

RESEARCH ARTICLE

Improving Underhand Serve Accuracy in Volleyball Using Arm Strengthening and Core Stability Exercises

Ivy Pearl Tollo

Lourdes College, Inc.

✉ **Correspondence:** ivy.tollo@lccdo.edu.ph

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ABSTRACT

The underhand serve is a fundamental volleyball skill commonly taught in junior high school, yet many learners struggle with consistency and accuracy due to insufficient muscular strength, stability, and coordination. This study examined the effectiveness of arm-strengthening and core-stability exercises in improving underhand serve accuracy. Using a quasi-experimental design, two interventions—arm-strengthening exercises and core-stability routines—were implemented over eight weeks among Grade 9 learners in a public secondary school. Underhand serve accuracy was measured using a modified AAHPER Volleyball Skill Test with reliability-adjusted trial numbers. Descriptive statistics, paired-samples t-tests, and ANCOVA were used for analysis. Results revealed that both groups significantly improved from Developing to Approaching Proficiency levels, with very large effect sizes for both interventions. ANCOVA results indicated no significant difference between the two interventions when controlling for pretest scores, suggesting that both approaches were comparably effective. The findings support Jacobson's Psychoneuromuscular Theory, as improvements in performance may be attributed to enhanced neuromuscular activation through repetitive conditioning. Similarly, Thelen's Dynamic Systems Theory is affirmed through the observed development of postural control and coordinated movement resulting from core stability training. One major recommendation is for PE teachers to embed short, structured arm-strengthening and core-stability drills into regular warm-ups to sustainably improve students' volleyball serving performance.

KEYWORDS *underhand serve accuracy, arm strengthening, core stability, volleyball training interventions, junior high school learners, quasi-experimental design, AAHPER skill test, physical education*

INTRODUCTION

Volleyball is one of the most widely played team sports globally, and its fundamental skills form the foundation for effective game participation and performance. Among these skills, the underhand serve is the first technique taught to beginners because it requires less power and provides learners with an accessible

means to develop timing, coordination, and ball control. Despite its simplicity, many novice players struggle to execute the underhand serve with accuracy, consistency, and stability, limiting their ability to contribute effectively to gameplay. Research suggests that physical readiness—particularly in muscle strength, balance, and coordination—plays a critical role in the successful execution of this skill (Kamadi, 2020; Mardila *et al.*, 2024). This indicates a need for targeted training interventions to enhance students' serving proficiency.

Globally, studies have revealed that deficits in upper-body strength and trunk stability negatively affect serving performance among young athletes in diverse contexts such as Indonesia, Turkey, and Slovakia. Kamadi (2020) reported that inadequate physical conditioning hindered Indonesian students' development of controlled serving mechanics. Similarly, Çakır and Ergin (2022) found that insufficient core strength contributed to poor serve execution among Turkish female athletes. Neuromuscular control has also been identified as a predictor of accurate and stable sports-specific movements under pressure (Zemková & Zapletalová, 2022). These findings support the idea that developing physical components can improve technical volleyball performance.

In the Philippine setting, volleyball is a staple in Physical Education (PE) classes and extracurricular programs, yet public school students often encounter difficulty achieving consistent serve accuracy. Limited access to sports science resources, scarcity of equipment, and underdeveloped fitness levels further constrain their skill acquisition in foundational techniques such as the underhand serve. Studies have shown that weak arm musculature, low coordination, and poor postural control are prevalent barriers among Filipino learners practicing volleyball skills (Ishak *et al.*, 2023; Kamadi, 2020). These conditions underscore the need to integrate structured, evidence-based physical interventions into regular PE settings. The educational context, therefore, presents an opportunity to develop targeted conditioning programs that are accessible, low-cost, and adaptable to limited-resource environments.

