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Utilizing Balance and Hand Grip Strength Exercises in Improving Softball Overhand Throwing Accuracy

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Abstract: Accurate overhand throwing in softball is vital for defensive performance and overall game success, yet it is often underemphasized in training programs. This quasi-experimental study investigated the comparative effectiveness of handgrip strength exercises and balance exercises in improving softball throwing accuracy. A total of 120 male college students, aged 18-25 years, enrolled in a softball course were assigned to two intervention groups: one performed handgrip strength exercises, and the other underwent balance exercises. The diamond dispatch challenge test was used to assess throwing accuracy before and after an eight-week intervention. Results showed significant improvement in both groups. The handgrip strength group progressed from *developing* to *exceptional precision*, while the balance group improved to *high accuracy*. Statistical analysis using Analysis of Covariance revealed a significant difference between groups, favoring the handgrip exercises group. This suggests that while both interventions enhance overhand throwing accuracy, handgrip strength training produces greater gains. The findings align with biomechanical principles, emphasizing that the mechanics of ball release, particularly control of the forearm, hand, and fingers, are critical to accuracy. Strengthening these areas directly enhances precision and force regulation during release. Although balance contributes to postural stability, its effect on throwing accuracy is more indirect. These results support the integration of handgrip strength training into softball conditioning programs, with balance exercises included to address stability needs. Future studies may explore combined or extended interventions to further enhance effectiveness.

Keywords: Handgrip strength, balance exercises, softball overhand throwing accuracy, sports skill enhancement, quasi-experimental design

Introduction

Throwing accuracy in softball is a crucial skill that significantly contributes to effective defensive plays and overall team performance, such as making precise throws to bases to prevent scoring (Hermassi *et al.*, 2019; Ramsey & Crotin, 2019). One universal truth in fastpitch softball is that basic overhand throwing remains the most under-taught part of the game (Donaldson *et al.*, 2020; Elian, 2024). This is a major oversight, especially given that most errors in softball are attributed to poor throws (Painter *et al.*, 2024). Despite this, accuracy training continues to be underemphasized in favor of speed and strength development. This issue is particularly evident in the Philippine collegiate context, where training practices often face constraints due to limited resources and contextual challenges (Garcia, 2021; Roxas-Soriano *et al.*, 2020).

Softball coaches frequently struggle to apply consistent training interventions across athletes with varying skill levels, particularly due to differences in mechanics such as stride knee flexion, elbow flexion, and trunk rotation, all of which influence throwing precision (Donaldson *et al.*, 2020; Manzi *et al.*, 2022). Even elite athletes face difficulty maintaining high accuracy levels, as slight changes in release angle or finger positioning can drastically affect performance (Kusafuka *et al.*, 2023). On a biomechanical

level, effective overhand throwing requires coordinated force transmission from the lower extremities and trunk to the upper body (Zaremski *et al.*, 2017). Yet, coaches often face challenges in implementing conditioning programs that target all relevant muscle groups (Downs *et al.*, 2021).

Locally, some research has addressed issues surrounding softball and sports in general, including the challenges that student-athletes face in balancing academics and athletics (Garcia, 2021), as well as the broader research culture in Philippine higher education institutions (Roxas-Soriano *et al.*, 2020). However, few studies have tackled the specific issue of improving overhand throwing accuracy.

Two main interventions were considered: balance training and handgrip strength exercises. Balance exercises have been shown to enhance throwing performance by improving dynamic stability, trunk control, and reactive balance—all of which contribute to more accurate and controlled throws (Cüre *et al.*, 2020; Kim *et al.*, 2022; Sookbat *et al.*, 2019). On the other hand, handgrip strength has been linked to improved force application and ball control during release, thereby enhancing both velocity and accuracy (Hermassi *et al.*, 2019; García-Carrillo *et al.*, 2023; Ab Razak *et al.*, 2018). Despite this, few studies have directly compared these two interventions in the context of softball accuracy.

