Effect of Closed and Open Kinematic Chain Exercises on Shoulder Stability of Archers

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Abstract: _Background: Archery is a precision sport requiring optimal shoulder stability for maintaining bow alignment and shooting accuracy. Both Closed Kinetic Chain (CKC) and Open Kinetic Chain (OKC) exercises are widely used in shoulder rehabilitation and strengthening, but limited evidence exists regarding their combined effect on archers. Objective: To determine the effect of closed and open kinetic chain exercises on shoulder stability in archers. Methods: Fifteen competitive archers (12 males, 3 females; age 15–25 years) participated in a 6-week exercise program (3sessions/week). Shoulder stability was assessed pre- and post-intervention using the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) and Upper Quarter Y-Balance Test (UQYBT). Paired t-test was used for statistical analysis. Results: Significant improvement was observed in CKCUEST (Pre: 19.47±2.29; Post: 22.20±1.93; p<0.001). Right UQYBT showed significant improvement (p<0.001), while left UQYBT showed non-significant change (p=0.103). Conclusion: Combined CKC and OKC exercises significantly improve shoulder stability in archers and may enhance performance while reducing injury risk._

Keywords: Archery, Shoulder Stability, Closed Kinetic Chain, Open Kinetic Chain, CKCUEST, UQYBT

1. Introduction

Archery is a static precision sport that demands upper limb strength, neuromuscular coordination, and shoulder stability. The shooting cycle includes stance, aiming, sighting, and release phases. During aiming and sighting phases, the shoulder girdle undergoes substantial isometric loading, requiring optimal muscular co-activation and proprioceptive control.

The primary muscles involved include trapezius, deltoid, latissimus dorsi, rotator cuff muscles, rhomboids, and serratus anterior. Shoulder stability is crucial to prevent deviations in arrow-target alignment.

Closed kinetic chain exercises enhance joint stability through compressive forces and muscle co-activation, whereas open kinetic chain exercises allow isolated strengthening of specific muscles. Studies by Wilk et al. (1996) and Reinold et al. (2009) have demonstrated the biomechanical advantages of CKC exercises for shoulder rehabilitation.

However, limited literature exists on their application in archers. Therefore, this study aimed to evaluate the effect of combined CKC and OKC exercises on shoulder stability in archers.

2. Methodology

15 Archers (12 males and 3 females) including both university and school level were recruited from Jhansi ranging from 15-25 years of age. Only healthy archers were included in the study. Individual with upper limb injury in last 6 months, systemic illness, psychological illness were excluded. All testing and training procedure, benefits and potential risks of study were explained to each subject both verbally and in written before their informed consent was obtained. The study was approved by the institutional Ethical committee.

Table 1: Participants Age, weight, Height, BMI

Characteristics	Minimum	Maximum	Mean	Std. Deviation
Age	15.0	24.0	19.667	2.8702
Weight	49.0	86.0	60.467	8.9989
Height	1.58	1.78	1.6947	0.06116
BMI	18.3768	27.4506	21.020926	2.5259920

Subjects Shoulder stability is measured by Closed Kinematic Chain Upper extremity Stability Test and the upper quarter Y-balance test (UQYBT).

In closed kinematic chain upper extremity stability test (CKCUEST) the starting position is push up position. Two strips of tape width of 1.5 inches placed parallel each other 36 inches apart on the floor. Place each hand on the strip. Shoulder is placed directly over hand. When examiner say start the subject remove one hand from floor and touches the opposite line and then return the hand on original position. The score is given by number of touches in 15 seconds. Each subject will perform a warm up trial and the three real trial of test with rest period of 45 seconds between the trials. Average of 3 trials is used for data analysis.

In upper quarter Y-balance test (UQYBT) Starting is push up position, feet no more than 12 inches apart. Subject performs maximal effort reaches with free hand in 3 directions (medial, superolateral, inferior) in relation to stationary arm. The distance reached in each direction is measured. Average of 3 trials are used for data analysis. The sum of reach direction is calculated as a total excursion score. For normalization of limb length, a composite score is calculated taking total excursion distance and dividing it by 3 times the upper limb length.

Then Subjects are participated to open and closed kinematic exercise programs include 3 sets of 10 repetitions for three

times per week for Six weeks. Closed kinematic exercise include Push up with hands placed on a ball, Push up with hands placed on balance system, Push-ups performed with hands placed on a balance system and With legs placed on a physioball to create greater demands on the dynamic stabilizers, Scapular press-up. Open kinematic exercise include Prone with full can Exercise, Diagonal Exercise for Subscapularis.