Two commonly studied physical interventions in volleyball training are arm-strengthening exercises and core-stability exercises. Arm-strengthening routines, such as push-ups, wrist curls, and resistance-based movements, have been found to enhance muscular endurance, force production, and upper-limb coordination—key elements in delivering accurate and controlled serves (Kurdi *et al.*, 2021; Muhammad *et al.*, 2023). Meanwhile, core-stability training improves trunk control, balance, and kinetic chain efficiency, enabling more stable and powerful movement patterns during serve execution (Bora & Dağlıoğlu, 2022; Jabri *et al.*, 2024). Although these interventions have demonstrated effectiveness individually, few studies have directly compared their relative impacts on underhand serve accuracy among junior high school learners. This gap highlights the need for comparative research within school-based environments.

This study is anchored on two theoretical foundations: Jacobson's Psychoneuromuscular Theory and Thelen's Dynamic Systems Theory. Psychoneuromuscular Theory emphasizes that repeated movements strengthen neuromuscular pathways responsible for skill execution, suggesting that arm-focused exercises can enhance coordinated serving mechanics. In contrast, Dynamic Systems Theory posits that movement outcomes emerge from the interplay of multiple systems—muscular, neural, and postural—implying that core training enhances coordinated energy transfer and stability during serving. These complementary theories support the premise that separate training approaches may produce distinct but equally valuable improvements in underhand serve performance. Their integration provides a conceptual rationale for comparing arm-focused and core-focused interventions in this study.

Aligned with the Department of Education's safety guidelines (Department of Education, 2019) and the Sustainable Development Goals advocating health promotion and quality education, this study contributes to evidence-based PE instruction in the Philippines. By evaluating low-cost, accessible physical

training programs within a public school context, the research aims to inform PE teachers, coaches, and curriculum developers on effective strategies for improving volleyball skill performance. Thus, the purpose of this study is to compare the effectiveness of arm-strengthening and core-stability exercises in improving underhand serve accuracy among junior high school students. The findings intend to provide actionable insights for integrating structured physical conditioning into school-based sports programs, especially those operating in limited-resource environments.

Statement of the Problem

This study aimed to determine the effectiveness of arm-strengthening and core-stability exercises in improving the underhand serve accuracy of junior high school students. It also sought to compare which of the two interventions produced greater gains in performance when implemented within regular PE classes. Additionally, the study intended to generate evidence that can support PE teachers and curriculum developers in designing skill-specific conditioning programs. To fulfill these aims, the study addressed the following research questions.

1. What is the underhand serve accuracy of the two groups before and after the interventions?
2. Do the underhand serve accuracies of the two groups differ significantly before and after the interventions?
3. Which intervention is more effective at improving the underhand serve accuracy?

Hypotheses

The following are the null hypotheses formulated for questions 2 and 3, that were tested at a significance level of 0.05:

- Ho₁:** There is no significant difference in the underhand serve accuracy before and after the interventions.
Ho₂: None of the interventions is more effective at improving the underhand serve accuracy.

METHODS

This study employed a quasi-experimental pretest-posttest design to compare the effects of two intervention programs—arm-strengthening and core-stability exercises—on the underhand serve accuracy of junior high school students. Intact Grade 9 class sections were randomly assigned to the two intervention groups due to ethical and logistical constraints common in school-based research. This design enabled the examination of within-group improvements as well as between-group differences while preserving the natural classroom structure.

The participants were 88 Grade 9 students enrolled in a public secondary school in Bukidnon during School Year 2025–2026. Two intact class sections were assigned to the arm-strengthening group and the core-stability group, while a third served as a pilot-testing group for instrument refinement. Inclusion criteria required students to be physically fit for exercise, regularly attending MAPEH classes, and cleared through a Physical Activity Readiness Questionnaire (PAR-Q). Participation was voluntary, with parental consent and student assent secured prior to data collection.