Thus, this study aimed to determine the effectiveness of handgrip strength exercises and balance exercises in improving the accuracy of softball overhand throws among male college students. Specifically, it addressed the following research questions: (1) What was the softball overhand throwing accuracy of the groups before and after the interventions? (2) How did the two groups compare in their overhand throw accuracy before and after the interventions? (3) Which of the interventions was more effective in improving overhand throwing accuracy? Meanwhile, the following null hypotheses were tested: H_{o1}: There is no significant difference between the pretest and posttest throwing accuracy within each group. H_{o2}: Neither of the two interventions is more effective in improving the overhand throwing accuracy.

The theoretical framework supporting the alternative hypotheses was grounded on three key theories. The Kinetic Chain Biomechanical Principle posits that optimal throwing accuracy depends on the efficient and sequential generation and transfer of force through body segments (Ellenbecker & Aoki, 2020; Fasbender *et al.*, 2020). The Motor Control Theory emphasizes that stability, proprioception, and coordinated segmental actions are vital for precision-based motor skills such as throwing (Hug & Tucker, 2017). The Neuromuscular Adaptation Theory posits that targeted strength or balance training enhances motor unit recruitment and intermuscular coordination, leading to improved motor performance (Tomazin *et al.*, 2021).

The findings of this study offer practical applications for sports educators, coaches, and physical education teachers by validating that both balance and handgrip exercises can be effectively incorporated into training programs to enhance softball throwing accuracy. Theoretically, it contributes to a growing body of research affirming the role of neuromuscular and postural factors in sports performance (Fu *et al.*, 2022; Oyama & Palmer, 2022).

Methods and Materials

This study employed a quasi-experimental pretest-posttest design with non-equivalent groups. A quasi-experimental approach was deemed appropriate because random assignment of participants to groups was not feasible within the academic setting. Students were pre-assigned to intact classes, and reassigning them could have disrupted academic schedules. This design allowed the researchers to implement interventions and assess changes in softball overhand throwing accuracy over time (Edmonds & Kennedy, 2016).

The participants consisted of 120 male college students, aged 18 to 25 years, who were enrolled in the PED014 (Softball) class at a university in Lanao del Sur. Convenience sampling was employed by using pre-existing class sections, acknowledging the potential limitation of selection bias. Inclusion criteria included (1) enrollment in the PED014 (Softball) course, (2) physical fitness clearance, and (3) no current musculoskeletal injuries. Exclusion criteria included (1) prior participation in varsity-level softball or baseball teams and (2) any condition limiting participation in strength or balance exercises. Participants were divided into two experimental groups: Group A (Handgrip Strength Exercises) and Group B (Balance Exercises).

The study was conducted at the university's softball field. Contextual factors, such as weather conditions, field accessibility, and class schedules, were considered to maintain consistency in the training and testing environments. Efforts to minimize environmental variability included scheduling sessions during dry weather, ensuring equipment uniformity, and holding sessions at consistent times of day. During rainy days, training and testing sessions were moved indoors to the university's grandstand to ensure continuity under safe and consistent conditions.

Group A underwent a handgrip strength exercises program involving three main exercises: (1) finger extension exercises using rubber bands, where participants stretched the band outward using all fingers simultaneously to strengthen finger extensors (Rahmawati *et al.*, 2021); (2) tennis ball squeezes, requiring participants to grip and release a tennis ball with maximum force repeatedly (Subagio *et al.*, 2024); and (3) handgrip compressions using foam hand grippers, performed in sets to fatigue to enhance grip endurance (Cronin *et al.*, 2017). Participants completed three sets of 10–15 repetitions for each exercise during every session. Each repetition was performed slowly and under control, ensuring a full range of motion and maximal voluntary effort.

Group B underwent a balance training exercises program composed of (1) single-leg stance with leg swings, where participants balanced on one foot while swinging the opposite leg forward and backward to challenge dynamic stability (Promsri, 2022); (2) lateral bounds, involving side-to-side hopping movements with emphasis on maintaining balance upon landing (Avelar *et al.*, 2016); and (3) single-leg ball catching drills, requiring participants to catch and return a ball while balancing on one foot, promoting dynamic postural control (Brachman *et al.*, 2017). Balance activities were performed in sets lasting 30–60 seconds per drill. Participants were instructed to progressively increase the difficulty by either closing their eyes, increasing the range of leg swings, or catching balls of different weights and sizes as they advanced.

