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EFFECTIVENESS OF A 15-MODEL PLYOMETRIC TRAINING PROGRAM FOR ELITE VOLLEYBALL ATHLETES IN SHANDONG PROVINCE: A RESEARCH AND DEVELOPMENT STUDY

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ABSTRACT

Plyometric training is widely used to improve volleyball-specific explosive actions (spike and block jumps), yet many programs remain generic and lack structured exercise classification, progressive sequencing, and feasibility evidence for elite training contexts. This study employed a Research and Development (R&D) framework based on Borg and Gall, including needs analysis, theoretical synthesis, initial model design, expert validation, small-group trials, large-group trials, and final effectiveness testing using a quasi-experimental nonequivalent control group design. The purpose of this study is to develop a structured 15-model plyometric training program tailored to elite volleyball athletes in Shandong Province and to test its effectiveness compared with conventional training. The results show that three experts validated the model for content relevance and feasibility. Effectiveness testing involved 70 elite athletes (35 experimental; 35 control). After 16 sessions, the experimental group improved from 28.74 ± 4.51 to 35.11 ± 4.46, while the control group improved from 29.06 ± 4.57 to 32.37 ± 4.45. Posttest differences were significant (t = 3.065; p = 0.003). N-gain analysis indicated effective improvement in the experimental group (mean 78.24%) versus less effective improvement in the control group (mean 43.24%). The developed 15-model plyometric program is feasible and more effective than conventional training in improving volleyball-related plyometric outcomes in elite athletes.

KEYWORDS: Plyometric Training; Volleyball; Explosive Power; Training Model; Elite Athletes.

1. INTRODUCTION

Volleyball is characterized by frequent high-intensity actions such as approach jumps, blocking, and repeated landing tasks. These actions place a premium on lower-limb explosive power and the efficient use of the stretch–shortening cycle, while also exposing athletes to substantial mechanical loads during take-off and landing. Plyometric jump training (PJT) is widely used to enhance jump-related performance in volleyball. Evidence syntheses focused on volleyball players report meaningful improvements in vertical jump height following PJT, although effect magnitude can vary with program design (e.g., exercise selection, intensity, and weekly dose) (Ramírez-Campillo & others, 2020). Complementary evidence indicates that PJT can also promote favorable neuromuscular and myotendinous adaptations that underpin explosive performance (Ramírez-delaCruz et al., 2022). Broader evidence mapping and umbrella-level summaries further emphasize that methodological quality, the presence of control groups, and well-described prescription variables are crucial for translating findings into coach-friendly programs (Ramírez-Campillo & others, 2020) (Kons et al., 2023)(Barrio et al., 2023).

Recent original studies provide practical insights into key programming variables for volleyball populations. Training surface is one such variable: interventions on sand or rigid floors may lead to different biomechanical and fitness adaptations (Ahmadi et al., 2021), and recent comparative work has also explored how varying surfaces influence training effects on jumping outcomes and related mechanics (Yu et al., 2025). Related evidence syntheses also summarize dose–response relationships of sand training compared with other surfaces for jump and change-of-direction outcomes (Zhang & others, 2025). In parallel, frequency and dose considerations remain relevant for youth volleyball athletes, with controlled interventions testing how weekly PJT frequency influences physical fitness responses (Hernández-Martínez & others, 2023).

Exercise modality and individualization are additional considerations. Drop-jump training that individualizes drop height using maximal rebound height has been proposed as a practical method to tailor plyometric stimulus in trained youth volleyball players (Hammami & others, 2024). In addition, related team-sport evidence suggests that vertical-, horizontal-, and combined-direction plyometric programs can produce distinct speed–power adaptations (Moran et al., 2024). Horizontal- or mixed-direction plyometrics may also complement vertical jumping demands by targeting stiffness and hopping capacities, with recent work reporting improvements in unilateral leg stiffness after horizontal plyometric training in post-peak-height-velocity female volleyball players (Sylvester & others, 2024). Supporting analyses highlight the relevance of reactive strength characteristics for approach-jump performance assessment and training monitoring (Pleša & others, 2022), and acute potentiation strategies based on drop jumps have also been discussed as a practical tool in volleyball warm-up and performance contexts (Krzysztofik et al., 2021).

