ¹ Young Athletes.

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Introduction

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Exercise is a vital aspect of human ¹⁰ life, providing not only physical benefits but also positive psychological and social impacts. The World Health Organization states that regular physical activity can help reduce the risk of various non-communicable diseases such as ²⁴ obesity, diabetes, and cardiovascular disorders (Maayan et al., 2022). Furthermore, sports also

play a vital role in improving the quality of life through the development of social skills, discipline, responsibility, and teamwork (Biddle & Mutrie, 2008; Lubans et al., 2016). Therefore, various countries, including Indonesia, continue to encourage increased public participation in sports activities to support the creation of a healthy, active, and productive generation. One sport that is growing rapidly in society is volleyball because it is easy to play, competitive, and able to foster teamwork among players (Lualhati, 2025; Lubis et al., 2025).

Volleyball ranks fourth in popularity with over 900 million fans (FIVB, 2023). In Indonesia, this sport is growing rapidly, with the Indonesian Volleyball Association (PBVSI) reporting a consistent increase in the number of athletes and clubs each year (PBVSI, 2022). In volleyball, basic techniques play a crucial role in determining a team's success. Basic techniques that every student must master include serving, passing, smashing, and blocking (Hudain et al., 2023).

Passing is a fundamental technique that is key to developing an effective game strategy. One of the most frequently used forms of passing is the underhand pass, which is used to receive the ball from the opponent and direct the ball to the setter to build an attack (Anderson et al., 2021; Febrio et al., 2025; Mardi et al., 2025). The underhand pass is one of the fundamental techniques in volleyball that plays a vital role in building attacks and maintaining a stable game rhythm (Anderson et al., 2021). A team's ability to maintain the flow of play is greatly influenced by the quality of the players' underhand passes, especially when facing fast-paced and dynamic match situations. However, a common problem found in youth volleyball clubs is the students' low underhand passing ability.

Studies in Indonesia indicate that underhand passing skills among young athletes are often suboptimal. Research by Aprianto et al (2025) found that a significant percentage of high school students' underhand passing skills ranged from "poor" to "fair." Many athletes aged 13-15 struggle with unstable body positioning, inaccurate ball contact, and poor hand-foot coordination. Coaches confirmed that many points are lost during internal matches due to these passing errors.

Based on observations of several volleyball clubs in Ponorogo Regency, it was found that many students are not yet able to execute underhand passes optimally. Common errors include poor body positioning, inaccurate ball contact, and suboptimal hand-foot coordination when executing underhand passes (Richard A. Schmidt & Lee, 2014; Schmidt & Wrisberg, 2008). This condition reduces the effectiveness of team play and often results in lost points in matches.

One of the main causes of low underhand passing skills is the lack of a structured and scientifically based training model (Camacho-Sánchez et al., 2023). Many clubs still employ conventional, repetitive methods that are not tailored to the specific needs of young athletes (Cheryl A. Coker, 2018). The 13-15 age range is a critical period known as the "Golden Age of Learning," during which motor skills develop optimally (I. Balyi et al., 2013; Norris, 2010). If proper technique is not instilled during this phase, it will be difficult to correct bad habits later in life. Furthermore, the rapid physical growth during this period requires a training model that considers biomechanics to prevent injury and ensure efficiency (Hirtz & Starosta, 2002). Some common errors in underhand passing include: (1) unstable body position; (2) inaccurate ball contact; (3) lack of hand-eye coordination, which occurs when students are unable to anticipate the direction of the ball properly, resulting in a delay in responding to incoming balls. Poor hand-eye coordination is often caused by a lack of reflex training and situational awareness in the game; and (4) errors in passing direction and speed (Gil-Arias et al., 2015; López-Ferrer et al., 2022; Taei et al., 2024).

