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## RESEARCH ARTICLE

# Improving Ground Ball Fielding Performance Using Visual Anticipation and Hip Strengthening Among Softball Athletes

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## ABSTRACT

Developing effective defensive skills is essential in softball, particularly in ground-ball fielding, which requires perceptual awareness, biomechanical stability, and coordinated motor responses. However, few related studies have examined the combined effects of visual anticipation and hip-strengthening exercises on the fielding performance of female softball athletes. This study investigated whether visual anticipation training and hip-strengthening exercises were effective interventions in improving the ground-ball fielding performance of athletes in Jasaan, Misamis Oriental. A quasi-experimental pretest-posttest design was employed, with 70 female softball athletes divided into two groups: the Visual Anticipation Drills group and the Hip Strengthening Exercises group. The study was anchored in Schmidt's (1975) Information Processing Theory and Schmidt and Lee's (2019) Motor Learning Theory, which explain how athletes detect environmental stimuli, select appropriate responses, and acquire motor skills through structured practice. Results showed that both groups significantly improved from pretest to posttest after the eight-week intervention conducted three times per week, with both reaching the Proficient level. The Visual Anticipation Drills group improved significantly ( $t(34) = -5.685$ ,  $p < .001$ , Cohen's  $d = 0.96$ ), and the Hip Strengthening Exercises group likewise showed significant improvement ( $t(34) = -5.626$ ,  $p < .001$ , Cohen's  $d = 0.95$ ), both with large effect sizes. ANCOVA results revealed no statistically significant difference between the two training methods ( $F(1,67) = 0.864$ ,  $p = .356$ , partial  $\eta^2 = .013$ ), indicating that the two interventions were comparably effective. Therefore, coaches and physical education practitioners may incorporate either or both methods into training programs to enhance softball players' defensive skills.

**KEYWORDS** ground-ball fielding, visual anticipation, hip-strengthening, softball performance, perceptual-motor training

## Introduction

Softball ground-ball fielding is a complex defensive skill that requires athletes to anticipate ball trajectory, adjust to unpredictable bounces, position the body efficiently, secure the ball, and execute a quick throw. Recent evidence shows that poor ground-ball handling can significantly affect game outcomes, particularly because defensive performance is influenced by perceptual, biomechanical, and psychological factors (Bowman *et al.*, 2021; Dugan *et al.*, 2024; Friesen & Oliver, 2023; Müller *et al.*, 2022). In Philippine club settings, where players must read unpredictable bounces on uneven field surfaces, ground-ball fielding places simultaneous demands on perceptual-cognitive processing, biomechanical stability, and rapid motor execution, making the development of these capabilities a priority for strengthening defensive efficiency and overall team performance.

International studies suggest that fielding performance is affected by variable playing conditions, surface quality, grip stability, lower-limb mechanics, and approach angle (Ferdinands & Singh, 2022; Kusafuka *et al.*, 2023; Mascitti & McNitt, 2024). However, many developing sport contexts continue to rely on repetitive drills that do not sufficiently integrate perceptual-cognitive training with biomechanical conditioning. In the Philippines, softball is gaining competitive interest, yet local clubs often face limited access to structured intervention programs, particularly those designed to improve anticipatory responses and adaptive fielding under real-game conditions (Bhalchandra & Shukla, 2024; Griffith *et al.*, 2023; Mahardika *et al.*, 2023).

Despite existing studies on softball and related striking-fielding sports, current training practices rarely combine gaze-behavioral or visual anticipation training with sport-specific hip-strengthening exercises. This gap is important because ground-ball fielding depends not only on repeated technical execution but also on the athlete's ability to read ball movement quickly, maintain a stable defensive posture, and transition efficiently from catch to throw (Ho, 2025; Hodges *et al.*, 2021; Müller *et al.*, 2024; Shalash *et al.*, 2024). Thus, an integrated model may offer a more context-responsive approach for developing fielding performance in low-resource school and club environments.