Beyond traditional PJT, volleyball research has examined combined or adjunct approaches, such as complex training configurations (Rong & Xiu, 2024) and comparisons between different jump programs (e.g., PJT versus Air Alert) (Valunpion & Rangubhet, 2025). At the same time, growing attention is directed toward landing technique and injury-relevant mechanics in volleyball players (Ruan & others, 2022) (Kim et al., 2025). From an applied perspective, coaches increasingly require clear guidance on progression rules (e.g., ground contacts, intensity, and recovery), monitoring indicators such as reactive strength measures, and integration of PJT within weekly volleyball microcycles to balance performance gains with fatigue and injury risk. Recent umbrella and evidence-mapping work highlights that insufficient reporting of prescription variables (e.g., volume, intensity, and exercise classification) can limit reproducibility and practical adoption, reinforcing the need for structured, coach-friendly models (Kons et al., 2023)(Barrio et al., 2023). In addition, measurement-informed approaches—linking reactive strength characteristics to approach-jump performance—support the use of standardized monitoring to individualize training and evaluate transfer (Pleša & others, 2022).

In view of the expanding evidence base—including recent meta-analyses in adolescents and female team-sport athletes (Ramírez-Campillo & others, 2023)(Chen et al., 2023)(Lin & others, 2025) there remains a practical need to integrate current findings into a structured, periodized PJT model that is feasible within team training environments. Therefore, the present study aimed to develop and evaluate an integrated plyometric training model to improve vertical jump performance and related movement control outcomes in competitive volleyball players.

2. MATERIALS AND METHODS

2.1 Research design

This study used a Research and Development procedure following Borg and Gall stages: needs analysis, literature synthesis, initial model design, expert validation, revision, limited field implementation (small group), broader field implementation (large group), and final effectiveness evaluation. The effectiveness phase applied a quasi-experimental nonequivalent control group design (pretest-posttest).

2.2 Participants

Effectiveness testing involved 70 elite athletes selected by cluster sampling: 35 in the experimental group and 35 in the control group. Athletes were drawn from the Shandong Volleyball Elite 2 training context. Research permission was obtained prior to implementation.

2.3 Program development

The intervention consisted of a structured 15-model plyometric program organized by movement objective and direction (e.g., vertical, unilateral, lateral, reactive), emphasizing technique, landing control, and progressive load management aligned with volleyball demands.

2.4 Expert validation and field trials

Expert judgment evaluated relevance, clarity, and feasibility. Small-group and large-group trials were conducted to identify implementation issues and guide revisions before the effectiveness test.

2.5 Instrument validity and reliability

Instrument testing showed a validity coefficient of 0.94 (very high) and a reliability coefficient r = 0.90 (very high) based on repeated testing.

2.6 Procedure

All athletes completed pretesting, followed by 16 training sessions. The experimental group implemented the new plyometric model, while the control group followed conventional training. Posttesting used the same instruments.

2.7 Data analysis

Normality and homogeneity assumptions were checked prior to hypothesis testing. Posttest group differences were analyzed using an independent samples t-test. Training effectiveness magnitude was also interpreted using N-gain categories.

3. RESULTS

3.1 Descriptive statistics

After 16 sessions, the experimental group improved from 28.74 ± 4.51 to 35.11 ± 4.46, while the control group improved from 29.06 ± 4.57 to 32.37 ± 4.45.

Table 1. Pretest and Posttest descriptive statistics

Group	n	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Change
Experimental	35	28.74 ± 4.51	35.11 ± 4.46	+6.37
Control	35	29.06 ± 4.57	32.37 ± 4.45	+3.31

3.2 Assumption checks

Normality testing indicated p-values > 0.05 for both groups, supporting normal distribution. Homogeneity testing supported equal variances.

3.3 Between-group effectiveness (posttest)

Posttest outcomes differed significantly between groups (t = 3.065; df = 68; p = 0.003), favoring the experimental group.

Table 2. Independent samples t-test (posttest)

Statistic	Value	df	p
t	3.065	68	0.003

3.4 N-gain effectiveness

The experimental group reached an effective category (mean N-gain 78.24%), while the control group was less effective (mean N-gain 43.24%).

