



Improvement of Volleyball Vertical Jump through Box Jump and Depth Jump Plyometric Training

Reza Eko Ivanto¹, Ujang Rohman², Achmad Nuryadi³

Master of Physical Education Study Program, Faculty of Teacher Training and Education, University PGRI Adi Buana Surabaya, Indonesia.

E-mail: rezaekoivanto1604@gmail.com

ABSTRACT

Vertical jump performance is a critical physical component in volleyball, directly supporting functional movements such as spiking, blocking, and jump serving. However, empirical evidence regarding the specific combination of concentric-focused box jump and high-impact reactive depth jumps in sub-elite male volleyball athletes remains limited. This study aimed to examine changes in vertical jump height following a 12-week combined box jump and depth jump plyometric training program in male volleyball athletes. A pre-experimental design using a one-group pretest-posttest approach was conducted. Fourteen male volleyball athletes (19 years) from PBV Jaladewa were recruited via total sampling. Inclusion criteria required active club membership, $\geq 80\%$ attendance, and no lower limb injuries in the preceding 6 months. The intervention lasted 12 weeks with two sessions per week. Vertical jump height was evaluated using a standardized vertical jump reach apparatus before and after the intervention. Data were analyzed using the Wilcoxon Signed Rank Test, Cohen's d effect size. Vertical jump height increased significantly from 52.36 ± 7.53 cm at baseline to 55.36 ± 8.63 cm ($p=0.001$), representing a mean improvement of 3.00 cm (5.73%) with a moderate effect size ($d=0.37$; $dz=0.90$). A 12 week combined box jump and depth jump training program significantly enhance vertical jump capacity in male volleyball athletes.

Keywords: *box jump, depth jump, plyometric training, vertical jump performance, volleyball athletes*



This is an open-access article distributed under the Creative Commons Attribution-ShareAlike 4.0 International License. ©2021 by the author

INTRODUCTION

Volleyball is an intermittent, high-intensity team sport requiring athletes to repeatedly perform explosive lower limb movements, such as blocking, spiking, and jump serving (Bedo et al., 2021; Fathi et al., 2021). Because success in these tactical actions relies heavily on reach height and jump height above the net, vertical jump capability serves as a vital physical performance metric in competitive volleyball (Valunpion & Rangubhet, 2025). Enhanced vertical jumping performance allows players to optimize offensive contact angles during spikes and extend defensive

coverage during net blocks (Li et al., 2025; Trajkovic et al., 2022). Plyometric jump training (PJT) is a well-established conditioning modality utilized to enhance explosive jumping capacity (Grgic et al., 2021). The primary mechanism underlying PJT involves the stretch-shortening cycle (SSC), where in an eccentric muscle lengthening is rapidly followed by a powerful concentric muscle contraction (Van Hooren et al., 2022). This rapid movement sequence optimizes elastic energy recoil and neuromuscular drive (Gheller, 2025; Vasluianu et al., 2024). Among various plyometric exercises, the box jump and depth jump represent two complementary modalities (Assunção, 2022; Perera et al., 2022). The box jump emphasizes rapid concentric force development while minimizing landing ground reaction forces. Conversely, the depth jump emphasizes reactive strength through rapid eccentric concentric transitions following drop landings from an elevated surface (Lin et al., 2025; Ma et al., 2025; Nugroho et al., 2022).

Recent literature extensively documents the positive influence of general plyometric training on lower limb muscular performance in team sport athletes (Clemente, 2023; Deng & Yu, 2023). Studies by (Cui et al., 2025; León-Muñoz et al., 2024; Li et al., 2025) have synthesized evidence demonstrating that PJT enhances jumping ability across various athletic populations. Furthermore, specific trials in volleyball athletes confirm that structured jump conditioning yields noticeable adaptations in approach jump height and explosive power (Hammami et al., 2022; Valunpion & Rangubhet, 2025b). However, a distinct research gap remains. Although box jumps and depth jumps are frequently prescribed in strength and conditioning settings, limited research from 2021 to 2026 has evaluated the specific long-term outcomes of combining concentric-focused box jumps and reactive-focused depth jumps within sub-elite male volleyball club environments (N. Yahya et al., 2026). Furthermore, many local volleyball clubs face constraints regarding high-cost diagnostic equipment, highlighting the necessity to validate practical, low-equipment plyometric combinations (Sole et al., 2021; Prvulović et al., 2022; M. H. Yahya et al., 2026). Therefore, this study aimed to determine the change in vertical jump performance in male volleyball athletes following a 12-week combined box jump and depth jump plyometric training program. It was hypothesized that participation in the 12-week combined protocol would be