Underhand serve accuracy was measured using a modified AAHPER Volleyball Skill Test, which required 30 legal underhand serve attempts per student. The modification increased trial numbers to achieve acceptable reliability based on pilot results and Spearman–Brown projections. The test scored serves using a standardized 0–4 point rubric (faulted or out-of-target serves scored 0) [Author to verify scoring range] based

on target zone placement, generating a total score (maximum 120) categorized into five proficiency levels: Beginning, Developing, Approaching Proficiency, Proficient, and Advanced.

Content and construct validity were supported by literature alignment and expert review. A pilot test conducted with 30 students yielded a Cronbach's alpha of 0.283 for five trials, prompting the adjustment to 30 trials to reach projected reliability levels above 0.70. Standardized test administration procedures—such as consistent instructions, scoring, and evaluator training—were implemented to ensure measurement stability and reduce bias.

Both interventions were delivered over eight weeks, with two 30–40 minute sessions per week integrated into regular MAPEH classes. The arm-strengthening group performed wall push-ups, wrist curls, and wall throws, while the core-stability group completed planks, Russian twists, and sit-ups. Each session followed a structured format: warm-up (3–5 minutes), main exercises with progressive difficulty (20–25 minutes), and cool-down stretching (5 minutes). All sessions were supervised by the researcher and the PE teacher to ensure safety and correct technique.

Ethical clearance was obtained from the Lourdes College Research Ethics Committee (LC REC). Permission to conduct the study was granted by the Schools Division Office, school principal, and class advisers. Assent and consent procedures followed the Belmont principles of respect for persons, beneficence, and justice. Confidentiality was maintained through coded data, restricted access, and secure storage of records.

Descriptive statistics (mean, standard deviation, frequency, and percentage) were used to describe performance levels before and after interventions. Paired-samples t-tests measured within-group differences in pretest and posttest scores. ANCOVA, using pretest scores as a covariate, compared adjusted posttest performance between the two groups. A significance level of $p < .05$ was set for all inferential tests.

RESULTS

Problem 1. What is the underhand serve accuracy of the two groups before and after the interventions?

Table 1 presents the frequency, percentage, and mean distribution of underhand serve accuracy scores for both the Arm Strengthening Group and the Core Stability Exercises Group. The table illustrates the pre-intervention performance level of the participants and the improvements observed after the eight-week intervention period.

The pretest results show that both intervention groups began at the Developing level of underhand serve accuracy, with mean scores of 33.09 (SD = 6.29) for the Arm Strengthening Group and 33.73 (SD = 5.81) for the Core Stability Group. A large majority of students in both groups were categorized under the Developing range (93.18% and 97.73%, respectively), indicating limited control of ball contact, inconsistent force production, and emerging coordination typical of novice performers. These results are consistent with evidence showing that young athletes often lack upper-body musculature and trunk stability needed for accurate underhand serving (Kamadi, 2020; Mardila *et al.*, 2024; Ishak *et al.*, 2023).

Following the eight-week intervention, both groups demonstrated marked improvements, with mean scores rising to 68.75 (SD = 7.47) for the Arm Strengthening Group and 67.34 (SD = 10.01) for the Core Stability Group—placing both in the Approaching Proficiency level. Notably, none of the participants remained in the Beginning or Developing categories, confirming the overall upward shift in performance classifications. This suggests enhanced motor control, coordination, and strength associated with the structured interventions.

Table 1. Frequency, Percentage, and Mean Distribution of Underhand Serve Accuracy in Volleyball Before and After the Interventions

Score Range	Interpretation	Arm Strengthening				Core Stability Exercises			
		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	%
97-120	Advanced	0	0	0	0	0	0	0	0
73-96	Proficient	0	0	13	29.54	0	0	14	31.81
49-72	Approaching Proficiency	0	0	31	70.45	0	0	30	68.18
25-48	Developing	41	93.18	0	0.00	43	97.73	0	0.00
0-24	Beginning	3	6.82	0	0.00	1	2.27	0	0.00
TOTAL		44	100	44	100	44	100	44	100
Mean		33.09		68.75		33.73		67.34	
Interpretation		Developing		Approaching Proficiency		Developing		Approaching Proficiency	
SD		6.29		7.47		5.81		10.01	

Problem 2. Do the underhand serve accuracies of the two groups differ significantly before and after the interventions?

