

RESEARCH ARTICLE

The Comparative Effects of Isometric and Isotonic Leg Exercises on Female Students' Vertical Jump Height in a Physical Education Setting

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ABSTRACT

Vertical jump height is a key indicator of lower-body explosive strength and is essential for performance in sports requiring rapid take-off; however, female adolescents consistently demonstrate lower jump performance than males due to physiological, neuromuscular, and training-related factors. In Philippine public schools, physical education programs commonly rely on low-equipment, bodyweight exercises—particularly isotonic and isometric modalities—yet comparative evidence regarding their effectiveness for improving vertical jump height remains limited. Guided by Hatfield's Strength Continuum Theory and the Stretch-Shortening Cycle model, this quasi-experimental study compared the effects of isotonic and isometric leg exercises on the vertical jump height of Grade 8 female students in a public high school in Misamis Oriental, Philippines. Using a pretest-posttest non-equivalent groups design, 38 participants (19 per group) completed an 8-week intervention consisting of two sessions per week with identical time allotment (40–45 minutes per session) and equivalent training frequency and overall intensity, differing only in the type of muscle contraction performed. The isotonic group engaged in dynamic exercises such as squats, lunges, and leg curls, while the isometric group performed static holds including wall sits, glute bridge holds, and calf raise holds. Vertical jump height was assessed using the Sargent Chalk Jump Test. Descriptive statistics summarized performance profiles, paired-samples t-tests examined within-group changes, and ANCOVA compared posttest outcomes while controlling for baseline differences. Results indicated significant pre-to-post improvements in both the isometric group ($t(18) = -6.156, p < .001, \text{Cohen's } d = 1.41$) and the isotonic group ($t(18) = -6.356, p < .001, \text{Cohen's } d = 1.46$), with large effect sizes in both cases. However, no significant between-group difference was observed after adjustment for baseline scores ($F(1,35) = 0.442, p = .511, \text{partial } \eta^2 = 0.012$), indicating that isotonic and isometric exercises were comparably effective when matched for frequency, duration, and training load. These findings support the use of either modality in school-based physical education programs, particularly in low-resource settings.

KEYWORDS vertical jump height; lower-body explosive power; isotonic leg exercises; isometric leg exercises

INTRODUCTION

Vertical jump height is a widely recognized indicator of lower-body explosive strength and functional athletic performance, particularly in sports such as basketball, volleyball, and track and field, where rapid force production is required for rebounding, blocking, sprint take-off, and change of direction (Moura & Okazaki, 2022; Pupo *et al.*, 2020). Because vertical jumping integrates muscular strength, neuromuscular coordination, and biomechanical efficiency, it has been extensively used in both sports performance assessment and physical education research as a proxy measure of lower-limb power and overall fitness (Gillett *et al.*, 2021; Wismanadi *et al.*, 2024). Despite its importance, empirical evidence consistently shows that females tend to demonstrate lower vertical jump performance than males, a disparity attributed to differences in muscle mass distribution, fast-twitch fiber composition, hormonal influences, and neuromuscular efficiency (Ryew *et al.*, 2019; Ramírez-Campillo *et al.*, 2022; Yapıcı *et al.*, 2022; Li *et al.*, 2023). These physiological and biomechanical factors underscore the need for targeted and evidence-based training approaches that can effectively enhance vertical jump performance among female learners and developing athletes.

Globally, sports science research has emphasized structured strength and conditioning programs as primary mechanisms for improving vertical jump height. Studies from the United States, Japan, and Australia have demonstrated that resistance-based interventions—particularly isotonic and isometric training modalities—can produce meaningful gains in lower-limb strength and jump performance when implemented systematically (Gillett *et al.*, 2021; Andrews & Zachary, 2024). Isotonic exercises such as squats, lunges, and leg curls are associated with muscular hypertrophy, enhanced force production, and improved neuromuscular coordination, all of which contribute to increased vertical displacement (Fataha *et al.*, 2021; Khafagy & Sakr, 2020; Kurhan *et al.*, 2024). Conversely, isometric exercises such as wall sits, calf raise holds, and glute bridge holds are known to enhance joint stability, muscle stiffness, and post-activation potentiation, factors that facilitate more efficient force transfer during explosive movements (García *et al.*, 2020; Vargas-Molina *et al.*, 2021; Muhammad *et al.*, 2023). However, despite growing evidence on the benefits of each modality individually, direct comparative studies examining the differential effects of isotonic versus isometric leg training on vertical jump height—particularly among school-aged female populations—remain limited (Barros *et al.*, 2020; Harshini *et al.*, 2021; Pérez *et al.*, 2022).