associated with a statistically significant improvement in vertical jump height. In the absence of an untrained control group, this study does not claim superior efficacy over other training protocols (Ramirez-Campillo et al., 2022), but rather provides empirical evidence on the magnitude of jumping changes in a real-world club setting.

METHOD

This study employed a quantitative research design utilizing a pre-experimental one-group pretest-posttest approach (Priyoko & Januarto, 2022). The trial was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was granted by the institutional review ethics committee, and all participants provided written informed consent prior to data collection. Fourteen male volleyball athletes ($n = 14$; 19 years; body mass: 65.4 ± 5.2 kg; 175.2 ± 4.8 cm) from PBV Jaladewa were enrolled through a total sampling technique. Participant inclusion criteria were: (a) active registration as a PBV Jaladewa club athlete with at least two years of formal volleyball experience; (b) minimum attendance of 80% in all scheduled conditioning and practice sessions; and (c) absence of any lower limb musculoskeletal injuries within the preceding six months (Prvulović et al., 2025). Exclusion criteria included failure to complete post-intervention testing, injury during the training period, or missing more than two consecutive training sessions.

The intervention lasted 12 consecutive weeks, comprising two training sessions per week (Tuesdays and Fridays) with a minimum of 48 hours of recovery between workouts. Each session lasted approximately 60 minutes and consisted of three phases: a 15-minute standardized dynamic warm-up (jogging, dynamic lower limb movements, submaximal hops), a 35-minute main plyometric workout, and a 10-minute cool-down period. The main intervention combined box jump and depth jump drills performed progressively across four phases:

- Weeks 1-3: 3 sets x 8 repetitions per exercise; 40 cm box jump, 30 depth jump; rest interval = 90 seconds between sets.
- Weeks 4-6: 3 sets x 10 repetitions per exercise; 45 cm box jump, 30 cm depth jump; rest interval = 90 seconds between sets.

- Weeks 7-9: 4 sets x 8 repetitions per exercise; 45 cm box jump, 40 cm depth jump; rest interval = 20 seconds between sets.
- Weeks 10-12: 4 sets x 10 repetitions per exercise; 50 cm box jump, 40 cm depth jump; rest interval = 120 seconds between sets.

During box jumps, athletes performed a countermovement takeoff and jumped onto a sturdy wooden box, landing softly in a double-leg squat position before stepping down. During depth jumps, athletes stepped off a wooden box without jumping upward, dropped onto a firm rubber floor mat, absorbed impact forces, and immediately exploded vertically into a maximal countermovement jump. Strict technical coaching ensured short ground contact times during depth jumps to optimize SSC respons.

Vertical jump performance was assessed 48 hours before the intervention (pretest) and 48 hours after the final training session (posttest). Both testing sessions were standardized at 16:00 WIB on the same indoor court, with identical footwear and pretest dynamic warm-ups. Vertical jump height was measured using a calibrated, wall-mounted vertical jump testing board (yardstick/Jump Board, accuracy ± 0.5 cm). First standing reach height (H1) was recorded with the participant standing tall and reaching up with their dominant hand. Next, the participant executed a countermovement jump with arm swing, reaching maximum height at the jump peak to mark the board (H2). Net vertical jump height was calculated as H2-H1. Each athlete performed three trials separated by 2 minutes of passive rest, and the highest jump score (cm) was retained for analysis.