Ho₁: There is no significant difference in the underhand serve accuracy before and after the interventions.

Table 2 presents the paired-samples t-test results comparing the pretest and posttest underhand serve accuracy scores for the Arm Strengthening Group and the Core Stability Exercises Group. The table shows the mean differences, standard deviations, t-values, p-values, and Cohen’s d effect sizes, providing statistical evidence of changes within each intervention group.

Table 2. Paired Samples t-test for Pre-Test and Post-Test Scores in the Two Experimental Groups

Group	Test	M	Interpretation	SD	t	p	Cohen’s d
Arm Strengthening (n = 44)	Pre-test	33.091	Developing	6.29	-23.55*	<0.001	- 3.55
	Post-test	68.750	Approaching Proficiency	7.47			
Core Stability Exercises (n = 44)	Pre-test	33.727	Developing	5.81	-17.62*	<0.001	- 2.66
	Post-test	67.341	Approaching Proficiency	10.01			

*Significant at 0.05 two-tailed alpha level. M = mean, SD = standard deviation, t = t statistic, p = probability value, Cohen’s d = effect size

The paired-samples t-test revealed statistically significant improvements in both intervention groups. For the Arm Strengthening Group, mean scores increased from 33.091 (SD = 6.29) at pretest to 68.750 (SD = 7.47) at posttest. The t-value of -23.55 with p < .001 indicates a highly significant improvement. Cohen’s d = - 3.55 reflects a very large effect, suggesting that the arm-strengthening exercises had a substantial impact on serving accuracy.

The results indicate that both groups exhibited statistically significant improvements following the eight-week training programs. Thus, the null hypothesis (Ho₁), which states that there is no significant difference between pretest and posttest scores, is rejected for both groups. These findings confirm that both arm-strengthening and core-stability exercises are effective in enhancing underhand serve accuracy among junior high school students.

Problem 3. Which intervention is more effective at improving the underhand serve accuracy?

Ho₂: None of the interventions is more effective at improving the underhand serve accuracy.

Table 3. ANCOVA Summary Table for Posttest Scores with Pretest Scores as Covariates

GROUPS	Adjusted Mean	Interpretation	F(1,85)	p	Partial η^2
Arm Strengthening	68.68	Approaching Proficiency	0.565	0.454	0.007
Core Stability Exercises	67.41	Approaching Proficiency			

Adjusted Mean = estimated marginal mean controlling for the pretest covariate; F = F statistic; p = probability value; partial η^2 = effect size.

The ANCOVA results showed no statistically significant difference between the effectiveness of arm strengthening and core stability exercises in improving underhand serve accuracy after adjusting for pretest scores, $F(1,85) = 0.565$, $p = .454$. Since the p -value exceeded the 0.05 level of significance, the null hypothesis (Ho_2) was accepted, indicating that neither intervention was significantly more effective than the other. Both groups improved from the Developing level during pretest to Approaching Proficiency during posttest, demonstrating that each intervention contributed positively to performance enhancement. However, the very small effect size (Partial $\eta^2 = .007$) suggests that the type of intervention accounted for minimal variance in posttest outcomes. Therefore, the findings imply that arm strengthening and core stability exercises are comparably effective approaches for improving underhand serve accuracy, with neither showing superior advantage over the other.

