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RESEARCH ARTICLE

Effectiveness of Closed Kinetic Chain and Core Exercises on Baseball Throwing Distance Among Grade 8 Student-Athletes

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ABSTRACT

This study examined the effectiveness of closed kinetic chain (CKC) and core exercises in improving baseball throwing distance among Grade 8 student-athletes. Using a quasi-experimental two-group pretest–posttest design, two intact class sections (n = 26 each) completed an eight-week intervention during MAPEH classes: one performed CKC exercises (squats, push-ups, lunges) and the other core exercises (planks, sit-ups, Russian twists). Throwing distance was measured with a standardized baseball throw-for-distance test. Data were analyzed using descriptive statistics, paired-samples t-tests, and analysis of covariance (ANCOVA) with pretest scores as the covariate, with rank-based transformation applied to meet assumptions. Both groups improved significantly from pretest to posttest (CKC: $t = -6.953$, $p < .001$, $d = -1.364$; Core: $t = -5.278$, $p < .001$, $d = -1.035$), with the CKC group moving from a "Fair" to a "Good" classification and the core group remaining at "Fair." The ANCOVA showed no significant between-group difference after adjusting for pretest, $F(1,49) = 2.822$, $p = .099$, partial $\eta^2 = 0.054$, indicating that the two programs were comparably effective. The findings support Kinetic Chain Theory and the Core Stability Model and suggest that both low-cost, school-deliverable programs can enhance throwing performance in physical education settings.

KEYWORDS *closed kinetic chain, core exercises, throwing distance, baseball, physical education*

INTRODUCTION

Throwing distance is a key indicator of performance in baseball, influencing a player's ability to make powerful, accurate throws across the field. Improving throwing distance can meaningfully affect gameplay, making the development of the techniques and physical attributes that support it an important training goal (Cross *et al.*, 2022; Naito, 2021).

Throwing distance depends on coordinated movement sequencing, muscular coordination, and the strength and elasticity of key muscle groups (Yamaura *et al.*, 2021). Because the phases of throwing demand kinetic efficiency and whole-body coordination, training that develops movement efficiency through the kinetic chain is increasingly emphasized in baseball conditioning, and functional strength training that engages multiple joints to mimic athletic movements has become a prominent approach (Earp *et al.*, 2023; Oyama & Palmer, 2022).

Despite these insights, few studies have examined how functional strength approaches such as closed kinetic chain (CKC) and core exercises jointly affect baseball throwing distance. Prior work has examined CKC benefits for joint stability and upper-limb performance (Chandler, 2020; Bi *et al.*, 2023) and core training for rotational power and postural control (Yang *et al.*, 2022; Mengyao & Seung-Soo, 2022) largely in isolation, and much of the evidence comes from elite athletes rather than school-aged or amateur players. School-based athletes often lack access to advanced equipment or specialized trainers, creating a need for practical, low-cost, structured programs.

Addressing this gap, the present study determined the effectiveness of CKC and core exercises in improving baseball throwing distance among Grade 8 student-athletes and compared the two programs. The findings offer an evidence-based model for physical education teachers and coaches and align with the goals of inclusive, quality physical education in schools.

This study sought to answer the following questions: (1) What are the throwing distances of the two groups before and after the interventions? (2) Do the throwing distances within each group differ significantly from pretest to posttest? and (3) Is there a significant difference between the two interventions in improving throwing distance after controlling for pretest scores?

The following hypotheses, tested at $\alpha = 0.05$, were examined: Ho_1: Within each group, throwing distance does not differ significantly from pretest to posttest. Ho_2: There is no significant difference between the two interventions in improving throwing distance after controlling for pretest scores.

METHODS AND MATERIALS

The study used a quasi-experimental two-group pretest–posttest design to compare the effects of CKC and core exercises on throwing distance under authentic school conditions. Random assignment of individual students was not feasible, so intact class sections were used; sections were allocated to the two intervention conditions to support comparison while preserving the natural instructional setting.