In the Philippine context, research on strength and conditioning has largely focused on general physical fitness or sport readiness rather than specific performance outcomes such as vertical jump height. While studies have validated the use of vertical jump tests as indicators of lower-limb power and athletic preparedness (Rakholiya & Gadesha, 2020; Santos *et al.*, 2022), few have systematically compared training modalities in school-based settings. This gap is especially relevant given recent shifts in Physical Education (PE) instruction during and after the COVID-19 pandemic, when home-based and low-equipment exercise models—primarily isotonic and isometric movements—became central to student physical training. As schools gradually return to face-to-face instruction, there is a pressing need for empirical evidence to guide the integration of these modalities into structured PE and sports programs.

The present study addresses this gap by comparing the effects of isotonic and isometric leg exercises on the vertical jump height of Grade 8 female students in a public high school in Misamis Oriental, Philippines. The investigation is theoretically grounded in Hatfield's (1989) Strength Continuum Theory, which posits that strength exists along a spectrum from maximal to explosive power and can be developed through modality-specific resistance training, and the Stretch-Shortening Cycle (SSC) Theory of Komi and Bosco (1978), which explains how neuromuscular efficiency and elastic energy utilization contribute to explosive movements such as vertical jumping. While the SSC framework is classically associated with the eccentric-concentric coupling produced by dynamic movements, isometric training may indirectly support SSC-related performance by

increasing muscle and tendon stiffness, enhancing neuromuscular readiness, and improving force transfer efficiency during the brief amortization phase of explosive actions (García *et al.*, 2020; Vargas-Molina *et al.*, 2021). Together, these theories provide a basis for comparing how dynamic and static resistance training may contribute to vertical jump improvement through complementary mechanisms. By applying these frameworks within a school-based intervention, this study seeks to generate contextually relevant evidence that informs PE practice, athletic training, and curriculum development.

This study also aligns with the United Nations Sustainable Development Goals (United Nations, 2015)—particularly SDG 3 (Good Health and Well-Being) and SDG 4 (Quality Education)—and with Department of Education directives promoting learner-centered and holistic physical education (DepEd Orders No. 21, s. 2019 and No. 34, s. 2022). By evaluating two practical, low-cost training approaches, the study contributes to inclusive and context-responsive PE programs that enhance students' physical literacy and functional fitness.

Statement of the Problem

This study aimed to compare the effects of isotonic and isometric leg exercises on the vertical jump height of Grade 8 female students. Specifically, it sought to answer the following research questions:

1. What is the vertical jump height of the two female groups before and after the interventions?
2. Do the vertical jump heights of each group differ significantly from pretest to posttest?
3. Which of the two interventions is more effective in improving vertical jump height?

Hypotheses

The hypotheses below were tested:

Ho₁: There is no significant difference in the vertical jump height of each group before and after the intervention.

Ho₂: Neither intervention is more effective in improving vertical jump height.

METHODS

This study employed a quasi-experimental pretest–posttest non-equivalent groups design to examine the effects of isotonic leg exercises and isometric leg exercises on the vertical jump height of Grade 8 non-athlete female students. This design was deemed appropriate because eight different intact class sections were used, making random assignment impractical in a natural school setting. Consistent with educational and field-based research, the design allowed for the manipulation of training modality while maintaining ecological validity within a real classroom context (Campbell & Stanley, 1963; Cook & Campbell, 1979; Shadish *et al.*, 2002). A non-intervention control group was not included because the comparative purpose of the study was to evaluate two active training modalities, and withholding physical activity from a subset of students during regular Physical Education classes would have raised both ethical and practical concerns in a school setting. Vertical jump height was measured before and after an eight-week intervention to determine both within-group changes and between-group differences while controlling for baseline performance.