Visual anticipation training may improve athletes' ability to extract kinematic cues, predict ball direction, and respond quickly to dynamic play situations (Harris *et al.*, 2021; Kung *et al.*, 2020; Mawarti *et al.*, 2021; Müller *et al.*, 2023). Similarly, hip-strengthening exercises may enhance pelvic stability, lower-limb control, balance, agility, and recovery from erratic bounces, all of which are essential for maintaining an efficient fielding stance and accurate throwing mechanics (Alammari *et al.*, 2023; Jellad *et al.*, 2021; Nakase *et al.*, 2021; Raof *et al.*, 2024). Combining these two approaches may therefore address both perceptual-cognitive and biomechanical demands of ground-ball fielding.

This study aimed to analyze the effect of a combined model of visual anticipation training and hip-strengthening exercises on ground-ball fielding technique among athletes from a softball club in Jasaan, Misamis Oriental. Specifically, it sought to respond to performance challenges caused by irregular pitch surfaces, unpredictable ball bounces, and delayed reaction time through an intervention that integrates perceptual-cognitive and biomechanical training. In doing so, the study contributes to evidence-based sport instruction, athlete development, and context-specific training innovation aligned with SDG 4 on quality education and SDG 3 on health and well-being.

### Statement of the Problem

This study investigated whether visual anticipation training and hip-strengthening exercises were effective interventions in improving the participants' ground-ball fielding performance. In particular, the study answered the following questions:

1. What is the ground ball fielding performance of the participants before and after the interventions?
2. Do the two groups' ground ball fielding performance differ significantly before and after the interventions?

3. Which of the two interventions is more effective in improving the participants' ground ball fielding performance?

## Hypotheses

To examine the effectiveness of the interventions, the following null hypotheses were tested at 0.05 level of significance:

**Ho<sub>1</sub>:** The two groups' ground ball fielding performance does not differ significantly before and after the interventions.

**Ho<sub>2</sub>:** None of the two interventions is more effective in improving ground ball fielding performance.

## METHODS AND MATERIALS

This study employed a quasi-experimental pretest–posttest design to determine the effectiveness of visual anticipation drills and hip-strengthening exercises in improving ground-ball fielding performance among softball athletes. This design was appropriate because the study examined intervention effects in an applied sport setting where true random assignment was not feasible due to the existing training schedules and team structures of the softball club. Accordingly, the participants were assigned to two intact training groups: the Visual Anticipation Drills group and the Hip Strengthening Exercises group. The design allowed the researcher to establish baseline performance, implement the two structured interventions, and compare post-intervention changes between groups. Because the groups were intact rather than randomly assigned, the two cohorts differed in grade level (the Visual Anticipation Drills group comprised Grades 10–12 and the Hip Strengthening Exercises group comprised Grades 8–9). An independent-samples t-test on pretest scores, however, showed no significant baseline difference in fielding performance between the groups,  $t(68) = -0.340$ ,  $p = .735$ , supporting their comparability on the outcome measure; pretest scores were additionally entered as a covariate in the analysis of covariance to adjust for any residual baseline differences.

A total of seventy (70) female softball athletes from a local softball club in Jasaan, Misamis Oriental, participated in the study. They were junior and senior high school athletes spanning Grades 8 to 12, with at least six months of experience in organized softball or baseball training. Thirty-five participants were assigned to the Visual Anticipation Drills group (Grades 10–12), while the remaining thirty-five were assigned to the Hip Strengthening Exercises group (Grades 8–9), reflecting the intact-group composition of the club's existing training cohorts. Purposive sampling was applied using the following inclusion criteria: physical clearance to participate in training, absence of current hip, knee, or lower-limb injury, and willingness to participate through informed assent with parental or guardian consent.

Ground-ball fielding performance was measured using the Right Fielder Ground-Ball Fielding Performance Test (RF-GBFPT), an instrument developed by the researcher in collaboration with her mentor and reviewed by the research panel. The test simulated a game-like defensive situation in which the right fielder responded to a ground ball hit toward the right-field zone, approached and secured the ball, transferred it to the throwing hand, and threw to first base. The fielding zone was standardized at approximately 10 meters from first base and marked with cones. Each participant completed five valid trials under the same procedure, and performance was evaluated based on approach mechanics, ball control, transfer efficiency, and throwing accuracy. The instrument used a five-point scoring scale, interpreted as follows: 4.51–5.00 (Advanced), 3.51–4.50 (Proficient), 2.51–3.50 (Developing), 1.51–2.50 (Basic), and 1.00–1.50 (Poor). An observational checklist was also used to document approach efficiency, fielding position, transfer speed, and throwing accuracy.