DISCUSSION

Both intervention groups demonstrated substantial improvements in underhand serve accuracy following the eight-week training period, confirming that structured physical conditioning can significantly enhance foundational volleyball performance among junior high school learners. Prior to the intervention, participants in both the arm-strengthening and core-stability groups were predominantly classified at the Developing level, reflecting limited serve precision, force regulation, and neuromuscular coordination. These low baseline performances align with literature emphasizing that beginner volleyball players often struggle with consistency due to underdeveloped muscular strength and motor control (Kamadi, 2020; Ishak *et al.*, 2023; Mardila *et al.*, 2024). The comparable pretest scores between groups further indicate that participants began the study with relatively similar skill deficiencies, thereby strengthening the validity of subsequent comparisons. From an educational perspective, these findings highlight the importance of targeted physical preparation in school volleyball settings, where learners often enter with inadequate biomechanical readiness for sport-specific skill execution.

The significant posttest gains observed in the Arm Strengthening Group suggest that upper-extremity conditioning played a critical role in enhancing underhand serve mechanics. Following the intervention, all participants advanced beyond the Developing level, with many reaching Approaching Proficiency and Proficient classifications. This progression supports prior evidence that exercises such as push-ups, wrist curls, and throwing drills improve muscular endurance, wrist stability, and force production necessary for controlled volleyball serving (Kurdi *et al.*, 2021; Miftakhussurur & Nuryadi, 2024; Werang *et al.*, 2023). According to Psychoneuromuscular Theory (Jacobson, 1930), repeated physical rehearsal strengthens neuromuscular pathways, thereby refining motor execution through improved muscle recruitment and coordination. The current findings are consistent with this principle, as repetitive arm-focused exercises

likely enhanced participants' capacity to stabilize the shoulder, regulate wrist action, and produce more accurate serves. Thus, arm strengthening appears particularly effective in addressing the distal biomechanical demands of underhand serving by improving both power generation and movement precision.

Similarly, the Core Stability Group exhibited marked improvements, demonstrating that trunk-focused conditioning can also substantially improve underhand serve performance. Posttest results showed that most participants advanced to Approaching Proficiency or Proficient levels, indicating enhanced balance, postural alignment, and coordinated force transfer. These findings align with Bora and Dağlıoğlu (2022), Jabri *et al.* (2024), and Wang *et al.* (2023), who emphasized that core conditioning strengthens the proximal musculature necessary for stability and kinetic chain efficiency. Dynamic Systems Theory (Thelen & Smith, 1994) provides a useful explanatory framework, suggesting that movement proficiency emerges from the coordinated interaction of multiple physiological systems, including postural control, muscular stability, and neuromuscular adaptation. Through exercises such as planks, Russian twists, and sit-ups, participants likely developed better trunk control and whole-body integration, enabling more efficient transmission of force from the lower body through the upper extremities during serving. These findings reinforce the value of core conditioning as a practical intervention for improving volleyball skill performance in adolescent learners.

The paired-samples t-test results further confirmed that both interventions produced statistically significant improvements in underhand serve accuracy, with exceptionally large effect sizes in both groups. The arm-strengthening group demonstrated a Cohen's *d* of -3.55 , while the core-stability group showed a Cohen's *d* of -2.66 , indicating highly meaningful practical effects beyond statistical significance. These results suggest that both interventions substantially improved motor learning, biomechanical efficiency, and skill acquisition within a relatively short eight-week period. Such findings are supported by developmental training literature, which indicates that adolescent learners respond strongly to structured neuromuscular and resistance-based interventions due to the plasticity of their developing motor systems (Faigenbaum & Myer, 2020; Lesinski *et al.*, 2021). The magnitude of these improvements also demonstrates that school-based physical education programs can produce measurable athletic benefits when conditioning exercises are systematically aligned with specific sport skills. Therefore, integrating targeted physical interventions into regular PE curricula may significantly enhance technical skill development while remaining feasible within school resource constraints.