Participants were Grade 8 students from a junior high school during School Year 2025–2026. The Grade 8 level comprised 57 students across three intact sections handled by the researcher (the MAPEH teacher): one section performed CKC exercises, one performed core exercises, and a third served as the try-out group for instrument testing and was excluded from the main analysis. After application of inclusion criteria (enrollment, physical readiness, regular attendance, and signed assent/consent) and the removal of incomplete or outlier data, the final analytic sample comprised 26 participants per group (52 in total).

Throwing distance was assessed using a baseball throw-for-distance test adapted from standardized youth fitness batteries (American Alliance for Health, Physical Education, Recreation and Dance, 1980). Participants performed maximal-effort throws from behind a designated line into an open field, and distance was measured in meters to the first point of ground contact using a calibrated tape, recorded to the nearest

0.1 m. Each participant was given three trial attempts, and the best (farthest) valid throw was recorded as the final score.

Throwing distance was classified using the study's operational five-level scale: Poor (10–28.99 m), Fair (29–46.99 m), Good (47–64.99 m), Very Good (65–82.99 m), and Outstanding (83–100.99 m). This author-defined classification was used to describe performance levels; it is not drawn from an external normative source, and future work may benefit from validating age-appropriate norms for Grade 8 throwers.

The test has established content and construct validity for assessing throwing-related upper-body power, and high test–retest reliability when standardized procedures are followed (Morrow *et al.*, 2016). Prior to the main study, the instrument and testing procedures were tried out with a separate group of students to confirm the clarity, consistency, and feasibility of administration, supporting the readiness of the protocol for the main data collection.

The eight-week program ran twice weekly during MAPEH classes using progressive overload. The CKC group performed squats, push-ups, and lunges; the core group performed planks, sit-ups, and Russian twists. Each session lasted about 30 minutes with standardized warm-up and cool-down, progressing from low intensity (Weeks 1–2) through moderate (Weeks 3–6) to higher intensity with emphasis on consistent execution (Weeks 7–8). Attendance and adherence were monitored throughout.

Descriptive statistics summarized pretest and posttest performance. Paired-samples t-tests assessed within-group change, and ANCOVA compared posttest performance between groups with pretest scores as the covariate. Because the original data violated normality and homogeneity of variances, two outliers were removed from the CKC group and a rank-based transformation was applied, after which assumptions were satisfied. All inferential tests used $\alpha = 0.05$.

RESULTS

Both groups improved in throwing distance after the intervention (Table 1). The CKC group increased from a pretest mean of 27.73 (Poor) to a posttest mean of 32.57 (Fair), and the core group from 26.45 (Poor) to 29.66 (Fair). The CKC group showed the larger gain (+4.84 m versus +3.21 m for the core group), and only the CKC group reached the Good band by posttest (3 students, 11.54%).

Table 1. *Descriptive Statistics of Throwing Distance Before and After the Interventions*

Score Range	Interpretation	CKC				Core			
		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	%
83–100.99	Outstanding	0	0	0	0	0	0	0	0
65–82.99	Very Good	0	0	0	0	0	0	0	0
47–64.99	Good	0	0	3	11.54	0	0	0	0
29–46.99	Fair	10	38.46	12	46.15	12	46.15	15	57.69
10–28.99	Poor	16	61.54	11	42.31	14	53.85	11	42.31
TOTAL		26	100	26	100	26	100	26	100
Mean		27.73		32.57		26.45		29.66	
Interpretation		**Poor**		**Fair**		**Poor**		**Fair**	
SD		9.32		10.23		7.46		8.67	

Both interventions produced statistically significant within-group improvements (Table 2). For the CKC group, scores rose from 27.73 (Poor) to 32.57 (Fair), t = −6.953, p < .001, d = −1.364 (large). For the core group, scores rose from 26.45 (Poor) to 29.66 (Fair), t = −5.278, p < .001, d = −1.035 (large). Ho_1 was therefore rejected for both groups.