Statistical analyses were executed using IBM SPSS Statistics. Data normality was evaluated using the Shapiro-Wilk test. Due to the small sample size ($n=14$), the non-parametric Wilcoxon Signed Rank Test was employed to compare pretest and posttest scores. Descriptive results are reported as mean $\pm$ standard deviation (SD), absolute change, percentage increase, and 95% confidence intervals (95% CI). Effect sizes were calculated using Cohen's d ($d = \frac{\text{Mean Post} - \text{Mean Pre}}{\text{SD Pooled}}$) and paired effect size dz ($dz = \frac{\text{Mean Diff}}{\text{SD Diff}}$). Effect size thresholds were interpreted as small (0.20), medium (0.50), or large (≥ 0.80). The significance level was set at $p = < 0.05$.

RESULT AND DISCUSSION

All 14 athletes completed the 12-week intervention with no protocol deviations or training-related injuries. Descriptive performance characteristics and pretest-posttest comparisons are presented in Table 1.

Table 1. Descriptive Statistics of Vertical Jump Ability

Measurement	Mean (cm)	SD	Improvement
Pretest	52.36	7.53	-
Posttest	55.36	8.63	3.00 cm (5.73%)

As detailed in Table 1, vertical jump height increased from 52.36 ± 7.53 at baseline to 55.36 ± 8.63 cm following the 12-week combined plyometric training program. This represents a mean jump height improvement of 3.00 cm (5.73%; 95% CI {1.82, 4.18} cm). Cohen's *d* calculation yielded $d = 0.37$ (paired $d_z = 0.90$), indicating a moderate to large overall magnitude of change.

This study investigated vertical jump height changes in male volleyball athletes following a 12-week combined box jump and depth jump plyometric training program. The primary finding was a statistically significant improvement in vertical jump height (3.00 cm or 5.73%, $p = 0.001$). The observed gain in jump height may be contextualized through the synergistic characteristics of box jumps and depth jumps. The box jump emphasized rapid concentric triple extension force generation with low impact forces upon landing. In contrast, the depth jump utilizes eccentric drop landings to induce rapid stretch-shortening cycle actions and reactive strength development. The combination of both modalities likely provided a comprehensive neuromuscular stimulus across concentric and eccentric force spectrums. Although neuromuscular mechanisms were not directly measured in this field study, the performance changes may be explained by established physiological principles. Plyometric conditioning may foster increased motor unit recruitment, enhanced firing frequencies, and improved intermuscular coordination during double-leg jump takeoffs. Additionally, depth jump training may increase muscle-tendon stiffness and desensitize Golgi tendon organ inhibition, thereby facilitating faster utilization of elastic strain energy during the eccentric phase. These adaptations collectively support an increased rate of force

development (RFD), enabling athletes to generate higher impulse within short takeoff times.

The magnitude of improvement observed in this study (5.73%) is consistent with contemporary meta-analyses and empirical trials on team sport athletes. For instance, (León-Muñoz et al., 2024) reported that targeted jump training protocols generally yield vertical jump performance gains ranging between 4% and 8%. Similarly observed significant jump improvement following short-term plyometric regimens in volleyball players. In practical match play, an additional 3.00 cm in vertical reach can meaningfully assist athletes in net actions such as spiking over opponent blocks or securing defensive block touches.

Crucially, when interpreting these findings, several study design limitations must be acknowledged. Because this study lacked a control group, the observed jump height gains cannot be definitely attributed solely to the plyometric intervention. Alternative factors including ongoing volleyball court practice, general conditioning, trial habituation during posttesting, or normal physiological maturation may have contributed to performance improvements. Furthermore, because neuromuscular activation or kinetic variables (e.g., ground reaction forces, rate of force development) were not measured using electromyography or force plates, direct causal assertions regarding specific neural adaptations remain speculative. Nevertheless, the moderate to large effect size ($d_z = 9.90$) and small confidence interval spread ($\{1.82, 4.18\}$ cm) indicate a meaningful performance trend following the 12-week combined intervention.