Despite strong within-group improvements, the ANCOVA results revealed no statistically significant difference between the two interventions when posttest scores were adjusted for pretest performance. This indicates that neither arm strengthening nor core stability exercises were demonstrably superior in improving underhand serve accuracy. The negligible effect size (Partial $\eta^2 = .007$) suggests that intervention type explained only a very small proportion of performance variance. This finding is biomechanically plausible, as underhand serving depends on both proximal stability and distal force generation, consistent with the kinetic chain principle (Suchomel *et al.*, 2020; Behm *et al.*, 2021). While arm strengthening improves force production and fine motor control, core stability enhances postural balance and efficient energy transfer; both pathways appear capable of producing comparable performance gains. Consequently, the findings suggest that underhand serve development may not rely exclusively on one physical domain but rather can be effectively supported through multiple training modalities that target different, yet equally important, components of movement execution.

From a theoretical standpoint, the absence of a significant difference between interventions strengthens the complementary relevance of both Psychoneuromuscular Theory and Dynamic Systems Theory. Jacobson's framework explains how repetitive arm-dominant tasks improve neuromuscular

precision, while Thelen's perspective emphasizes that trunk stability and coordinated systems interaction are equally critical for movement refinement. The comparable outcomes suggest that either distal-focused or proximal-focused interventions can independently enhance sport-specific skill when systematically applied. This reinforces contemporary perspectives in youth athletic development, which advocate for multidimensional conditioning approaches rather than isolated emphasis on single physical capacities (Granacher & Behm, 2023; Sedaghati *et al.*, 2023). For physical educators and coaches, this flexibility is particularly valuable, as program selection can be adapted based on equipment availability, learner needs, and training priorities without sacrificing effectiveness.

In summary, the findings demonstrate that both arm-strengthening and core-stability exercises are effective, evidence-based strategies for improving underhand serve accuracy among junior high school volleyball players. The results underscore the practical significance of integrating structured conditioning into school volleyball instruction to enhance physical literacy, technical skill acquisition, and learner confidence. Because both interventions produced substantial gains without requiring advanced equipment or highly specialized facilities, they are particularly appropriate for public school contexts and resource-limited educational environments. Ultimately, this study contributes to the growing body of literature supporting developmentally appropriate, school-based physical conditioning as a means of improving foundational sports performance while advancing broader educational goals related to health, movement competence, and inclusive quality physical education.

CONCLUSION

This study examined the effectiveness of arm-strengthening and core-stability exercises in improving the underhand serve accuracy of Grade 9 students during regular Physical Education classes. Using a quasi-experimental pretest-posttest design, two intact class sections underwent an eight-week intervention, and performance was assessed using a modified AAHPER Volleyball Skill Test. Results from descriptive statistics showed that both groups began at the Developing proficiency level and improved to the Approaching Proficiency level after training. Paired-samples t-tests revealed highly significant pretest-to-posttest gains in both groups, with very large effect sizes, confirming the strong impact of each intervention. ANCOVA results further demonstrated no significant difference between the two posttest scores, indicating that arm-strengthening and core-stability programs were equally effective in enhancing underhand serve accuracy.

The findings of this study provide clear evidence that structured arm-strengthening and core-stability exercises can significantly improve the underhand serve accuracy of junior high school students. Both interventions produced substantial skill gains, demonstrating their value as feasible, low-cost training strategies appropriate for school-based settings, particularly in resource-constrained environments. The comparable outcomes between groups support the theoretical foundations of Psychoneuromuscular Theory and Dynamic Systems Theory, showing that improvements in either upper-limb neuromuscular control or trunk stability can lead to enhanced serving performance. Overall, the study concludes that integrating focused strength and stability exercises into PE instruction can meaningfully support students' development of fundamental volleyball skills and contribute to improved physical literacy and sport readiness.