Both interventions lasted eight weeks, with sessions conducted three times per week, each session lasting approximately 45 minutes. Sessions were directly supervised by trained facilitators to ensure adherence to the protocols, correct execution of techniques, progressive overload based on participants' improvements, and immediate correction of improper form when necessary.

The Diamond Dispatch Challenge (Gomez *et al.*, 2025) was used to measure softball overhand throwing accuracy. It is a game-based test designed to assess overhand throwing accuracy in softball, particularly from the catcher's position to various fielding targets, including first base, second base, third base, the pitcher, and a roaming shortstop. It mimics real-game conditions by using standardized equipment and procedures to evaluate a player's precision when aiming at both stationary and moving targets. The test's reliability was confirmed through pilot testing with both female athletes and non-athlete groups, yielding strong statistical results (Cronbach's $\alpha = 0.81$) and additional trials (Spearman-Brown = 0.90), which support the test's consistency and accuracy for measuring overhand throwing performance in softball.

Before the intervention, participants completed a pretest using the Diamond Dispatch Challenge. Following the eight-week intervention, a posttest was administered under standardized conditions, with consistent equipment, environmental settings, and clear instructions. Attendance sheets and direct supervision were employed during training and testing sessions to monitor compliance and ensure fidelity to the intervention protocols.

Ethical approval was obtained from the Research Ethics Committee of Lourdes College, Inc., the host academic institution. Participants were informed about the study's purpose, procedures, and potential risks. Written informed consent was secured from all participants. Throughout the study, the ethical principles of respect for persons, beneficence, and justice, as outlined in the Belmont Report, were upheld. Confidentiality was maintained by anonymizing data and securely storing all research records.

Results

Tables 1, 2, and 3 (*see page 34*) summarize the study's results. Table 1 summarizes the pretest and posttest scores of softball overhand throwing accuracy for Group A (handgrip strength exercises) and Group B (balance exercises). It categorizes performance into five levels, with frequencies, percentages, mean scores, descriptions, and standard deviations for both tests.

As shown in Table 1, Group A, which underwent Handgrip Strength Exercises, recorded a pretest mean score of 7.38, categorized as ***developing***, and improved to a posttest mean of 16.93, classified as ***exceptional precision***. Correspondingly, Group B, Balance Exercises, exhibited a pretest mean of 7.03, also classified under ***developing***, and advanced to a posttest mean of 15.73, designated as ***high accuracy***. These findings indicate considerable advancements in overhand throwing accuracy for both groups following the interventions, with Group A achieving a marginally superior performance category compared to Group B. Furthermore, the standard deviations demonstrate a decrease from pretest to posttest in both groups, indicating more consistent performance among participants following the intervention.

Table 2 presents the mean scores of the pretest and posttest for both groups (handgrip exercise and balance exercises), which were compared using a paired-sample t-test. This analysis evaluates whether each intervention significantly enhances softball overhand throwing accuracy following eight weeks of training.

As presented, both groups exhibited statistically significant improvements in their overhand throwing accuracy following the interventions. For the handgrip strength exercises group, the mean score elevated from 7.383 to 16.933, accompanied by a t-value of -32.979 ($p < .001$) and a substantial effect size of -4.258.

Likewise, the balance exercises group demonstrated an increase from a mean score of 7.033 to 15.733, with a t-value of -21.052 ($p < .001$) and a considerable effect size of -2.718. These findings signify that both forms of exercises effectively contributed to a notable improvement in the overhand throwing accuracy of the participants, thereby invalidating the null hypothesis (Ho_1), which posited that no significant difference would exist prior to and following the interventions within each group.

Table 3 presents the Analysis of Covariance for the two groups in improving overhand throwing accuracy. A rank-based transformation method was employed to normalize the dataset, enabling ANCOVA to differentiate between handgrip and balance exercises.