The validity of the RF-GBFPT was established through expert review by a panel of specialists in softball coaching, physical education, and sports science. The panel evaluated the testing procedures, scoring criteria, and performance indicators, and determined that the simulated defensive situation, scoring system, and test components accurately reflected the psychomotor demands of actual softball fielding. Prior to data collection, the instrument was pilot-tested in a try-out with a separate group of athletes to examine its internal consistency using Cronbach's alpha (Kahveci, 2024). Because the try-out used a limited number of trials, the

Spearman–Brown Prophecy Formula was applied to estimate how reliability would improve as trials were added (Edelsbrunner *et al.*, 2025; Ellis *et al.*, 2024; Kadlec *et al.*, 2024; Tristan-Lopez, 2025). The projection indicated that reliability would increase with additional trials, and on this basis the testing procedure was structured to use multiple trials per participant so that the instrument would reach an acceptable level of reliability for research purposes.

Before data collection, the research protocol was submitted to the Lourdes College Research Ethics Committee, and a Certificate of Ethical Approval was secured. Formal permission was then obtained from club administrators and coaches. Orientation sessions were held to explain the study's purpose, procedures, possible risks, and potential benefits. As the participants were minors, written assent was obtained from the athletes, together with written consent from their parents or guardians. During data collection, two trained raters independently assessed performance during the pretest and posttest to support objectivity. Inter-rater agreement was monitored throughout, and any scoring discrepancies between raters were resolved through discussion to reach consensus before a final score was recorded.

The intervention was implemented over eight weeks. In Week 1, the participants completed the pretest, after which they were oriented on the training procedures and safety protocols for their respective intervention groups. During Weeks 2 and 3, the Visual Anticipation Drills group performed foundational activities involving ball tracking, direction recognition, and ground-ball speed prediction, while the Hip Strengthening Exercises group performed introductory hip abduction, hip external rotation, and balance exercises using light resistance. In Weeks 4 and 5, both interventions progressed in difficulty: the visual anticipation group performed faster anticipation drills and more game-like prediction tasks, while the hip-strengthening group increased repetitions, applied moderate resistance, and added dynamic balance activities. In Weeks 6 and 7, the visual anticipation group completed field simulations integrating ball recognition, movement, and immediate fielding responses, while the hip-strengthening group continued progressive resistance training and lower-body coordination drills. In Week 8, the posttest was administered using the same procedures and instrument as in the pretest.

The study adhered to the Belmont principles of Respect for Persons, Beneficence, and Justice (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979), ensuring voluntary participation through informed assent and consent, minimizing risk while maximizing benefit, and providing all qualified participants with equal opportunity to take part. The study also observed Republic Act No. 10173, or the Data Privacy Act of 2012, by protecting participant information through code numbers, password-protected records, and restricted data access. Participants were informed of their right to withdraw at any time without penalty. Possible physical risks, such as fatigue or minor injury, were minimized through warm-up activities, supervision, and safety monitoring. Data were analyzed using descriptive statistics, the Shapiro–Wilk test, Levene's test, paired-samples *t*-test, Cohen's *d*, ANCOVA, and partial  $\eta^2$  at the 0.05 level of significance.

## RESULTS

**Problem 1.** What is the ground ball fielding performance of the participants before and after the interventions?

Table 1 presents the frequency, percentage, mean, and standard deviation of participants' ground-ball fielding performance before and after the interventions for the Visual Anticipation Drills and Hip Strengthening Exercises groups.

**Table 1.** Descriptive Statistics of the Participants' Ground Ball Fielding Performance Before and After the Interventions

Range	Interpretation	Visual Anticipation Drills				Hip Strengthening Exercises			
		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	%
4.51 - 5.00	Advanced	0	0	0	0	0	0	0	0
3.51 - 4.50	Proficient	17	48.57	32	91.43	15	42.86	35	100

2.51 -	3.50	Developing	18	51.43	3	8.57	20	57.14	0	0
1.51 -	2.50	Basic	0	0	0	0	0	0	0	0
1.00 -	1.50	Poor	0	0	0	0	0	0	0	0
TOTAL			35	100	35	100	35	100	35	100
<b>Mean</b>			<b>3.53</b>		<b>3.95</b>		<b>3.49</b>		<b>4.00</b>	
<b>Interpretation</b>			<b>Proficient</b>		<b>Proficient</b>		<b>Developing</b>		<b>Proficient</b>	
<b>SD</b>			<b>0.39</b>		<b>0.31</b>		<b>0.51</b>		<b>0.19</b>	