Existing passing training models are generally repetitive, technique-oriented, and rarely integrate game-based learning through small-sided games. Consequently, athletes often experience limited ball contacts and low decision-making opportunities during training. few studies have developed and validated a structured game-based underhand passing model

specifically designed for athletes aged 13–15 years. Therefore, the present study addresses this gap by integrating technical drills with small-sided games and transition activities. Therefore, a structured game-based underhand passing model is needed.

Therefore, this study aims to address this gap by developing an innovative underhand passing model. This model is designed to be more systematic, varied, and game-based, integrating small-team games (2v2 and 3v3) to improve ball contact, enhance decision-making, and enhance tactical understanding. This study specifically aims to: 1) develop an effective underhand passing training model for athletes aged 13-15 years, 2) test the feasibility of the developed model, and 3) measure its effectiveness in improving underhand passing skills.

Method

This study employed a Research and Development (R&D) method, following the simple seven-step model by Borg et al (2007) which is suitable for creating and validating educational or training products. The stages are: 1) preliminary study (needs analysis), 2) planning, 3) initial draft development, 4) expert validation and revision, 5) small-scale product trial, 6) large-scale product trial, and 7) effectiveness testing. This study was conducted at five volleyball clubs in Ponorogo Regency: Young Star, Tunas Harapan, Kusuma Bhirawa, Ganesha, and Delta. The study time was adjusted to the clubs' regular training schedules. The population consisted of 88 male athletes aged 13-15 from these clubs. Using a purposive sampling method, 30 athletes were selected for the large-scale trial based on the following criteria: age 13-15, male, active training, and willingness to participate. A separate sample of 10 athletes from the Young Star club was used for the small-scale trial.

The independent variable was the developed underhand passing training model, and the dependent variable was the improvement of underhand passing skills. Skills were measured using a validated passing test focusing on accuracy, consistency, and ball control. Data collection techniques included: 1) observation of initial training sessions, 2) a questionnaire for needs analysis and athlete responses using a Likert scale, and 3) a pre-test and post-test underhand passing skills test.

The product development process began with a needs analysis through observation and coach interviews. An initial draft model was designed based on this analysis and motor learning theory, integrating fundamental drills with 2v2 and 3v3 game situations and transitions such as passing to setup. The draft was validated by three experts: a volleyball subject matter expert, a coaching expert, and a methodology expert. After validation, the model was revised and tested in a small-scale trial (4 sessions, 10 athletes). Following the second evaluation and revision, a large-scale trial (6 sessions, 30 athletes) was conducted. To test its effectiveness, a single-group pre-test, post-test design was used. All athletes in the large-scale trial underwent pre-testing, intervention (model development), and post-testing. Data were analyzed using descriptive statistics, paired-sample t-tests to compare pre-test and post-test scores, and N-Gain analysis to determine effectiveness categories. All statistical tests were performed at a significance level of $p < 0.05$.

Results

A needs analysis of a questionnaire conducted with 10 coaches revealed the following common technical errors among athletes: 1) unstable body position (60-72% of athletes observed), 2) uncontrolled ball direction, 3) insufficient arm position, resulting in suboptimal ball contact, 4) inconsistent arm angle, resulting in poor ball control, 5) unsynchronized footwork and body coordination, 6) inadequate transition readiness, and 7) incomplete integration of passing into simple game patterns.

Based on the high number of errors mentioned above, there was a strong demand for a new underhand passing training model, with an average score of 85.6% (highly needed). The product developed is a structured underhand passing model for ages 13-15, consisting of:

- Basic Drills: Pair passes, wall passes, and movement drills.
- Miniature Games: 2v2 (focusing on control and accuracy) and 3v3 (focusing on transitions and teamwork).

The 2v2 training variations are as follows: 1) Backward rotation, 2) Forward rotation, 3) Two-ball drill, 4) Rolling defense drill, 5) Two-team game, 6) Sideways road. The 3v3 training variations are as follows: 1) Zig-zag, 2) Over-jump, 3) Forward sprint, 4) Sideways sprint, 5) Kun rotation, 6) Side high lift.