S. No	Exercise Description	Protocol
	Closed kinematic chain exercises	
1.	Push up with hands placed on a ball.	3 sets of 10 repetitions for three times per week for Six weeks.
2.	Push up with hands placed on balance sytem.	3 sets of 10 repetitions for three times per week for Six weeks.
3.	Push-ups performed with hands placed on a balance system and With legs placed on a physioball to create greater demands on the dynamic stabilizers	3 sets of 10 repetitions for three times per week for Six weeks.
4.	Scapular press-up	3 sets of 10 repetitions for three times per week for Six weeks.
	Open kinematic chain exercies	
5.	Prone with full can Exercise.	3 sets of 10 repetitions for three times per week for Six weeks.
6.	Diagonal Exercise For Subscapularis.	3 sets of 10 repetitions for three times per week for Six weeks.
7.	Bilateral external rotation for Infraspinatus and Lower Trapeziu	3 sets of 10 repetitions for three times per week for Six weeks.
8.	Dynamic hug exercise for the Serratus Anterior.	3 sets of 10 repetitions for three times per week for Six weeks.

After 6 weeks of exercise program again the Shoulder stability is measured by Closed Kinematic Chain Upper extremity Stability Test and the upper quarter Y-balance test (UQYBT). Then compared pre and post values.

Statistical analysis: The data analysis was done by using IBM SPSS Statistics 23 software. Paired t-Test is used for analysis of pre and post data. Also checked the normality of data and the data was normally distributed. We used Error bar plot with 95% confidence interval using standard deviation. The upper quarter Y-balance test (UQYBT) for right side before exercise was 0.830115 ± 0.0529730 and after 6 weeks of exercise program it is increased to 0.876235 ± 0.0420069. There is significant difference between Right UQYBT. +Pre and Right UQYBT. Post ($P=0.000$). Upper quarter Y-balance test (UQYBT) for left side before exercise was 0.830115 ± 0.0529730 and after 6 weeks of exercise program it is increased to 0.876235 ± 0.0420069. There is no significant difference between Left UQYBT. Pre and Left UQYBT. Post ($P=0.000$).

**Summary of the closed kinematic chain upper extremity stability test (CKCUEST)**

	Minimum	Maximum	Mean	Std Deviation	P-Value
CKCUEST Pre Value	16.0	24.0	19.467	2.2949	0.000
CKCUEST Post Value	18.0	25.0	22.200	1.9346	

Summary of the upper quarter Y-balance test (UQYBT)

Side	UQYBT	Minimum	Maximum	Mean	Std. Deviation	P-Value
Right	UQYBT. Pre	0.7292	0.9418	0.830115	0.0529730	0.000
	UQYBT. Post	0.8103	0.9748	0.876235	0.0420069	
Left	UQYBT. Pre	0.769	1.018	0.86469	0.061443	0.103
	UQYBT. Post	0.8212	1.0463	0.886876	0.0618925	
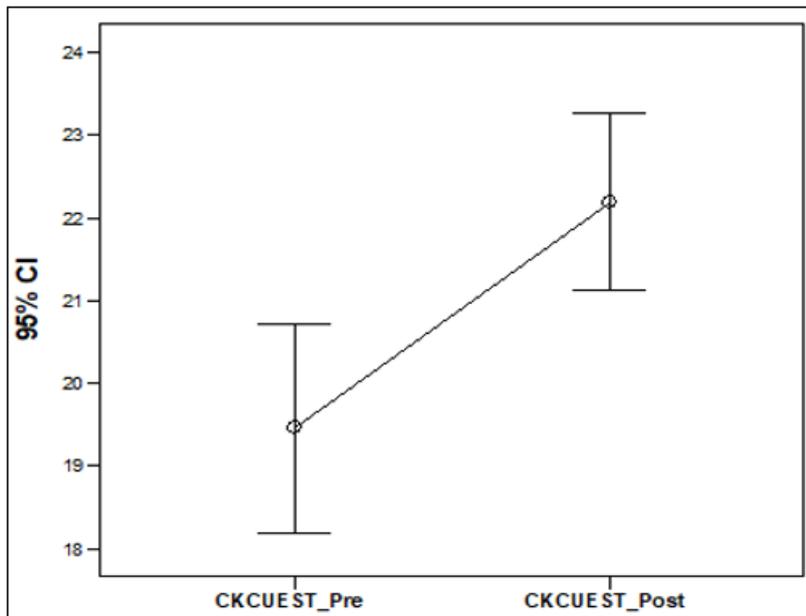
Graph 1: Error bar plot denotes CKCUEST pre and post means with 95% confidence interval using standard deviation.
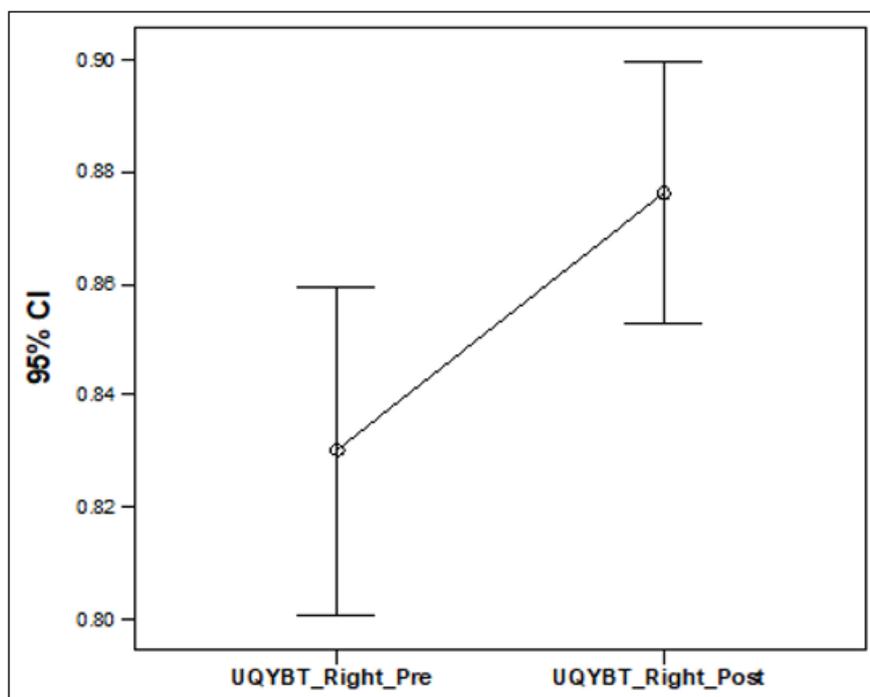
Graph 2: Error bar plot denotes Right **UQYBT** pre and post means with 95% confidence interval using standard deviation.