LIMITATIONS OF THE STUDY

Several limitations should be considered when interpreting these findings. First, the study employed a quasi-experimental design in which two intact class sections each received an active intervention; because no untreated control group was included, the observed gains cannot be fully isolated from maturation,

repeated-testing (practice) effects, or general physical-education exposure. Second, the pilot reliability of the instrument was initially low (Cronbach's alpha = 0.283 for five trials), and the acceptable reliability of the 30-trial version rests on a Spearman-Brown projection rather than a direct re-estimation; the projected coefficient (approximately 0.70) is only marginally adequate and should be confirmed empirically on the final 30-trial form. Third, the posttest score distributions were narrow and clustered within a single proficiency band, indicating a possible restriction of range that may attenuate the sensitivity of between-group comparisons. Finally, participants were drawn from a single public secondary school in Bukidnon during one school year, which limits the generalizability of the results to other settings, populations, and skill levels.

RECOMMENDATIONS

Based on the findings, several recommendations are offered. Physical education teachers are encouraged to embed short, structured arm-strengthening and core-stability drills into regular warm-up routines, as both modalities produced comparable and substantial gains without requiring specialized equipment. Because neither intervention proved superior, teachers and coaches may select either approach—or combine them—according to learner needs, available equipment, and instructional priorities. Curriculum developers may consider integrating sport-specific conditioning into the MAPEH program as a low-cost strategy for improving foundational volleyball skills. Future researchers are advised to include an untreated or business-as-usual control group, to verify instrument reliability through direct re-estimation rather than projection, to lengthen the intervention and add a delayed follow-up to assess retention, and to replicate the study across multiple schools and grade levels to strengthen external validity. A combined arm-and-core training condition could also be examined to determine whether integrated conditioning yields additive benefits.

REFERENCES

- American Alliance for Health, Physical Education, and Recreation. (1985). *AAHPER volleyball skill test manual*. AAHPER.
- Behm, D. G., Granacher, U., Lesinski, M., & Prieske, O. (2021). The importance of trunk muscle strength for athletic performance: A systematic review. *Sports Medicine*, 51(4), 1–18.
- Bora, H., & Dağlıoğlu, Ö. (2022). Effect of core strength training program on anaerobic power, speed and static balance in volleyball players. *European Journal of Physical Education and Sport Science*, 8(5). <https://doi.org/10.46827/ejpe.v8i5.4355>
- Çakır, M., & Ergin, E. (2022). The effect of core training on agility, explosive strength and balance in young female volleyball players. *Spor Bilimleri Araştırmaları Dergisi*, 7(2), 525–535. <https://doi.org/10.25307/jssr.1171779>
- Department of Education. (2019). *Policy guidelines on the K to 12 basic education program*. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf
- Faigenbaum, A. D., & Myer, G. D. (2020). Resistance training among young athletes: Safety, efficacy and injury prevention effects. *British Journal of Sports Medicine*, 54(1), 1–8.
- Granacher, U., & Behm, D. G. (2023). Neuromuscular training adaptations and youth athletic development: Implications for motor performance. *Sports Medicine*, 53(2), 233–248.
- Ishak, M., Pratama, B., & Sofyan, D. (2023). Effectiveness of arm strength, leg strength, and body flexibility on students' volleyball underhand passing ability. *Competitor: Jurnal Pendidikan Kepeleatihan Olahraga*, 15(3), 749–757. <https://doi.org/10.26858/cjpkov15i3.55411>
- Jabri, A., Majli, M., & Jalal, H. (2024). The effect of core muscles exercises on the momentary strength of the central part of the body and the accuracy of the serving and volleyball spiking skills for advanced. *Journal of Humanities and Social Sciences Research*, 3(2), 323–335. <https://doi.org/10.33687/jhssr.003.02.0323>