4. DISCUSSION

This study developed and validated a structured 15-model plyometric program and demonstrated superior effectiveness compared with conventional training. The significant posttest difference (p = 0.003) and higher N-gain in the experimental group indicate that a more systematic exercise classification and progression can produce meaningful improvements in plyometric-related performance in elite volleyball athletes, consistent with evidence that well-designed plyometric jump training improves volleyball-relevant jump outcomes (Ramírez-Campillo & others, 2020)(Ramírez-Campillo & others, 2021). When compared with the broader literature, the observed improvement aligns with umbrella evidence showing that plyometric training reliably enhances jumping and related power outputs across athletic populations (Kons et al., 2023). Importantly, recent work emphasizes that program effectiveness depends on exercise selection, direction of force (vertical vs horizontal), and progression strategy (Moran et al., 2024)(Barrio et al., 2023). The present 15-model structure likely improved training fidelity by providing clear exercise groupings and a practical pathway for progression rather than relying on a narrow drill set. Volleyball-specific transfer may be explained by the inclusion of exercises that target reactive strength and approach-jump qualities. Reactive strength index is associated with approach-jump performance in volleyball players (Pleša & others, 2022), and training designs that combine plyometric elements with appropriate strength/complex configurations can further support jump performance adaptations (Rong & Xiu, 2024). Therefore, organizing the program into multiple models may have increased the likelihood that athletes trained complementary jump qualities (reactive, unilateral, and multidirectional components) relevant to match demands.

Physiologically, plyometric improvements are typically attributed to enhanced stretch-shortening cycle efficiency, neuromuscular activation patterns, and changes in muscle-tendon stiffness and coordination. Beyond performance, recent studies highlight that structured plyometric programs can improve landing biomechanics and movement control, which may support safer high-frequency jumping exposure in volleyball (Ruan & others, 2022)(Kim et al., 2025). Horizontal-oriented drills can also influence unilateral stiffness characteristics, potentially benefiting court movement and approach mechanics (Sylvester & others, 2024).

Training surface is another important moderator for both performance response and mechanical loading. Studies comparing sand versus rigid surfaces suggest that surface selection can influence jump-related adaptations and acute potentiation response. More recent evidence in volleyball indicates that surface type may shape the magnitude of plyometric effects and dose-response relationships. Although surface was not manipulated in the current effectiveness test, the model can be adapted by periodizing surface exposure to balance overload and recovery, especially in congested competition phases.

From a coaching perspective, the main practical value of the developed model is its usability: coaches can select exercises by category, progress from lower to higher intensity, and maintain technical cues for take-off and landing. This approach is consistent with recent recommendations to individualize plyometric prescriptions (e.g., drop-jump parameters) and manage training frequency to optimize adaptation while minimizing fatigue. In addition, evidence suggests that combining vertical and horizontal plyometrics can broaden performance transfer, which supports the multi-model structure used in this program. Several limitations should be acknowledged. First, the quasi-experimental design and single regional setting may limit generalizability. Second, the outcomes focused on a primary plyometric-related performance measure; additional sport-specific outcomes (approach jump, block jump, sprint, change of direction) and biomechanical or neuromuscular markers would strengthen inference. Third, the intervention duration captured short-term adaptations; future studies should include follow-up testing and injury surveillance to evaluate retention and safety. Future research should test the model using randomized designs, compare different surface periodization strategies, and examine dose-response relationships and sex/age subgroups to refine prescriptions.

5. CONCLUSIONS

A 15-model plyometric training program for elite volleyball athletes in Shandong Province was successfully developed using an R&D framework and validated by experts. Effectiveness testing showed significantly greater improvements than conventional training after 16 sessions. Coaches may adopt the program as a structured reference emphasizing technique, landing control, and progressive overload.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Ahmadi, H., Shirvani, H., Parsian, H., & others. (2021). Effects of plyometric training on sand versus rigid surface on jump-related performances and physical fitness in young male volleyball players. *International Journal of Environmental Research and Public Health*, *18*(24), 13093. https://doi.org/10.3390/ijerph182413093

Barrio, E. D., Thapa, R. K., Villanueva-Flores, F., Garcia-Atutxa, I., Santibãnez-Gutierrez, A., Fernández-Landa, J., & Ramírez-Campillo, R. (2023). Plyometric Jump Training Exercise Optimization for Maximizing Human Performance: A Systematic Scoping Review and Identification of Gaps in the Existing Literature. *Sports*, *11*(8), 150. https://doi.org/10.3390/sports11080150

Chen, L., Zhang, Z., Huang, Z., Yang, Q., Gao, C., Ji, H., Sun, J., & Li, D. (2023). Meta-Analysis of the Effects of Plyometric Training on Lower Limb Explosive Strength in Adolescent Athletes. *International Journal of Environmental Research and Public Health*, *20*(3), 1849. https://doi.org/10.3390/ijerph20031849

Hammami, R., & others. (2024). Effect of individualized drop jump training using maximal rebound height versus standard drop jump training on physical fitness in elite youth volleyball players. *Sports*, *12*(12), 336. https://doi.org/10.3390/sports12120336