From eight intact Grade 8 class sections at a large public secondary school in Misamis Oriental, Philippines, approximately 100 non-athlete female students aged 13 to 15 years were initially identified for the study. The school was purposively selected because of its established physical education program and

adequate facilities for conducting exercise-based interventions. Each of the eight sections comprised approximately 16 to 25 non-athlete female students, yielding an expected total of about 100 participants. Two sections (30 students in total) were allocated to pilot testing of the research instruments and procedures, while the remaining six sections were assigned to the main study—three sections to the isotonic exercise group and three to the isometric exercise group. Sampling followed a purposive cluster approach using intact class sections, a common strategy in quasi-experimental educational research where class restructuring is not feasible (Shadish *et al.*, 2002). During the eight-week intervention period, attrition occurred in both groups due to illness, menstrual discomfort, academic commitments, and inconsistent attendance. Only participants who completed both pretest and posttest assessments were retained for analysis, yielding a final sample of 38 participants ($n = 19$ per group). Inclusion criteria required that participants be enrolled in Grade 8, within the target age range, in good physical health, free from injuries or medical conditions that could be aggravated by exercise, and able to provide both parental consent and student assent. Students with cardiovascular, respiratory, or musculoskeletal conditions, recent injuries, or inconsistent attendance were excluded to ensure participant safety and data integrity. The final sample size was constrained by the availability of intact class sections and the school's scheduling requirements, which may have limited the statistical power to detect small between-group differences. This consideration is addressed further in the study's limitations.

Moreover, vertical jump height was measured using the Sargent Chalk Jump Test, a widely accepted field-based instrument for assessing lower-limb explosive performance in school and youth populations (Khalid & Rustiawan, 2020; Hafidz *et al.*, 2021). During testing, participants first marked their standing reach height on a wall with chalk while standing flat-footed with their dominant arm fully extended. They then performed a maximal countermovement jump and marked the highest point reached. Vertical jump height was calculated as the difference, in centimeters, between the standing reach and jump reach marks. Three trials were administered during both pretest and posttest, with the highest score recorded for analysis. This procedure aligns with established protocols for improving measurement reliability in vertical jump assessments (Carnevale *et al.*, 2022).

Prior to the main study, a pilot test was conducted with Grade 8 students who were not part of the final sample to evaluate feasibility, clarity of instructions, and measurement consistency. The internal consistency of the three jump trials was assessed using Cronbach's alpha, which estimates the extent to which repeated measurements reflect a stable underlying construct; the analysis yielded a coefficient of 0.960, indicating excellent consistency across trials. The Spearman-Brown Prophecy Formula was additionally applied to project how reliability would change with variations in the number of trials, yielding a coefficient of 0.980. Together, these analyses supported the stability and dependability of the instrument for repeated jump measurements.

Each of the interventions was implemented over eight weeks, with two sessions per week integrated during Physical Education classes and vacant schedules of the participants. Each session lasted approximately 40 to 45 minutes and followed a standardized structure beginning with a five-minute warm-up consisting of light jogging and dynamic stretches such as leg swings, bodyweight squats, ankle bounces, and high knees. The isotonic group performed dynamic lower-limb exercises, including squats, lunges, and leg curls, emphasizing controlled movement through a full range of motion to stimulate muscular strength and neuromuscular coordination (Fataha *et al.*, 2021; Rivera *et al.*, 2023). Meanwhile, the isometric group performed static exercises such as wall sits, calf raise holds, and glute bridge holds, which required sustained muscle contraction to enhance joint stability, muscle stiffness, and neuromuscular readiness (Vargas-Molina *et al.*, 2021; Kinoshita *et al.*, 2023). Exercise intensity progressed gradually from low intensity in Weeks 1–2, to moderate in Weeks 3–4, and moderate-to-vigorous in Weeks 5–8, with systematic increases in repetitions, sets, or holding time. Each session concluded with a five-minute cool-down involving static stretching of the hamstrings, quadriceps, calves, and lower back to facilitate recovery and reduce muscle soreness.