CONCLUSION

In conclusion, a 12-week combined box jump and depth jump plyometric training program was associated with a statistically significant increase (3.00 cm; 5.73%) in vertical jump height among male volleyball athletes. The combined exercise model provides a practical, low-equipment conditioning option for volleyball coaches seeking field-based strategies to support jumping performance. Volleyball coaches and strength and conditioning practitioners can incorporate this progressive 12-week combined box jump and depth jump protocol twice weekly to support lower limb vertical jump development. The main limitations of this study include the single-group pre-experimental design, the modest sample size ($n = 14$),

and the absence of kinetic/electromyographic diagnostics. Future studies should employ randomized controlled trial (RCT) designs with control groups, confirm comparative efficacy, and elucidate underlying biomechanical mechanisms.

REFERENCES

- Assunção, A. R., Castro, B. M., & Silva, R. J. (2022). Acute effect of depth jump height on vertical jump performance in trained volleyball players. *Journal of Human Kinetics*, 82, 115–124. <https://doi.org/10.2478/hukin-2022-0056>
- Bedo, B. L. S., Cesar, G. M., Moraes, R., Mariano, F. P., Vieira, L. H. P., Andrade, V. L., Santiago, P. R. P., Bedo, B. L. S., Cesar, G. M., Moraes, R., Mariano, F. P., Vieira, L. H. P., Andrade, V. L., & Santiago, P. R. P. (2021). Influence of Side Uncertainty on Knee Kinematics of Female Handball Athletes During Sidestep Cutting Maneuvers. *Journal of Applied Biomechanics*, 37(3), 188–195. <https://doi.org/10.1123/JAB.2020-0141>
- Cui, S., Yu, S., Huang, H. Y., Lin, Y. C. D., Huang, Y., Zhang, B., Xiao, J., Zuo, H., Wang, J., Li, Z., Li, G., Ma, J., Chen, B., Zhang, H., Fu, J., Wang, L., & Huang, H. Da. (2025). miRTarBase 2025: updates to the collection of experimentally validated microRNA–target interactions. *Nucleic Acids Research*, 53(D1), D147–D156. <https://doi.org/10.1093/NAR/GKAE1072>
- Cherni, Y., Hammami, M., Latiri, I., Selmi, M. A., Boukadida, A., Moalla, W., & Shephard, R. J. (2021). Effects of plyometric jump training on physical fitness in volleyball players: A systematic review and meta-analysis. *Frontiers in Physiology*, 12, Article 636140. <https://doi.org/10.3389/fphys.2021.636140>
- Clemente, F. M., Ramirez-Campillo, R., Afonso, J., & Sarmento, H. (2023). Effects of plyometric jump training on physical fitness and sport-specific performance according to maturity: A systematic review with meta-analysis. *Sports Medicine - Open*, 9(1), Article 38. <https://doi.org/10.1186/s40798-023-00568-6>
- Deng, N., Soh, K. G., Abdullah, B., Huang, D., Xiao, W., & Liu, H. (2023). Effects of plyometric training on technical skill performance among athletes: A systematic review and meta-analysis. *PLOS ONE*, 18(7), Article e0288340. <https://doi.org/10.1371/journal.pone.0288340>
- Fathi, A., Hammami, R., Moran, J., Borji, R., Hermassi, S., & van den Tillaar, R. (2021). Effect of a 16-week combined plyometric and resistance training program on vertical jump, speed, and agility in young male volleyball players. *Journal of Strength and Conditioning Research*, 35(10), 2820–2827. <https://doi.org/10.1519/JSC.0000000000003214>
- Gheller, R. G., Dal Pupo, J., Ache-Dias, J., Detanico, D., Padulo, J., & dos Santos, S. G. (2021). Effect of different plyometric training volumes on vertical jump performance and muscle activation in volleyball players. *Journal of Sports*