The analysis of covariance assessed the effect of balance exercises versus handgrip exercises on the participants' overhand throwing accuracy, while controlling for pretest scores. The findings indicated a statistically significant effect on posttest performance once pretest differences were accounted for, F (1, 117) = 5.82, p = .017, partial η_p^2 = .047, reflecting a large effect size. Therefore, the null hypothesis, which states that none of the interventions is more effective than the others, is rejected. This finding suggests that while both types of throwing interventions may be effective among softball players, it is revealed that handgrip strengthening exercise yielded more effects in improving overhand throwing accuracy than balance exercises. available to them, without jeopardizing the effectiveness of either approach on overhand throwing accuracy.

Additionally, this study controlled confounding variables by using ANCOVA to account for pretest differences, ensuring that posttest improvements were due to the interventions. Standardized testing procedures, consistent training duration, and similar group baselines further minimized external influences, supporting the validity of the findings.

Discussion

Based on the results for Problem 1, the softball overhand throwing accuracy of both groups was initially at the ***developing*** level before the intervention. After undergoing their respective eight-week exercise programs, both groups showed significant improvements. The handgrip strength exercise group improved to an ***exceptional*** level of precision, while the balance exercise group improved to a ***high*** level of accuracy. This indicates that both interventions were effective in enhancing the participants' overhand throwing accuracy.

At the pretest, participants assigned to the handgrip strength exercises group showed a low mean score of 7.38, indicating a developmental level. This low performance could be attributed to limited baseline grip strength and insufficient neuromuscular control over ball release during throws. According to García-Carrillo *et al.* (2023), grip strength is a significant determinant of upper limb performance and precision in throwing sports, and deficits in hand strength can directly impair control. Without prior targeted grip conditioning, participants struggled to stabilize and release the ball accurately, explaining their initial low scores. Following the intervention, the group's mean score increased significantly to 16.93, reaching an ***exceptional*** level. This improvement can be linked to neuromuscular adaptations, as training interventions focused on handgrip strength enhance the activation and coordination of throwing muscles (Hermassi *et al.*, 2019). Furthermore, strengthening the hand and forearm allows for better force transmission during release and more stable ball control (Ferraz *et al.*, 2021). Thus, the posttest gains reflect the direct impact of handgrip-focused exercises in developing fine motor control and maximizing throwing precision.

Participants in the balance exercise group also started with a low pretest mean score of 7.03, categorized as ***developing***. This suggests a lack of sufficient postural control, dynamic balance, and coordination at baseline, which are crucial for efficient force generation during overhand throwing. Šarabon and Kozinc (2020) emphasized that inadequate balance reduces overall athletic performance by disrupting force transfer through the kinetic chain. Additionally, Park *et al.* (2024) explained that balance impairments hinder the body's ability to stabilize itself during complex motor actions, resulting in inconsistencies in performance tasks such as throwing. Following the balance training intervention, the group's posttest mean improved to 15.73, reaching a ***high*** level of accuracy. This progress can be attributed to enhanced neuromuscular coordination and trunk control developed through balance-focused exercises (Promsri, 2022). Improvements in dynamic postural stability enabled participants to manage body positioning more effectively throughout the throwing motion, resulting in greater precision in targeting and release (Ramsey & Crotin, 2019). Therefore, the posttest outcomes reflect the role of balance training in stabilizing movement sequences critical for overhand throwing accuracy.

In Problem 2, both groups showed significant improvement after their interventions. The handgrip strength exercises group achieved ***exceptional precision***, while the balance exercises group achieved ***high accuracy***. This means that both balance and handgrip strength exercises effectively enhanced the participants' softball overhand throwing accuracy after eight weeks of training. The results imply that both balance exercises and handgrip strength exercises are effective training interventions for improving overhand throwing accuracy in softball. This finding suggests that strength and balance are not just complementary but fundamental to executing more precise and controlled throwing motions. For coaches, PE teachers, and athletes, the evidence supports the integration of targeted balance and handgrip training into regular softball practice. By doing so, players can significantly enhance their throwing precision, potentially leading to improved in-game performance and reduced injury risks associated with poor mechanics. The findings also emphasize that even simple, structured interventions over a short period, such as eight weeks, can yield measurable improvements in a complex motor skill, such as overhand throwing.