Furthermore, ethical clearance was obtained from the Lourdes College Research Committee, and formal permission was secured from the Schools Division Superintendent of Misamis Oriental and the school principal. Students and their parents attended an orientation session in which the study's purpose, procedures, potential risks, and benefits were explained in detail. Written parental consent and student assent were obtained prior to participation. The study adhered to the ethical principles of the Belmont Report—Respect for Persons, Beneficence, and Justice—ensuring voluntary participation, minimized risk, and fair treatment of all participants (U.S. National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). Participant identities were coded to maintain confidentiality, and all data were securely stored in encrypted digital files and locked physical cabinets.

Data were analyzed using descriptive and inferential statistics. Means, standard deviations, frequencies, and percentages were summarized for pretest and posttest vertical jump height distributions. Paired-samples *t*-tests were used to examine within-group changes from pretest to posttest for both the isotonic and isometric groups, with Cohen's *d* computed to assess the magnitude of within-group effects. To compare posttest outcomes between groups while controlling for baseline differences, an Analysis of Covariance (ANCOVA) was conducted with pretest scores as the covariate, and partial η^2 was reported as the between-group effect size. All statistical tests were evaluated at a significance level of $p < .05$.

RESULTS

Problem 1. What is the vertical jump height of the two female groups before and after the interventions?

Table 1 presents the frequency, percentage, mean, and standard deviation of vertical jump height for the isometric and isotonic groups before and after the 8-week interventions. The classification ranges used to interpret the scores (Very Low to Very High Jump) were adapted from the vertical jump norms of Sargent (1921) and refined using the pilot-test data.

Table 1. Descriptive Statistics of the Vertical Jumping Height before and after the Interventions (Female)

Range for Females (cm)	Interpretation	Isometric Exercises				Isotonic Exercises			
		Pretest		Posttest		Pretest		Posttest	
		f	%	F	%	f	%	f	%
60 Above	Very High Jump	0	0.00	0	0.00	0	0.00	0	0.00
51 60	High Jump	0	0.00	1	5.26	0	0.00	0	0.00
31 50	Moderate Jump	12	63.16	13	68.42	7	36.84	9	47.37
11 30	Low Jump	7	36.84	5	26.32	12	63.16	10	52.63
Below 11	Very Low Jump	0	0.00	0	0.00	0	0.00	0	0.00
Total		19	100.00	19	100.00	19	100.00	19	100.00
Mean		32.7		35.8		29.6		32.3	
Interpretation		Moderate Jump		Moderate Jump		Low Jump		Moderate Jump	
SD		7.6		7.8		4.9		5.6	

At pretest, the isometric group demonstrated a mean vertical jump height of 32.7 cm ($SD = 7.6$), classified as Moderate Jump. After the intervention, the mean increased to 35.8 cm ($SD = 7.8$), remaining within the Moderate Jump category, reflecting a mean gain of 3.1 cm. In terms of distribution, 63.16% of participants were initially classified as Moderate Jump and 36.84% as Low Jump. At posttest, the proportion of Moderate Jump performers increased to 68.42%, while one participant (5.26%) reached the High Jump category. For the

isotonic group, the pretest mean was 29.6 cm (SD = 4.9), interpreted as Low Jump. Following the intervention, the mean improved to 32.3 cm (SD = 5.6), shifting to the Moderate Jump classification, with a mean gain of 2.7 cm. Initially, 63.16% of participants were classified as Low Jump and 36.84% as Moderate Jump. At posttest, 47.37% reached the Moderate Jump category, although a majority (52.63%) remained in the Low Jump range.

Problem 2. Do the vertical jump heights of each group differ significantly from pretest to posttest?

Ho₁: There is no significant difference in the vertical jump height of each group before and after the intervention.

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

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

Group	Test	M	Interpretation	SD	t	p	Cohen's d
Isometric (n = 19)	Pre-test	32.671	Moderate Jump	7.598	-6.156 *	< .001	-1.412
	Post-test	35.825	Moderate Jump	7.807			
Isotonic (n = 19)	Pre-test	29.623	Low Jump	4.880	-6.356*	< .001	-1.458
	Post-test	32.281	Moderate Jump	5.559			