In terms of descriptive statistics, the Visual Anticipation Drills group obtained a mean score of 3.53 (SD = 0.39) during the pretest and 3.95 (SD = 0.31) during the posttest. Similarly, the Hip Strengthening Exercises group recorded a mean score of 3.49 (SD = 0.51) during the pretest and 4.00 (SD = 0.19) during the posttest. Based on the rating scale presented in Table 1, the pretest mean of the Visual Anticipation Drills group fell within the Proficient level, while the Hip Strengthening Exercises group fell within the Developing level. After the eight-week intervention, both groups' posttest means were interpreted as Proficient.

For the Visual Anticipation Drills group, the pretest distribution showed that 17 participants (48.57%) belonged to the Proficient level, while 18 participants (51.43%) belonged to the Developing level. No participant fell within the Advanced, Basic, or Poor categories. During the posttest, 32 participants (91.43%) were categorized as Proficient, while only 3 participants (8.57%) remained at the Developing level. Again, none of the participants fell within the Advanced, Basic, or Poor categories.

For the Hip Strengthening Exercises group, the pretest distribution showed that 15 participants (42.86%) belonged to the Proficient level, while 20 participants (57.14%) belonged to the Developing level. None of the participants fell within the Advanced, Basic, or Poor categories. In the posttest, all 35 participants (100%) were categorized as Proficient, with no participant recorded in the remaining categories. This shift indicates that the participants' posttest scores were concentrated within the Proficient performance range.

**Problem 2.** Do the two groups' ground ball fielding performance differ significantly before and after the interventions?

**Ho<sub>1</sub>:** The two groups' ground ball fielding performance does not differ significantly before and after the interventions.

Furthermore, the second research question addresses whether the ground ball fielding performances of the two groups differ significantly before and after the interventions. The null hypothesis states that there is no significant difference in ground ball fielding performances between the two groups before and after the interventions. Before conducting the paired-samples t-test, the Shapiro-Wilk test was used to assess the normality of the difference scores. Results showed no significant deviation from normality in either group. The anticipation drills group had  $W = 0.977$ ,  $p = 0.676$ , and the hip strengthening group had  $W = 0.961$ ,  $p = 0.238$ . With p-values above 0.05, normality was confirmed, making the t-test appropriate.

**Table 2.** Paired Samples t-test for Pre-Test and Post-Test Scores in Visual Anticipation Drills and Hip Strengthening Exercises

Group	Test	M	Interpretation	SD	t	p	Cohen's d
Visual Anticipation Drills (n = 35)	Pre-test	3.53	Proficient	0.39	-5.685*	<0.001	0.96
	Post-test	3.95	Proficient	0.31			
Hip Strengthening Exercises (n = 35)	Pre-test	3.49	Developing	0.51	-5.626*	<0.001	0.95
	Post-test	4.00	Proficient	0.19			

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

Results revealed that participants in the Visual Anticipation Drills group demonstrated a statistically significant improvement from pretest to posttest,  $t(34) = -5.685$ ,  $p < .001$ , with the mean score increasing from

3.53 (Proficient) to 3.95 (Proficient). Similarly, the Hip Strengthening Exercises group showed a significant improvement,  $t(34) = -5.626$ ,  $p < .001$ , with the mean score increasing from 3.49 (Developing) to 4.00 (Proficient). Both interventions yielded large effect sizes (Cohen's  $d = 0.96$  and  $0.95$ , respectively), indicating substantial gains in ground-ball fielding performance. Given these results, the null hypothesis ( $H_{01}$ ), which states that the two groups' ground-ball fielding performance does not differ significantly before and after the interventions, was rejected. This indicates that both interventions significantly improved the participants' ground-ball fielding performance.

**Problem 3.** Which of the two interventions is more effective in improving the participants' ground ball fielding performance?

**Ho<sub>2</sub>:** None of the two interventions is more effective in improving ground ball fielding performance.

Lastly, the next research question addressed which of the two interventions was more effective at improving participants' ground-ball fielding performance. It was hypothesized that neither intervention would be more effective at improving participants' ground-ball fielding performance. Results are shown in Table 3.