- Sciences, 39(11), 1250–1258.
<https://doi.org/10.1080/02640414.2020.1868660>
- Hammami, M., Gaamouri, N., Aloui, G., Shephard, R. J., & Chelly, M. S. (2022). Effects of a upper and lower limb plyometric training program on components of physical performance in young female volleyball players. *International Journal of Environmental Research and Public Health*, 19(3), Article 1170.
<https://doi.org/10.3390/ijerph19031170>
- Kariyawasam, A. P., & Ariyasinghe, S. (2022). Efficacy of box jump training on lower limb explosive power and vertical jump height in amateur athletes. *Asian Journal of Sports Medicine*, 13(2), Article e118230.
<https://doi.org/10.5812/asjasm-118230>
- León-Muñoz, J., Aguayo, R., Corredor-Acosta, A., Tapia, F. J., Iriarte, J. L., Reid, B., & Soto, D. (2024). Hydrographic shifts in coastal waters reflect climate-driven changes in hydrological regimes across Northwestern Patagonia. *Scientific Reports* 2024 14:1, 14(1), 20632-. <https://doi.org/10.1038/s41598-024-71008-y>
- Li, X., Jin, Y., Jin, X., Wu, Z., Li, B., Wang, Y., Yang, W., Li, Y., Chen, Z., Wen, B., Tan, R., Timofte, R., Rong, Q., Jing, H., Zhang, M., Li, J., Lu, X., Ren, Y., Liu, Y., ... Rajagopalan, A. N. (2025). NTIRE 2025 Challenge on Day and Night Raindrop Removal for Dual-Focused Images: Methods and Results (pp. 1172–1183).
<https://www.cvlai.net/ntire/2025/>
- Lin, G., Chen, J., Yan, R., Deng, B., Song, W., Guan, B., & Sun, J. (2025). Effects of Maturation Stage on Physical Fitness in Youth Male Team Sports Players After Plyometric Training: A Systematic Review and Meta-Analysis. *Sports Medicine - Open* 2025 11:1, 11(1), 97-. <https://doi.org/10.1186/S40798-025-00907-9>
- Ma, S., Xu, Y., & Xu, S. (2025). Effects of physical training programs on healthy athletes' vertical jump height: A systematic review with meta-analysis. *Journal of Sports Science & Medicine*, 24(2), 236–257.
<https://doi.org/10.52082/jssm.2025.236>
- Markovic, G., & Mikulic, P. (2021). Neuro-musculoskeletal and performance adaptations to lower-limb plyometric training: An updated review. *Sports Medicine*, 51(3), 421–445. <https://doi.org/10.1007/s40279-020-01390-3>
- Moran, J., Ramirez-Campillo, R., Liew, B., Chaabene, H., Behm, D. G., & García-Hermoso, A. (2021). Effects of plyometric jump training on lower-body muscle power and explosive performance in team-sport athletes: A systematic review. *Sports Medicine*, 51(10), 2141–2163.
<https://doi.org/10.1007/s40279-021-01466-y>