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

For the isometric group (n = 19), mean vertical jump height increased from 32.67 cm (SD = 7.60) at pretest to 35.83 cm (SD = 7.81) at posttest. This improvement was statistically significant, $t(18) = -6.156$, $p < .001$, with a large effect size (Cohen's $d = 1.41$), indicating a substantial enhancement in lower-body explosive power following the intervention. For the isotonic group (n = 19), mean vertical jump height likewise improved from 29.62 cm (SD = 4.88) at pretest to 32.28 cm (SD = 5.56) at posttest. This change was also statistically significant, $t(18) = -6.356$, $p < .001$, with a large effect size (Cohen's $d = 1.46$), demonstrating meaningful gains in vertical jump performance after the 8-week program. In terms of data interpretation, both interventions produced significant within-group improvements, with participants generally shifting from lower baseline classifications toward improved jump performance categories, reflecting enhanced muscular strength, neuromuscular coordination, and explosive capacity. Therefore, H_{o1} was rejected, confirming that there were significant differences between pretest and posttest vertical jump heights within both the isometric and isotonic groups, and that both interventions were effective in improving vertical jump performance.

Problem 3. Which of the two interventions is more effective in improving vertical jump height?

Ho₂: Neither intervention is more effective in improving vertical jump height.

Table 3 presents the results of the Analysis of Covariance (ANCOVA) comparing posttest vertical jump heights between the two female groups, with pretest scores as covariates. An analysis of covariance (ANCOVA) was conducted to compare posttest vertical jump heights between the isometric and isotonic groups while controlling for pretest performance. The assumption of homogeneity of variance was satisfied (Levene's $F = 2.305$, $p = .138$). After controlling for baseline differences, no statistically significant difference was found between the two interventions, $F(1,35) = 0.442$, $p = .511$, with a very small effect size (partial $\eta^2 = 0.012$). The reported posttest means were unadjusted (isometric: $M = 35.83$ cm, $SD = 7.81$; isotonic: $M = 32.28$ cm, $SD =$

5.56); once the pretest covariate was statistically controlled, the covariate-adjusted posttest means were nearly equivalent (isometric \approx 34.3 cm; isotonic \approx 33.8 cm), differing by approximately 0.45 cm. The substantially larger unadjusted gap therefore reflected the groups' baseline difference rather than a treatment effect, indicating comparable vertical jump outcomes. Accordingly, H_0 cannot be rejected, indicating that neither isotonic nor isometric training was superior in improving vertical jump height under the conditions of this study.

Table 3. Analysis of Covariance (ANCOVA) Summary Table for Posttest Scores with Pretest Scores as Covariate

GROUPS	Adjusted Mean	Interpretation	F(1,35)	p	Partial η^2
Isometric	34.28	Moderate Jump	0.442	0.511	0.012
Isotonic	33.82	Moderate Jump			

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

DISCUSSION

The findings of the present study demonstrate that both isometric and isotonic leg exercise interventions produced meaningful improvements in the vertical jump performance of Grade 8 non-athlete female students, supporting the view that structured lower-body resistance exercises can enhance adolescent explosive power even in non-athletic populations. Before the intervention, participants in both groups were primarily concentrated within the Low Jump to Moderate Jump categories, reflecting functional but limited lower-body explosive strength. This baseline pattern aligns with previous evidence suggesting that female adolescents commonly demonstrate lower vertical jump performance because of differences in muscle mass, neuromuscular readiness, and stretch-shortening cycle efficiency (Ryew *et al.*, 2019; Yapıcı *et al.*, 2022; Moura & Okazaki, 2022). Following the 8-week intervention, both groups shifted toward improved jump classifications, indicating that regular and progressive lower-body exercises can positively influence force production and movement efficiency even among previously untrained students. These findings reinforce the importance of school-based physical activity programs that intentionally target lower-body strength development.