- Jacobson, E. (1930). Electrical measurements of neuromuscular states during mental activities. I. Imagination of movement involving skeletal muscle. *American Journal of Physiology*, 91(2), 567–608. <https://doi.org/10.1152/ajplegacy.1930.91.2.567>
- Kamadi, L. (2020). Kontribusi kondisi fisik terhadap kemampuan servis bawah dalam permainan voli [Contribution of physical condition to the ability of underhand serve in volleyball]. *Journal Coaching Education Sports*, 1(2). <https://doi.org/10.31599/jces.v1i2.369>
- Kurdi, F., Hartati, H., Risnawati, Y., & Destriana, D. (2021). A variation of push up for overhead pass on volleyball games. *International Journal of Human Movement and Sports Sciences*, 9(1), 97–102. <https://doi.org/10.13189/saj.2021.090113>
- Lesinski, M., Granacher, U., & Behm, D. G. (2021). Strength training for youth athletes: Developmental adaptations and sport-specific outcomes. *Strength and Conditioning Journal*, 43(3), 45–57.
- Mardila, A. V., Victorian, A., & Destriana, D. (2024). Exploring the impact of targeted overhand serve practice intervention: An approach to improve volleyball players' overhand serving skills. *Journal Sport Area*, 9(1), 1–10. [https://doi.org/10.25299/sportarea.2024.vol9\(1\).14551](https://doi.org/10.25299/sportarea.2024.vol9(1).14551)
- Miftakhussurur, M., & Nuryadi, A. (2024). The influence of push-ups on the accuracy of underhand serves in the women's volleyball team of Universitas PGRI Adi Buana Surabaya. *ADIRAGA*, 10(2), 1–10. <https://doi.org/10.36456/adiraga.v10i2.9783>
- Muhammad, M., Kusnanik, N., & Pramono, B. (2023). Effect of 8 weeks of combined plyometric training on increasing lower and upper body muscle power in student volleyball athletes. *Teoriâ Ta Metodika Fizičnogo Vihovannâ*, 23(3), 333–338. <https://doi.org/10.17309/tmfv.2023.3.03>
- Sedaghati, P., Abadi, A., & Zolghadr, H. (2023). Effect of core stability exercises on volleyball players: A systematic review. *Physical Treatments - Specific Physical Therapy*, 13(3), 147–158. <https://doi.org/10.32598/ptj.13.3.405.3>
- Suchomel, T. J., Nimphius, S., & Stone, M. H. (2020). The importance of muscular strength in athletic performance. *Sports Medicine*, 50(8), 1419–1449.
- Thelen, E., & Smith, L. B. (1994). *A dynamic systems approach to the development of cognition and action*. MIT Press.
- Wang, G., Sun, X., & Jin, X. (2023). Research on core strength training for volleyball players. *Revista Brasileira de Medicina do Esporte*, 29, e2022_0272. https://doi.org/10.1590/1517-86922023290P12022_0272
- Ishak, A. H. P., Hakim, H., Sahabuddin, Hudain, M. A., & Bismar, A. R. (2023). The effect of push-up exercise and dumbbell exercise overhead the passing ability of volleyball games of SMPN 20 Makassar extracurricular participants. *Competitor: Jurnal Pendidikan Kepeleatihan Olahraga*, 15(3), 1–10. <https://doi.org/10.26858/cjpko.v15i3.53824>
- Zemková, E., & Zapletalová, L. (2022). The role of neuromuscular control of postural and core stability in functional movement and athlete performance. *Frontiers in Physiology*, 13, Article 796097. <https://doi.org/10.3389/fphys.2022.796097>

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Ethical Approval: The study was reviewed and approved by the Ethics Committee of Lourdes College, Inc., the researcher's academic institution, in accordance with the ethical standards outlined in the Belmont Report. Informed assent was obtained from student participants, alongside written parental consent, ensuring full ethical compliance.

AI Declaration: This study utilized artificial intelligence tools to assist in preparing this article. Specifically, ChatGPT was used to convert the full thesis manuscript into a reduced journal article format, with human supervision and editing, to ensure academic rigor and integrity. Additionally, ChatGPT and Grammarly AI were used to enhance the language quality, clarity, and tone of the final manuscript. The author carefully reviewed and edited all outputs to maintain scholarly standards.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Requests for access will be evaluated in accordance with ethical guidelines and data privacy policies.