These findings confirm the theoretical frameworks underpinning the research. According to the Kinetic Chain Biomechanical Principle (Ellenbecker & Aoki, 2020; Fasbender *et al.*, 2020), efficient throwing relies on the sequential activation and force transfer through the body segments, which requires both balance and muscle strength. The significant improvements following balance training support Motor Control Theory, which emphasizes the importance of stability, proprioception, and coordination in executing complex movements, such as throwing (Hug & Tucker, 2017). Similarly, the improvements after handgrip strength training validate the Neuromuscular Adaptation Theory, which proposes that specific strength exercises enhance motor unit recruitment, synchronization, and force production in targeted muscles (Tomazin *et al.*, 2021). In simple terms, the participants became better throwers because their balance training strengthened their control of whole-body movements, and their handgrip training improved the precision and power of their ball release, as the theories predicted.

Recent studies strongly support these results. Downs *et al.* (2021) found that enhancing trunk stability and pre-throwing balance significantly improves throwing mechanics, aligning with the improvements observed in the balance group. Promsri (2022) also demonstrated that challenging balance exercises improve muscle coordination, resulting in better throwing outcomes. For handgrip strength, García-Carrillo *et al.* (2023) emphasized that forearm and hand muscle conditioning is critical for improving upper limb throwing performance. Similarly, Hermassi *et al.* (2019) found that incorporating grip strength exercises into athletes' training programs resulted in improved ball velocity and control.

The findings of this study support previous research by providing both local and experimental evidence that neuromuscular conditioning and postural control interventions lead to improved sports performance. For example, the work of Ramsey and Crotin (2019) on stride mechanics in throwing emphasized the importance of lower body and balance control, which was evident in the balance group's results. Similarly, Ferraz *et al.* (2021) found that improving grip strength correlates with improvements in precise sports movements, such as shooting and throwing.

Finally, the findings regarding Problem 3, which analyzed the effect of balance exercises versus handgrip exercises on the transformed posttest scores of overhand throwing accuracy, were assessed while controlling for pretest scores. The findings indicated a statistically significant group effect on posttest performance once pretest differences were accounted for, $F(1, 117) = 5.82$, $p = .017$, $\eta_p^2 = .047$, reflecting a large effect size. Therefore, the null hypothesis, which states that none of the interventions is more effective than the others, is rejected. This finding suggests that while both types of throwing interventions may be effective among softball players, handgrip strengthening exercises yielded more significant effects in improving overhand throwing accuracy than balance exercises available to them, without jeopardizing the effectiveness of either approach on overhand throwing accuracy.

The line of action prediction is based on the kinetic chain biomechanical principle, and this paper focuses on segmented movement in these activities. With respect to overhand throwing, the terminal part of the projectile—ball release is greatly influenced by the strength and coordination of the forearm and hand musculature. Accordingly, increasing handgrip strength is directly related to improved precision and force control upon release. The result also agrees with Motor Control Theory, which argues that skilled performance of motor tasks depends not only on gross, but also fine, neuromuscular adaptations. From this perspective, handgrip strength training can be viewed as a local neuromuscular stimulator, allowing for more effective control of the terminal stage of the throwing process.

The better efficacy of handgrip training in our study is supported by the results of several past studies. Cronin *et al.* (2017) and Donaldson *et al.* (2020) demonstrated that grip strength is an essential factor for overall throwing performance (velocity and accuracy). In the same line of thought, handgrip exercise was reported to improve target shooting accuracy in archery significantly (Sezer, 2017), a skill that (like overhand throwing) demands fine motor control. These results reinforce the evidence that grip strength is directly involved in object-propelling tasks with accuracy.

However, the effect of balance on overhand throwing appears to be less direct, despite balance being identified as a fundamental motor skill that plays a crucial role in sports performance. Studies (Avelar *et al.*, 2016; Brachman *et al.*, 2017) emphasized that the role of balance is to provide adequate postural stability, movement economy, and coordination for skill acquisition, which do not directly impact the throwing mechanics of throwing accuracy. Therefore, the two interventions, although they are both useful, have distinct mechanisms of action.