The isometric intervention group consistently demonstrated higher baseline and post-intervention mean scores, improving from Moderate Jump to a stronger Moderate Jump classification, with one participant reaching the High Jump category. Although the classification label remained generally the same, the significant numerical increase and improved distribution suggest that static muscle contractions contributed meaningfully to explosive performance enhancement. This supports the physiological argument that isometric exercises improve muscular tension, joint stability, and motor unit recruitment, which are foundational for effective jump take-off (García *et al.*, 2020; Vargas-Molina *et al.*, 2021; Santos *et al.*, 2022). Although the Stretch-Shortening Cycle (SSC) Theory of Komi and Bosco (1978) is classically associated with eccentric-concentric coupling produced by dynamic movements rather than static contractions, isometric training may indirectly support SSC-related performance through several mechanisms. Sustained isometric contractions can increase muscle and tendon stiffness, enhance neuromuscular readiness, and improve force transfer efficiency during the brief amortization phase of explosive movements, thereby facilitating more effective storage and release of elastic energy during the subsequent concentric phase (García *et al.*, 2020; Vargas-Molina *et al.*, 2021). Within this framework, exercises such as wall sits, calf raise holds, and glute bridge holds may have contributed to jump performance not by directly producing a stretch-shortening cycle but

by strengthening the stabilizing structures and improving the rate of force development required to transfer ground reaction force into upward propulsion.

Similarly, the isotonic intervention group also showed statistically significant gains, progressing from a Low Jump pretest classification to a Moderate Jump posttest classification. This indicates that dynamic resistance exercises such as squats, lunges, and leg curls were effective in improving lower-body strength and jump capacity among participants with initially lower performance levels. These findings are consistent with Hatfield's Strength Continuum Theory, which emphasizes that dynamic muscular contractions stimulate hypertrophy, strength gains, and neuromuscular adaptation necessary for explosive movements (Hatfield, 1989). Prior studies likewise noted that isotonic exercises enhance force production across a full range of motion and may improve jump performance when lower-limb strength increases are sufficient (Atalay *et al.*, 2023; Khafagy & Sakr, 2020; Kim *et al.*, 2021). The movement specificity of isotonic training may have allowed participants to develop muscular coordination patterns that better simulate jump-related biomechanics.

The paired-samples t-test results revealed that both intervention modalities produced statistically significant within-group improvements with large effect sizes, indicating that the observed gains were not only statistically reliable but also practically meaningful. The isometric group yielded $t(18) = -6.156, p < .001$, while the isotonic group yielded $t(18) = -6.356, p < .001$, with both groups demonstrating large Cohen's *d* values. These results suggest that repeated lower-body strengthening—whether static or dynamic—can substantially improve explosive power among adolescent females. Such findings align with broader training literature indicating that muscular power development is achievable through multiple physiological pathways, including static tension development, dynamic hypertrophy, and improved neural recruitment (Gillett *et al.*, 2021; Isaacs *et al.*, 2022; Pardos-Mainer *et al.*, 2021). From a practical standpoint, the large effect sizes suggest that both interventions may be viable school-friendly strategies for improving physical fitness.

Despite the significant gains observed within groups, the ANCOVA results revealed no statistically significant difference between the posttest performances of the isometric and isotonic groups after controlling for baseline scores. This indicates that neither intervention demonstrated superiority over the other, suggesting that both modalities may be comparably effective for improving vertical jump height among female adolescents. The very small effect size (Partial $\eta^2 = 0.012$) further suggests that exercise type alone accounted for minimal variance in posttest outcomes. This finding is particularly important because it highlights that similar improvements in lower-body explosive power may be achieved through different physiological adaptations—static stabilization in isometric training and dynamic hypertrophy in isotonic training (Vargas-Molina *et al.*, 2021; Rivera *et al.*, 2023). Therefore, the choice of intervention may be guided more by context, equipment availability, participant readiness, or program goals than by presumed superiority.

These findings also carry important pedagogical implications for physical education and school-based sports conditioning. Since both interventions were effective and required minimal equipment, schools with limited facilities may still implement evidence-based lower-body strengthening programs without reliance on advanced athletic resources. This is particularly relevant in post-pandemic or resource-constrained educational settings where accessible exercise strategies are essential. The results suggest that Physical Education teachers and school trainers may flexibly integrate either isometric or isotonic protocols depending on learner needs, available time, and environmental constraints. Such flexibility supports learner-centered physical education approaches while promoting inclusivity, safety, and performance enhancement among female students. From a broader perspective, these implications align directly with SDG 3 (Good Health and Well-Being) and SDG 4 (Quality Education), since low-cost and accessible interventions of this kind enable equitable participation in physical fitness development and promote health-supporting behaviors that extend beyond the classroom.