Table 2. *Paired-Samples t-test for Pretest and Posttest Scores (Rank-Transformed)*

Group	Test	M	Interp.	SD	t	p	Cohen's d
CKC	Pre-test	27.73	Poor	9.319	−6.953*	<0.001	−1.364
	Post-test	32.57	Fair	10.23			
Core	Pre-test	26.45	Poor	7.462	−5.278*	<0.001	−1.035
	Post-test	29.66	Fair	8.671			

**Significant at the 0.05 two-tailed level. M = mean, SD = standard deviation, t = t statistic, p = probability value, Cohen's d = effect size. A rank-based transformation was applied to address normality.*

After adjusting for pretest scores, the difference between the two groups was not statistically significant, F(1,49) = 2.822, p = .099, partial η^2 = 0.054 (Table 3). Although the CKC group had a higher posttest mean, the adjusted difference was small and not statistically meaningful; Ho_2 was not rejected. Both programs were comparably effective, with both groups reaching a "Fair" posttest classification.

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

GROUPS	Adjusted Mean	Interpretation	F(1,49)	p	Partial η^2
Closed Kinetic Chain (CKC)	31.89	Fair	2.822	0.099	0.054
Core Exercises	30.33	Fair			

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

Note. F(1, 49); posttest scores were compared between the two groups with the pretest as covariate (N = 52).

DISCUSSION

Both CKC and core exercises significantly improved throwing distance, with large within-group effects, but neither was significantly superior after adjusting for pretest performance. These results are consistent with Kinetic Chain Theory (Steindler, 1955) and the Core Stability Model (Panjabi, 1992): throwing depends on coordinated force transfer across interdependent segments rather than any single component. CKC exercises develop force production and stability in the lower and upper segments of the chain, while core exercises strengthen the trunk that links them; because both target essential, complementary parts of the same system, comparable overall gains are expected.

The findings align with evidence that CKC training improves joint stability, neuromuscular coordination, and functional strength (Akhil *et al.*, 2022; Chandler, 2020) and that core training enhances rotational power, postural control, and energy transfer in overhead tasks (Eraslan *et al.*, 2020; Mengyao & Seung-Soo, 2022). They also echo reports that distinct but integrated training modalities can yield similar performance improvements (Crotin *et al.*, 2023). For physical education, the practical implication is encouraging: both low-cost, equipment-light programs can be integrated into ordinary MAPEH classes to improve throwing performance.

LIMITATIONS OF THE STUDY

Several limitations should be noted. The design used intact, non-randomized sections from a single school with a small sample (26 per group) and no passive control group, limiting causal inference and generalizability. The performance-classification norm requires validation for this age group, and some assumption violations necessitated outlier removal and data transformation, which should be interpreted with care.

CONCLUSION

Closed kinetic chain and core exercises each significantly improved baseball throwing distance among Grade 8 student-athletes, moving both groups from a “Poor” to a “Fair” level, with no significant difference between the two programs. Both approaches are therefore viable, accessible options for enhancing throwing performance in school-based physical education, supporting the value of coordinated, whole-body training grounded in kinetic-chain and core-stability principles.

Physical education teachers may incorporate either CKC or core exercise programs into MAPEH classes to enhance throwing performance, since both proved comparably effective and require minimal equipment. Future research should use larger, randomized samples across multiple schools, include a control group, validate age-appropriate throwing-distance norms, and examine whether combining CKC and core training yields additional benefits, as well as longer-term retention of gains.

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AI Declaration: *This study utilized artificial intelligence tools to assist in preparing this article. Specifically, AI assistance was used to help condense the full thesis manuscript into a reduced journal-article format and to refine language quality, clarity, and tone, with human supervision and editing throughout. All statistical results were checked against the author's thesis and source data, and the author carefully reviewed and edited all outputs to maintain 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.*