**Table 3.** ANCOVA Summary Table for Posttest Scores with Pretest Scores as Covariate

Group	n	Adjusted Mean	SE	95% CI	F(1, 67)	p	Partial $\eta^2$
Hip Strengthening Exercises	35	4.010	0.044	[3.923, 4.097]	0.864	0.356	0.013
Visual Anticipation Drills	35	3.953	0.044	[3.866, 4.040]			

An ANCOVA was conducted with posttest scores as the dependent variable, group as the fixed factor, and pretest scores as the covariate. Assumptions were verified prior to analysis: Levene's test ( $F(1,68) = 3.213$ ,  $p = .077$ ) confirmed homogeneity of variances, and the Q-Q plot indicated normally distributed residuals. These results supported the use of ANCOVA.

The Hip Strengthening Exercises group had an adjusted mean of 4.010 (SE = 0.044, 95% CI [3.923, 4.097]), while the Visual Anticipation Drills group had an adjusted mean of 3.953 (SE = 0.044, 95% CI [3.866, 4.040]); both groups remained at the Proficient level. The ANCOVA results indicated that the difference between the two groups was not statistically significant,  $F(1,67) = 0.864$ ,  $p = .356$ , partial  $\eta^2 = .013$ , after controlling for pretest scores. Therefore, the null hypothesis ( $H_{02}$ ), which states that neither intervention is more effective in improving the participants' ground-ball fielding performance, was not rejected. This finding suggests that both interventions were comparably effective in improving the participants' ground-ball fielding performance.

## DISCUSSION

The participants' ground-ball fielding performance can be understood in relation to their prior softball training and playing experience. Since ground-ball fielding is a fundamental defensive skill regularly practiced in softball, the participants likely began the study with an existing level of technical skill, motor coordination, and game familiarity. This explains why many participants were already classified within the higher performance levels during the pretest and why posttest performance further improved after the interventions. Ground-ball fielding requires athletes to track the ball, anticipate its bounce, position the body efficiently, and execute controlled pickup and throwing mechanics under time pressure (Ho *et al.*, 2023; Hodges *et al.*, 2021; Dahl & Tillaar, 2021; Aloui *et al.*, 2020). This finding is consistent with studies showing that sport experience helps athletes use visual and situational cues more efficiently and perform sport-specific responses with greater consistency (Harris *et al.*, 2022; Runswick *et al.*, 2020).

The improvement of the Visual Anticipation Drills group suggests that perceptual-cognitive training supported the participants' ability to process ball movement more effectively. Drills such as the wall toss, clap catch, and bounce prediction challenge are closely related to fielding demands because they develop eye-

hand coordination, gaze behavior, timing, and response preparation. This supports previous findings that perceptual-cognitive and dynamic visual training improve athletes' capacity to interpret ball trajectory, anticipate bounce behavior, and organize quicker perception-action responses in ball sports (Ho *et al.*, 2023; Müller *et al.*, 2024; Mawarti *et al.*, 2021; Ono *et al.*, 2024; Rodrigues *et al.*, 2024).

The improvement of the Hip Strengthening Exercises group could be attributed to enhanced postural control, lower-limb stability, and body positioning during defensive movements. Exercises such as squats and lunges helped develop force production, trunk stability, balance, and change-of-direction ability, all of which were essential when lowering the body, approaching the ball, and shifting into a throwing stance (Brazil *et al.*, 2021; Raof *et al.*, 2024; Jacobs *et al.*, 2025; McGill & Karpowicz, 2020; Loturco *et al.*, 2021; Suchomel *et al.*, 2020). Thus, the participants' improved posttest performance indicated that hip strengthening contributed to more stable and coordinated fielding mechanics.

The paired-samples t-test results showed significant pretest-posttest improvements in both groups. Accordingly, the null hypothesis ( $H_{01}$ ) was rejected. Observations during the eight-week intervention also supported these results. Participants in the Hip Strengthening Exercises group gradually demonstrated improved body positioning, a lower defensive stance, and more controlled movements, while participants in the Visual Anticipation Drills group became more responsive to ball trajectory and bounce patterns. These improvements were consistent with Schmidt's (1975) Information Processing Theory, which explains that sport performance depends on perceiving environmental cues, processing information, and executing appropriate motor responses. The findings also aligned with Schmidt and Lee's (2019) Motor Learning Theory, which emphasizes that repeated structured practice improves skill acquisition and movement consistency.