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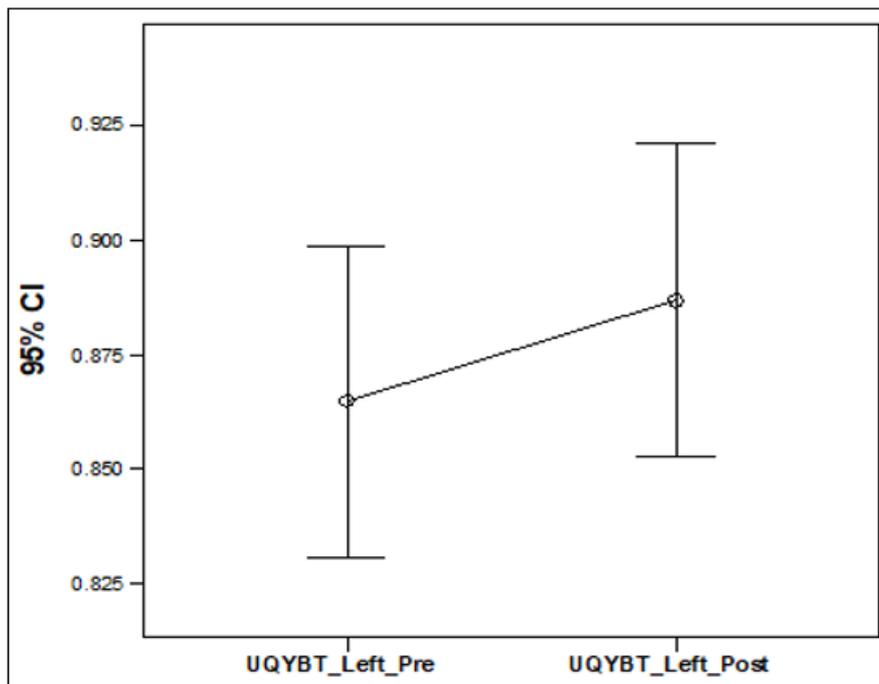
Graph 3: Error bar plot denotes Left UQYBT pre and post means with 95% confidence interval using standard deviation.