- Transition Drills: Integrating passing with positioning, defense, and transition movements.
- The final product is a guidebook and a video guide..

Expert validation by three judges: Volleyball Material Expert, Coaching Expert, and Methodology Expert. The validation results yielded an average score of 85%, categorized as "adequate" to "very adequate." Revisions based on expert input included adjusting the training duration and refining instructions for small-team play.

The small-scale trial (n=10) showed an increase in the average passing score from 66.8 (pre-test) to 75.9 (post-test), a 9.1-point increase. Athletes' and coaches' responses were positive. Athletes felt the training was more varied compared to regular training, with more active movement and more opportunities to touch the ball. Coaches found the training model relatively easy to implement and more focused. The feedback led to Revision I, which focused on reducing training duration and simplifying game rules. The results of the large-scale trial (n=30) are summarized in Tables 1, 2, and 3.

Table 1. Pre-test and Post-test Descriptive Statistics for Large-Scale Trials (n=30)

Statistics	Pretest	Posttest
Mean	67,40	79,20
Median	67,00	79,00
Standard Deviation	1.56	2.05
Minimum	65	75
Maximum	70	83

The average score increased by 11.8 points. This increase was higher than the small-scale stage, indicating that after the revision, the model became more effective and stable in its application. A paired-sample t-test was used to determine whether this difference was significant. The assumption of normality was met (Shapiro-Wilk test, $p > 0.05$).

The paired-sample t-test indicated a statistically significant difference between pre-test and post-test scores ($p < 0.001$), confirming that the intervention contributed positively to the improvement of underhand passing performance. The mean improvement of 11.8 points demonstrates a substantial increase in skill acquisition following implementation of the developed training model.

Table 2. Paired sample t-test results

Berarti	Deviasi Standar	t	df	Sig. (2 ekor)
Pre- and Post-tests and tests	11.80	0,98	65,56	29

The analysis showed a significant difference between the pre-test and post-test scores ($p < 0.001$). Next, the N-Gain score was calculated to assess the level of effectiveness..

Table 3. Interpretasi Skor N-Gain

Skor N-Gain	Category
0,36	Medium

The athlete response questionnaire after the large-scale trial gave a score of 84%, indicating “Good” to “Excellent” acceptance of the model. In addition to statistical significance, practical significance should also be considered. The observed improvement suggests that the training model produced meaningful changes in athlete performance.

Discussion

The development process successfully produced a feasible and effective training model. The training model consists of six variations of 2v2 drills and six variations of 3v3 drills. The 2v2 underhand passing drill in volleyball is an effective method for improving the fundamental skills of students aged 13-15. By providing more touches of the ball in small-sided games, this model helps students develop underhand passing techniques more systematically and adaptively. This drill can also improve tactical understanding and team communication, which are crucial elements of volleyball.

The improvement observed in this study can be explained through motor learning theory, which suggests that skill acquisition is enhanced when athletes are exposed to meaningful, repetitive, and context-specific practice situations. The use of small-sided games increased the frequency of ball contacts, decision-making opportunities, and athlete engagement. As a result, athletes were able to develop technical proficiency while simultaneously improving perceptual and tactical skills.

The 3v3 underhand passing drill in volleyball can improve the accuracy of underhand passing in volleyball games. For example, in pass control drills, students must precisely direct underhand passes to the setter or designated target. In defense under pressure drills, students are trained to maintain underhand passes under pressure from opponents who are trying to return the ball faster. In transition drills, students must quickly switch from defense to attack while prioritizing accurate underhand passing.

The high demand from coaches for developing underhand passing technique (85.6%) reflects the gap between conventional training methods and the need for more engaging and game-based approaches, as highlighted by (C. A. Coker, 2017). The feasibility of the model (expert validation 85%) confirms that its structure, based on motor learning and biomechanical principles (Schmidt & Wrisberg, 2008; García-de-Alcaraz et al., 2020), is suitable for the 13-15 age group, taking into account their physiological and psychological characteristics (Istvan. Balyi et al., 2015; Weiss & Williams, 2004).