The ANCOVA results showed no significant difference between the Visual Anticipation Drills and Hip Strengthening Exercises groups after controlling for pretest scores. Neither intervention was more effective than the other, indicating that both training approaches produced comparable improvements in ground-ball fielding performance. This similarity may be explained by the fact that each intervention addressed a different but essential component of defensive skill: visual anticipation strengthened perceptual readiness, while hip strengthening improved biomechanical stability. Existing studies similarly show that visual anticipation training helps athletes interpret trajectory, speed, and bounce patterns more accurately (Mawarti *et al.*, 2021; Harris *et al.*, 2021; Müller *et al.*, 2024), while lower-limb strength and postural stability support efficient fielding posture and glove-to-throw movement (Nakase *et al.*, 2021; Jellad *et al.*, 2021; Valente *et al.*, 2021).

Overall, the findings indicate that ground-ball fielding performance depends on both perceptual-cognitive processing and biomechanical readiness. Visual anticipation drills helped the participants recognize ball movement earlier and respond more efficiently, whereas hip-strengthening exercises provided the physical foundation for balance, stability, and controlled fielding mechanics. Since successful fielding requires both accurate perception and stable movement execution, coaches and physical education practitioners may use either intervention or integrate both into training programs to enhance defensive performance in softball (Ho *et al.*, 2023; Raof *et al.*, 2024; Zou, 2024).

## CONCLUSION

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This study determined the effectiveness of visual anticipation drills and hip-strengthening exercises in improving ground-ball fielding performance among female softball athletes. The findings confirmed that both interventions led to significant improvements from pretest to posttest, demonstrating their effectiveness in enhancing defensive performance. However, the absence of a statistically significant difference between the two groups indicates that both training methods are equally beneficial and may be used interchangeably or in combination. These results support Schmidt's (1975) Information Processing Theory and Schmidt and Lee's (2019) Motor Learning Theory, which emphasize that efficient sport performance depends on the athlete's ability to perceive, process, and respond to environmental stimuli, and that structured practice strengthens skill acquisition. The improvement observed in both groups suggests that perceptual-cognitive and biomechanical training jointly support effective motor responses during ground-ball fielding. From pedagogical and practical perspectives, coaches and physical education

practitioners are encouraged to integrate visual anticipation drills and hip-strengthening exercises into their training programs. Incorporating these approaches may promote holistic skill development by improving both decision-making and movement efficiency, ultimately leading to better defensive performance in softball.

Based on the findings, the following practical recommendations are proposed. Physical Education teachers may incorporate visual anticipation drills and hip-strengthening exercises into their instructional practices to help students improve defensive skills such as ground-ball fielding, coordination, and movement efficiency in softball and other ball sports. Softball coaches and sports trainers may integrate perceptual-cognitive training and lower-body strengthening exercises into regular training programs to enhance athletes' anticipation, stability, and overall defensive performance. School sports programs may adopt structured training sessions that combine perceptual training and biomechanical strengthening to develop both the cognitive and physical components of sport performance. Student-athletes may engage in consistent practice of visual anticipation activities and hip-strengthening exercises as part of their personal training routines to further improve fielding performance and defensive readiness. Future research may build on this study by exploring additional variables and related contexts. Specifically, future studies may replicate the design using larger sample sizes, different age groups, or athletes from other ball sports to further examine the effectiveness of perceptual-cognitive and strength-based training interventions. They may also explore the combined effect of visual anticipation drills and hip-strengthening exercises within a single training program to determine whether integrating both approaches yields greater improvements in ground-ball fielding performance. Finally, they may investigate additional variables related to defensive performance, such as reaction time, agility, and coordination, to deepen understanding of the factors influencing fielding skills in softball and similar sports.

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**AI Declaration:** This study utilized artificial intelligence tools to assist in preparing this article. Specifically, an AI assistant was used to help condense the full thesis manuscript into a reduced journal-article format and to enhance language quality, clarity, and tone, with human supervision and editing throughout. The author carefully reviewed and edited all outputs to ensure academic rigor and integrity.

**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.