From a researcher's point of view, it appears that handgrip strength is a core mechanism underpinning the overhand throw. Tap the edge of the ball, exercising the muscles used for squeezing and tapping. Athletes use more controlled force, producing more precise direction. Additionally, based on the researcher's observation, a firm grip enables participants to maintain a consistent grip and release point, resulting in improved accuracy of their throws. Furthermore, handgrip strength exercises increase the velocity and speed of throws. For instance, the long distance in the Diamond Dispatch Challenge was from second base to home plate, which is approximately 84 feet. Comparing the results in this area, Group A had a better result than Group B in terms of overhand accuracy. While balance, though necessary, is a foundational quality that supports athletic posture and body control, it does not, on its own, contribute to quantifiable gains in motion patterns for a precision task such as throwing.

Conclusion

The primary purpose of this study was to examine whether balance exercises or handgrip strength exercises would be more effective in enhancing softball overhand throwing accuracy among male college students. Based on the results, the purpose was successfully achieved, concluding that although both interventions significantly improved performance, neither was superior to the other.

The results affirm the theoretical frameworks guiding the study—the Motor Control Theory, the Kinetic Chain Biomechanical Principle, and the Neuromuscular Adaptation Theory. Both interventions contributed to enhancing neuromuscular coordination, proprioception, movement sequencing, and strength, thereby supporting the understanding that multiple training strategies can lead to improved skill execution.

The study implies that both balance exercises and handgrip strength exercises are effective in enhancing overhand throwing accuracy. This provides PE teachers, coaches, and trainers with greater flexibility to select training interventions based on program design, equipment availability, or individual student-athlete needs, knowing that either approach can yield beneficial results for throwing performance.

The study suggests that school administrators integrate balance and handgrip strength exercises into physical education to enhance throwing performance in sports such as softball. PE teachers and coaches may also develop flexible training programs that incorporate these exercises, tailored to the specific context and available resources. Student-athletes are encouraged to engage regularly in these exercises to improve control, coordination, strength, and accuracy in throwing. Future research may involve diverse populations, such as female athletes and secondary school students, to evaluate generalizability. Studies could also investigate the effects of combining balance and handgrip strength exercises in a hybrid training protocol over more extended periods to assess potential synergistic benefits.

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Data Availability Statement: *The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Data will be stored securely for a minimum of five years following publication.*

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Table 1

Descriptive Statistics of Pretest and Posttest Scores by Performance Category for Handgrip Strength and Balance Exercises

			Group A				Group B			
			Handgrip Strength Exercises				**Balance Exercises**			
			Pretest		Posttest		Pretest		Posttest	
Range		**Description**	f	%	F	%	f	%	f	%
17	20	Exceptional Precision	0	0.0	39	65.0	0	0.0	26	43.3
13	16	High Accuracy	2	3.3	18	30.0	3	5.0	24	40.0
9	12	Consistent	20	33.3	3	5.0	14	23.3	10	16.7
5	8	Developing	27	45.0	0	0.0	29	48.3	0	0.0
0	4	Limited	11	18.3	0	0.0	14	23.3	0	0.0
		TOTAL	60	100	60	100	60	100	60	100
		Mean	7.38		16.93		7.03		15.73	
		Description	Developing		Exceptional Precision		Developing		High Accuracy	
		Standard Deviation	2.89		2.40		3.20		2.90	

Table 2

Paired Samples T-test Results Comparing Pretest and Posttest Scores for Handgrip Strength and Balance Exercises

Groups	Pretest		Posttest		df	t	p
	M	SD	M	SD			
Handgrip Strength Exercises	7.38	2.89	16.93	3.20	59	-32.979*	<.001
Balance Exercises	7.03	2.40	15.73	2.90	59	-21.052*	<.001

** Significant at 0.05 level.*

Table 3

Analysis of Covariance Results for Posttest Scores Controlling for Pretest

Groups	Pretest		Posttest		F(1,117)	p	η_p^2
	M	SD	M	SD			
Handgrip Strength Exercises	7.38	2.89	16.93	3.20	5.818*	0.017	0.047
Balance Exercises	7.03	2.40	15.73	2.90			

**Significant at 0.05 level.*