A significant improvement in passing skills ($p < 0.001$) and a "moderate" N-Gain score (0.36) demonstrated the model's effectiveness. During the training, athletes' engagement was also more evenly distributed, the intensity of ball touches increased, communication between players in small-sided games began to develop, and athletes became more responsive in transitioning after passes (Rumpf et al., 2025). Fundamental training to improve underhand passing should also encompass basic technique, body coordination, and adaptation to real-life game conditions (Liu et al., 2026). A combination of technical drills such as the Wall Pass and Partner Pass, along with small-sided game-based drills like 2v2 and 3v3, can provide optimal results for volleyball students in improving their underhand passing skills.

Small-sided games such as 2v2 and 3v3 provide a learning environment that closely resembles competitive situations while maintaining a manageable level of complexity for young athletes. Because fewer players participate in each game, athletes experience more active involvement, increased ball possession, and more opportunities to execute passing actions. This

condition facilitates accelerated learning and promotes greater confidence in performing volleyball skills under pressure.

These skill improvements indicate that the training model impacts not only technical aspects but also simple game aspects. This aligns with the principles of specificity and progressive overload (Bompa & Haff, 2019). The integration of small-team games (2v2, 3v3) likely increases the number of touches of the ball, forces quicker decision-making, and improves contextual understanding of passing, making the training easier to apply to real-life game situations (García-de-Alcaraz et al., 2022; Marzano-Felisatti et al., 2024). The inclusion of transition drills (passing to passing) also increases tactical relevance, surpassing isolated technique drills (Anderson et al., 2021).

The higher improvement in the large-scale trial (11.8 points) compared to the small-scale trial (9.1 points) indicates that Revision I, which refined the training structure and intensity, successfully optimized the model. Positive athlete responses (84%) indicate that the varied, game-like format increases motivation, a key factor in maintaining training adherence and maximizing learning for this age group (Weinberg & Gould, 2020). The developed training regimen is tailored to the athletes' age and developmental level to enhance learning effectiveness and prevent training boredom (Navaja & Cancio, 2024). Therefore, coaches must tailor training loads to the individual needs of their students to optimize their progress without increasing the risk of injury (Jayanthi et al., 2022).

In conclusion, these findings support that a structured, game-based model is more effective than conventional repetitive training for improving underhand passing skills in young volleyball athletes.

The integration of technical drills and game-based activities appears to provide a balanced learning environment that promotes both technical mastery and tactical understanding. Therefore, the developed model may serve as an alternative training approach for coaches seeking to improve underhand passing performance among youth volleyball athletes while maintaining athlete motivation and engagement during training sessions.

Conclusion

Based on the results, it can be concluded that a structured underhand passing training model that integrates basic exercises with 2v2 and 3v3 small-sided games and transition movements was successfully developed for athletes aged 13-15 years. The developed model was declared feasible to use and received positive feedback from coaches and athletes. The model was effective in significantly improving the underhand passing skills of volleyball athletes aged 13-15 years. The results of this study are expected to encourage coaches to implement this model gradually according to the athlete's ability, and conduct regular evaluations. Clubs need to provide supporting facilities and conduct training for coaches for optimal implementation. Implementation is carried out through socialization of the model through coach workshops, the development of practical guidebooks, long-term trials (3-6 months), the development of further variations, and the dissemination of research results to other clubs in Ponorogo and the surrounding area. With these steps, this model can make a significant contribution to improving the performance of youth volleyball players.

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1 Conflict of Interest

The author declares that there is no conflict of interest in the conduct of the research and preparation of this thesis. There are no affiliations, financial involvement, or personal or professional interests that could influence the objectivity and results of the research. All research funding came from the author's personal sources without the involvement of external sponsors that could potentially cause bias. The author also ensures that no party has a special interest in the research results, so that every process and findings are presented transparently and can be scientifically accounted for.

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