Hernández-Martínez, C., & others. (2023). Plyometric jump training frequency and physical fitness responses in youth male volleyball players: A randomized controlled trial. *Frontiers in Physiology*, *14*, 1270512. https://doi.org/10.3389/fphys.2023.1270512

Kim, J., Tamminen, K. A., & Cai, R. (2025). Social norms and emotion regulation among youth athletes. *International Journal of Sport and Exercise Psychology*. https://doi.org/10.1080/1612197X.2025.2493690

Kons, R. L., Orssatto, L. B. R., Ache-Dias, J., De Pauw, K., Meeusen, R., Trajano, G. S., & others. (2023). Effects of plyometric training on physical performance: An umbrella review. *Sports Medicine - Open*, *9*(1), 4. https://doi.org/10.1186/s40798-022-00550-8

Krzysztofik, M., Wilk, M., Stastny, P., & Golas, A. (2021). Post-activation performance enhancement induced by drop jumps performed on sand or rigid surface in volleyball players. *Applied Sciences*, *11*(11).

Lin, G., & others. (2025). Effects of plyometric training on performance in female team-sport athletes: A systematic review and meta-analysis. *Frontiers in Physiology*, *16*, 1639477. https://doi.org/10.3389/fphys.2025.1639477

Moran, J., Vali, N., Sand, A., Beato, M., Hammami, R., Ramírez-Campillo, R., & Chaabene, H. (2024). Effect of vertical, horizontal, and combined plyometric training on jump, sprint and change of direction performance in male soccer players. *PLOS ONE*, *19*, e0295786. https://doi.org/10.1371/journal.pone.0295786

Pleša, J., & others. (2022). The relationship between reactive strength index and approach jump performance in male volleyball players. *PLOS ONE*, *17*(3), e0264144. https://doi.org/10.1371/journal.pone.0264144

Ramírez-Campillo, R., & others. (2020). Effects of plyometric jump training on vertical jump height of volleyball players: A systematic review with meta-analysis of randomized-controlled trials. *Journal of Sports Science \& Medicine*, *19*, 489–499.

Ramírez-Campillo, R., & others. (2021). Effects of plyometric jump training on physical fitness in amateur and professional volleyball: A meta-analysis. *Frontiers in Physiology*, *12*, 636140. https://doi.org/10.3389/fphys.2021.636140

Ramírez-Campillo, R., & others. (2023). Effects of plyometric jump training on physical fitness in children and adolescents: A systematic review and meta-analysis. *Sports Medicine - Open*, *9*(1). https://doi.org/10.1186/s40798-023-00568-6

Ramírez-delaCruz, M., Bravo-Sánchez, A., Esteban-García, P., Jiménez, F., & Abián-Vicén, J. (2022). Effects of plyometric training on lower body muscle architecture, tendon structure, stiffness and physical performance: A systematic review and meta-analysis. *Sports Medicine - Open*, *8*(1), 40. https://doi.org/10.1186/s40798-022-00431-0

Rong, D., & Xiu, F. (2024). Complex training set configuration effects on jump performance in young male volleyball players. *Journal of Sports Science \& Medicine*, *23*, 822. https://doi.org/10.52082/jssm.2024.822

Ruan, M., & others. (2022). Improvements in landing biomechanics after a plyometric training program in women's volleyball players. *Isokinetics and Exercise Science*, *30*, 1–10. https://doi.org/10.3233/IES-210149

Sylvester, K. V, & others. (2024). Horizontal plyometric training improves unilateral leg stiffness in post-peak height velocity female volleyball players. *Frontiers in Physiology*, *15*, 1346624. https://doi.org/10.3389/fphys.2024.1346624

Valunpion, P., & Rangubhet, K. (2025). Comparative effects of plyometric training and Air Alert training on jumping performance and movement control in volleyball players. *Frontiers in Sports and Active Living*, *7*, 1735291. https://doi.org/10.3389/fspor.2025.1735291

Yu, L., Chen, L., & Guo, H. (2025). The influence of training surface on the effectiveness of plyometric training on physical fitness attributes of volleyball players. *Scientific Reports*, *15*, 1073. https://doi.org/10.1038/s41598-024-84243-0

Zhang, H., & others. (2025). Dose-response relationships of sand training compared to other surfaces on change-of-direction and jump performance: A systematic review and meta-analysis. *Frontiers in Physiology*, *16*, 1737074. https://doi.org/10.3389/fphys.2025.1737074