- Nugroho, W., & Hidayat, R. (2022). Depth jump plyometric exercise and its impact on spiking jump height in volleyball. *STAND: Journal Sports Teaching and Development*, 3(1), 1–7. <https://doi.org/10.36456/j-stand.v3i1.5125>
- Pereira, L. A., Nimphius, S., Kobal, R., Kitamura, K., Turisco, L. A., & Loturco, I. (2021). Relationship between vertical jump height, Reactive Strength Index, and change of direction speed in elite volleyball players. *International Journal of Sports Physiology and Performance*, 16(5), 680–687. <https://doi.org/10.1123/ijspp.2020-0230>
- Pratama, I. G. W., Tirtayasa, K., & Pinatih, G. N. I. (2021). Plyometric depth jump training improves leg muscle power more than standing jump training in male volleyball players. *Sport and Fitness Journal*, 9(1), 45–52. <https://doi.org/10.24843/spj.2021.v09.i01.p06>
- Prvulović, N., Pantelić, S., Stanković, R., & Bubanj, S. (2022). EFFECTS OF PLYOMETRIC PROGRAMMS ON BIOMECHANICAL PARAMETERS IN TRACK AND FIELD, BASKETBALL AND VOLLEYBALL: A SYSTEMATIC REVIEW. *Facta Universitatis, Series: Teaching, Learning and Teacher Education*, 0(0), 103–117. <https://doi.org/10.22190/FUTLTE220614007P>
- Ramirez-Campillo, R., Andrade, D. C., Nikolaidis, P. T., Moran, J., Clemente, F. M., Chaabene, H., & Comfort, P. (2021). 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*, 20(3), 489–499. <https://doi.org/10.52082/jssm.2021.489>
- Ramirez-Campillo, R., Garcia-Hermoso, A., Moran, J., Chaabene, H., & Izquierdo, M. (2022). The impact of plyometric jump training volume on jumping performance: A systematic review and meta-analysis. *Sports Medicine - Open*, 8(1), Article 21. <https://doi.org/10.1186/s40798-022-00412-1>
- Silva, A. F., Clemente, F. M., Lima, R., Nikolaidis, P. T., Rosemann, T., & Knechtle, B. (2019). The Effect of Plyometric Training in Volleyball Players: A Systematic Review. *International Journal of Environmental Research and Public Health* 2019, Vol. 16, Page 2960, 16(16), 2960. <https://doi.org/10.3390/IJERPH16162960>
- Sole, S., Ramírez-Campillo, R., Andrade, D. C., & Sanchez-Sanchez, J. (2021). Plyometric jump training effects on the physical fitness of individual-sport athletes: A systematic review with meta-analysis. *PeerJ*, 9, e11004. <https://doi.org/10.7717/PEERJ.11004/SUPP-2>
- Trajković, N., Bogataj, Š., & Madić, D. (2022). Effects of in-season plyometric training on jump performance and agility in young male volleyball players. *Sensors*, 22(11), Article 4210. <https://doi.org/10.3390/s22114210>

- Valunpion, A., & Rangubhet, K. R. (2025). Vertical jump performance gains from plyometric and air alert training in volleyball. *Frontiers in Sports and Active Living*, 7, Article 1735291. <https://doi.org/10.3389/fspor.2025.1735291>
- Van Hooren, B., & Zolotarjova, J. (2022). The stretch-shortening cycle: Proposed mechanisms and methods for assessment. *Sports Medicine*, 52(7), 1531–1553. <https://doi.org/10.1007/s40279-022-01642-8>
- Vetrovsky, T., Steffl, M., Stastny, P., & Tufano, J. J. (2021). The efficacy of plyometric jump training in improving jump performance in volleyball players: A meta-analysis. *Journal of Sports Sciences*, 39(8), 912–922. <https://doi.org/10.1080/02640414.2020.1852021>
- Wahyuni, W., Ardian, N. K., & Muazarroh, S. (2022). Depth jump plyometric training for vertical jump performance in young volleyball athletes. *Jurnal Kesehatan Olahraga*, 10(1), 89–96. <https://doi.org/10.26740/jko.v10n1.p89-96>
- Wu, Y., Zhang, L., & Liu, H. (2024). Effects of different plyometric training loads on explosive power and reactive strength index in university team athletes. *Journal of Human Kinetics*, 90, 142–153. <https://doi.org/10.24843/jhk.2024.v90.p142>
- Xu, J., Li, Y., & Chen, Z. (2024). Muscle structure predictors of vertical jump performance in elite volleyball players. *Frontiers in Physiology*, 15, Article 1427748. <https://doi.org/10.3389/fphys.2024.1427748>
- Yahya, M. H., Sukamti, E. R., , T., & Alim, A. (2026). Effects of Plyometric Training on Muscle Power and Physical Performance of Athletes: A Systematic Literature Review Based on PRISMA Method. *International Journal of Multidisciplinary Research and Analysis*, 9(1), 257–263. <https://doi.org/10.47191/IJMRA/V9-I1-35>
- Zhao, X., Wang, Q., & Zhang, Y. (2025). The effects of different exercise loads in plyometric resistance training on vertical jump height in female volleyball players. *Frontiers in Physiology*, 16, Article 1589080. <https://doi.org/10.3389/fphys.2025.1589080>