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Effect of Lower Body, Core and Upper Body Kinematic Chain Exercise Protocol on Throwing Performance and Shoulder Muscle Strength among University Shot Put Athletes – A Randomized Controlled Trial

Vinod Kumar K C [1,*,†], Shenbaga Sundaram Subramanian [2,†], Riziq Allah Mustafa Gaowgzeh [3], Samira Ahmed Alsenany [4], Sally Mohammed Farghaly Abdelaliem [5], Amany Anwar Saeed Alabdullah [6] and Saad Suleman Alfawaz [7]

[1] Associate Professor, College of Physiotherapy, Dayananda Sagar University, Devarakaggalahalli, Harohalli Kanakapura Road, Dt, Ramanagara, Karnataka 562112, vinod-mpt@dsu.edu.in
[2] Associate Professor, Chettinad School of Physiotherapy, Chettinad Academy for Research and Education, Chettinad Health City, Rajiv Gandhi Salai, Kelambakkam, Tamil Nadu 603 dr.subramanian@care.edu.in103
[3] Professor, Department of Physical Therapy Faculty of Medical Rehabilitation Sciences, King Abdulaziz University, Jeddah, Saudi Arabia, rizikjoresearch@Gmail.com.
[4] Associate professor, Department of Public Health, Faculty of Nursing, King Abdulaziz University، Jeddah, Saudi Arabia. salsenany@kau.edu.sa
[5] Associate professor, Department of Nursing Management and Education, College of Nursing, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia. S.M.A. smfarghaly@pnu.edu.sa
[6] Assistant Professor, Department of Maternity and Child Health Nursing, College of Nursing, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia Riyadh; aaalabdullah@pnu.edu.sa
[7] Assistant Professor, Department of Physical Therapy Faculty of Medical Rehabilitation Sciences, King Abdulaziz University, Jeddah, Saudi Arabia. Saadlfawaz@kau.edu.sa
* Correspondence: vinod-mpt@dsu.edu.in

Abstract: Background/Objectives: This study looks at how a kinematic chain exercise regimen that targets the lower, core, and upper body affects university shot put participants' shoulder muscle strength and throwing efficiency. This study fills an apparent research void on shot put training approaches by presenting a comprehensive kinematic chain workout program. It was anticipated that this method would improve performance the most, considering the complex biomechanical requirements of the sport. **Methodology:** Athletes, seventy in age (19.87 ± 1.31 years), were assigned into two groups at random: experimental (n = 35) and control (n = 35). While the control group carried on with their usual training, the experimental group participated in an 8-week kinematic chain training program, pre- and post-training evaluations were carried out to evaluate shot put throwing ability, shoulder muscle strength, and participant satisfaction with the exercise regimen. **Results:** demonstrated that, when compared to the control group, the athletes in the kinematic chain program had a significantly improved throwing distance (p = 0.01) and shoulder muscle strength (p = 0.01). Furthermore, there was a significant difference (p = 0.005) in the athletes' satisfaction levels with the workout program among those in the experimental group. This implies that a kinematic chain-focused strategy improves performance and emphasizes the significance this type of training is for shot put athlete performance. **Conclusion**: As an improvement forward in sports science, the study's finding promotes the inclusion of kinematic chain workouts in shot put training programs and calls for more research on kinematic chain-based approaches in a variety of sports.

Keywords: shot put; kinematic chain; exercise regimen; shoulder muscle strength; throwing efficiency; performance improvement; training program; Athlete satisfaction

1. Introduction

Shot put athletes must possess strength, speed, and technique to execute well. Biomechanics and training techniques are essential for effective performance. In order to ensure the best possible distances and greatest force, the shot put emphasizes an athlete's strength, momentum, and skill [1]. The history of the sport and its influence on kinematic chain exercises emphasize how crucial effective training are. The technique of shot-put throwing involves a combination of linear and rotational movements, including the glide or rotational technique, which involves executing the shot at the optimal angle and velocity. With the glide technique, body weight is shifted linearly over the throwing circle and the shot is released with force. On the other hand, the athlete spins inside the circle before releasing the shot in the rotating technique. Every style has distinct biomechanical qualities that call for specific training to become proficient in. Technique and strength training are crucial for improved throwing performance. Strength training targets the lower body, core, and upper body musculature, while technique refinement through technical drills enhances coordination. Throwing practice allows athletes to apply learned skills under competitive conditions, enhancing their overall strength and speed [2]. Functional exercises and kinetic chain training are gaining popularity in recent years, enhancing athletic performance through integrated exercises, focusing on coordinated muscle recruitment for optimal movement efficiency [3]. Kinematic chain activation exercises enhance movement patterns in throwing sports, promoting synchronicity and efficiency by engaging multiple muscle groups simultaneously. This promotes proper sequencing, enabling greater force and velocity during the throwing motion. Throwing requires coordinated activation of muscles throughout the body, from the lower body for power generation to the core for stability and energy transfer [4]. Core stability exercises strengthen abdominal, lower back, and pelvis muscles, enhancing stability and control during the throwing motion. Shot put throwing requires the use of key muscles, therefore training plans should be customized for each individual based on their unique body type, muscle fiber composition, and neuromuscular coordination [5]. Height and BMI are two factors that can affect performance, but they are only one component of the complex equation [6]. A preliminary study by Patel et al. (2020) revealed significant kinematic variability in throwing styles among elite and sub-elite athletes, emphasizing the need for specialized training methods [7]. The significance of kinematic analysis in comprehending shot put method efficiency and performance was emphasized by Ciacci et al. (2022). Kinetic analysis was highlighted in their research as a useful technique for improving athlete training and maximizing performance tactics [8]. The biological aspects of throwing performance in track and field sports were examined by Zaras et al. (2021). Their research led to the creation of more efficient training regimens by illuminating the neurological and muscular components influencing athlete performance [9]. In order to identify research gaps and trends, Ramasamy et al. (2023) summarized biomechanical studies on shoulder kinematics in overhead sports. Their review acts as a guide for upcoming studies on shoulder dynamics [10]. Alberta et al.'s (2023) research concentrated on the validity of assessments assessing athletes' ability to throw overhead. They emphasized how crucial accurate assessment instruments are to tracking the development of athletes and prevent injuries [11]. The predictive usefulness of kinematic variables on shot put outcomes and novice athlete selection were investigated by Almadhkhori et al. (2021). Their research revealed significant correlations between particular kinematic aspects and shot-put accuracy, offering guidance for athlete selection and training [12]. In overhead athletes experiencing shoulder pain, Zawadka et al. (2024) investigated the connection between upper limb function, shoulder mobility, and trunk strength. The significance of an in-depth evaluation of musculoskeletal function for pain management and performance improvement is emphasized by their findings [13]. A study procedure for evaluating the effects of customized, pleasure-oriented exercise sessions in health clubs was presented by Teixeira et al. in 2023. Their study investigates the