Paired samples Test

		Paired Differences					t	df	Sig (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the difference				
					Lower	Upper			
Pair 1	CKCUEST (Pre) & CKCUEST (Post)	-2.7333	1.5796	0.4079	-3.6081	-1.8586	-6.702	14	0.000
Pair 2	Right UQYBT (Pre) & Right UQYBT (Post)	-0.04612	.0322735	.0083330	-.0639924	-.0282475	-5.535	14	.000
Pair 2	LEFt UQYBT (Pre) & Left UQYBT (Post)	-.0221897	.0492075	.0127053	-.0494399	.0050605	-1.746	14	.103

3. Results

Before exercise the shoulder stability was measured by CKCUEST was 19.467±2.2949 and after 6 weeks of exercise protocol it is increased to 22.200±1.9346. There is a significant difference between CKCUEST Pre. Value and CKCUEST Post Value (P=0.000).

The upper quarter Y-balance test (UQYBT) for right side before exercise was 0.830115±0.0529730 and after 6 weeks of exercise program it is increased to 0.876235±0.0420069. There is significant difference between Right UQYBT. +Pre and Right UQYBT. Post. (P=0.000). Upper quarter Y-balance test (UQYBT) for left side before exercise was 0.830115±0.0529730 and after 6 weeks of exercise program it is increased to 0.876235±0.0420069. There is no significant difference between Left UQYBT. Pre and Left UQYBT. Post (P=0.000).

4. Discussion

The result of present study shows that after 6 weeks of closed and opened kinematics exercises as per protocol, When paired t test was applied within the groups then there was a significant difference found on CKCUEST (Pre) & CKCUEST (Post) .(P= **0.000)**. Also there is significant

difference between Right UQYBT (Pre) & Right UQYBT (Post) (**P=0.000)**. But there is no significant difference found on LEFT UQYBT(Pre) & Left UQYBT(Post) (P=**0.103).**

The closed kinematic chain upper extremity stability test (CKCUEST)
Our study shows a significant improvement in CKCUEST after 6weeks of open and closed kinetic chain exercise. This shows that closed and open kinetic exercise have a positive effect on the shoulder stability of archers. The increased shoulder stability could be due to closed kinetic chain exercise that could stimulate muscle co-activation and increased proprioceptive stimulation..CKC exercises using an unstable base of support make greater demands on the neuromuscular system and thus will lead to an increase in joint stability, proprioception, and muscle control and muscle co-activation. CKC exercises with an unstable base of support generate a series of patterns of movement due to the sudden changes in the direction of movement. This perturbation stimulates mechanoreceptors and results in increased joint stabilization.

Some studies shows that after 4 weeks of upper extremity exercise conduction balance board have a significant improvement in the CKCUEST (Elise P. STRUTT et.al, 2018). Also some studies says that after 3 months of

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specialized training program for strengthening the main scapular stabilizing muscles there is significant improvement in the CKCUEST (Dainius Grigaliūnas et.al2015).

The upper quarter Y-balance test (UQYBT).
Our study shows a significant improvement in UQYBT after 6weeks of open and closed kinetic chain exercise. This shows that closed and open kinetic exercise have a positive effect on the shoulder stability of archers. The upper quarter Y-balance test (UQYBT)is used for assessing upper quarter stability and mobility. So this study shows that by giving specific exercise program that include open and closed kinetic exercise will improve shoulder stability.

The result of present study are in relation with findings of Dainius Grigaliūnas et.al (2015) on the influence of specialized training programme on rugby players scapular stability and shoulder injury risk reduction. After 3 months of specialized training program for strengthening the main scapular stabilizing muscles, he found that there is significant improvement in UQYBT. This is the first study that shows the effect of closed and open kinetic chain exercise on shoulder stability.

Since the shoulder stability is very important to avoid deviations in arrow-target alignment and cause deviation from the score, we can say that closed and open kinetic exercises are effective to improve shoulder stability of archers

5. Conclusion

Shoulder stability of bow arm and drawing arm though out the phases of shooting to avoid deviations in arrow target alignment and to achieve a great score from thius study we can conclude that open and closed kinetic chain exercise have a significant role in the improving the shoulder stability of archers. And also it will helps to stimulate the muscle co-ordination and proprioceptive stimulus. So this exercise can be used to improve the shoulder stability of archers.

6. Clinical Implications

1) CKC + OKC exercises can be incorporated in archery conditioning programs.
2) May reduce shoulder injury risk.
3) Improves proprioception and muscle coordination.
4) Randomized controlled trials with larger samples.
5) EMG-based muscle activation studies.
6) Long-term follow-up studies.
7) Performance-based outcome measures.

7. Limitation of the Study

1) The small sample size. The study can be done with a large sample size for more accurate and betterment of the results.
2) The study data was collected from a limited area which can be collected from a larger geographical area.
3) The study was performed with male subjects. Thus this result can be generalized to female subjects.
4) The study has Short intervention duration (6 weeks) and Limb dominance not analyzed, No control group

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