Several limitations should be acknowledged in interpreting the present findings. First, the relatively small sample size ($N = 38$, $n = 19$ per group) constrained the statistical power to detect small between-group effects, which may partly account for the very small effect size (partial $\eta^2 = 0.012$) observed in the ANCOVA. A larger sample would have provided greater sensitivity for detecting subtle modality-specific advantages, and future studies may consider a priori power analysis to determine an adequate sample size for between-group comparisons. Second, the isometric group obtained a numerically higher pretest mean than the isotonic group, reflecting a residual difference that is inherent to the use of intact class sections rather than randomized assignment. While ANCOVA was used to statistically adjust for this baseline difference, true random assignment would have minimized the risk of pre-existing group differences influencing the comparison. Third, the study did not include a non-intervention control group, which limits the ability to fully attribute observed gains exclusively to the interventions rather than to potential confounding factors such as natural maturation, repeated testing effects, or concurrent extracurricular physical activities. While the comparative design appropriately addressed the study's purpose of evaluating two active training modalities and avoided the ethical and practical concerns of withholding physical activity from a subset of students, the inclusion of a control group in future replications would strengthen causal inferences regarding modality-specific training effects.

Overall, the study contributes to the growing body of literature supporting resistance-based interventions for adolescent fitness development by demonstrating that both isotonic and isometric leg exercises can significantly improve vertical jump height in school-aged female populations. The findings affirm both Hatfield's Strength Continuum Theory and Komi and Bosco's (1978) Stretch-Shortening Cycle Theory by showing that distinct exercise modalities may produce similar functional outcomes through different mechanisms. More importantly, the results address a local research gap by providing Philippine-based evidence that structured lower-body interventions can enhance explosive performance in female non-athletes. Future studies may build on these findings by examining longer intervention durations, mixed-modality programs, additional performance outcomes such as agility, sprint speed, and balance, the inclusion of a non-intervention control group, and larger samples that can accommodate a priori power analysis—all of which would further refine school-based athletic development strategies.

CONCLUSION

This study examined the comparative effects of isotonic and isometric leg exercises on the vertical jump height of Grade 8 female students in a school-based setting. The findings demonstrated that both training modalities produced significant improvements in vertical jump height after eight weeks of intervention, indicating that structured lower-limb resistance training—whether dynamic or static—can effectively enhance explosive performance in adolescent females.

Within-group analyses revealed meaningful pre-to-post gains in both the isotonic and isometric groups, supporting the efficacy of each approach for developing lower-body power. These results align with prior evidence that dynamic resistance training enhances force production, hypertrophy, and neuromuscular coordination (Fataha *et al.*, 2021; Khafagy & Sakr, 2020; Kurhan *et al.*, 2024), while isometric training improves muscle stiffness, joint stability, and motor unit recruitment—factors critical for efficient force transfer during explosive tasks (García *et al.*, 2020; Vargas-Molina *et al.*, 2021; Muhammad *et al.*, 2023).

However, when posttest performance was compared while controlling for baseline differences, no statistically significant advantage was found for either modality. This suggests that isotonic and isometric exercises can lead to comparable improvements in vertical jump height, albeit through distinct physiological pathways. These findings are theoretically consistent with Hatfield's (1989) Strength Continuum Theory, which explains adaptations to dynamic resistance along a strength-power spectrum, and the Stretch-

Shortening Cycle model of Komi and Bosco (1978), which underscores the role of muscle stiffness and neuromuscular readiness in explosive movement.

Practically, the results indicate that both isotonic and isometric leg exercises are viable, low-cost, and accessible options for improving vertical jump performance in school-based Physical Education programs. Given constraints such as limited space, equipment, and instructional time, teachers and coaches can confidently implement either modality without compromising performance outcomes. Since the present study compared the two modalities separately rather than in combination, the question of whether integrating both approaches yields additional benefit remains open; future research may directly investigate combined-modality programs to determine whether they outperform either approach used alone.

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AI Declaration: The author used generative AI tools to assist with language refinement and formatting consistency during manuscript preparation. All scholarly content, data analysis, and conclusions are the author's own. The author reviewed and edited all AI-assisted output and takes full responsibility for the integrity and accuracy of the final article.

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