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impact of exercise adaptation on participant satisfaction and motivation [14]. Need for the study: A thorough kinematic chain workout regimen can enhance throwing ability and shoulder muscular strength in collegiate players, according to research on shot put performance. The precise effect of these workouts on performance parameters like throwing velocity and distance, however, is not well understood. To determine the precise effect of these exercises on these athletes and to offer important information on strategies for performance optimization and injury avoidance, a focused randomized control trial is required. This research will add to the corpus of knowledge already available on shot put training techniques. The study assesses the performance of athletes using integrated lower body, core, and upper body kinematic chain exercises compared to conventional training, focusing on shoulder muscle strength, preferred throwing style, and exercise protocol satisfaction levels

2. Materials and Methods:

2.1. Study Design and Setting:

This research was carried out at Dayananda Sagar University in Karnataka, India, between August 2022 and March 2024. It was planned as a randomized controlled experiment. On August 4, 2023, the College of Physiotherapy's Institutional Ethics Committee (IEC/IRB/DSU/FAC/2023/001) obtained approval for this experiment. Before the study began, the protocol was registered at Clinical Trials Registry-India (CTRI/202309057242). The CONSORT (reporting a randomized trial) checklist from 2010 was followed in the reporting of this randomized controlled experiment [15]. There were two groups in this study: The Experimental Group (EG) and the Control Group (CG). Participants were randomized at random to either the intervention or control groups. To minimize bias in group allocation and maintain blinding, allocation concealment procedures were employed [16]. Figure 1 illustrates the study design's flow.

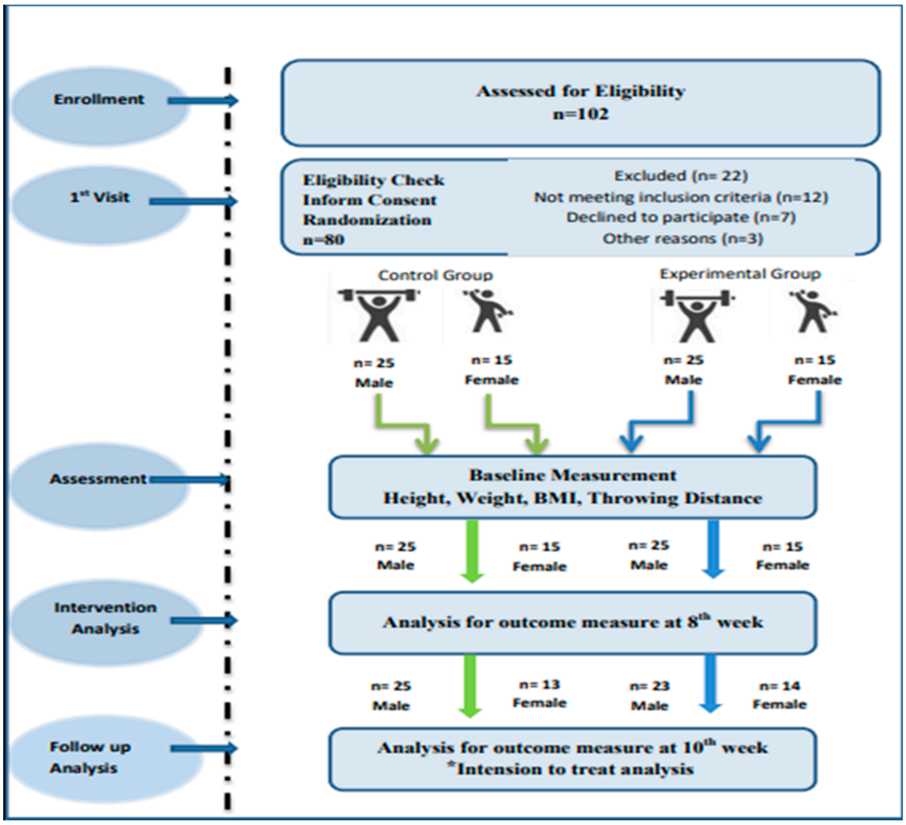

Figure 1. Flow of the study design.

2.2. Sample Size Calculation:

Eighty participants were required for the current study to have a power of 0.80, an effect size of 0.75 (significant, accessible for sample recruitment), and a = 0.05, according to a power analysis performed with G*POWER 3.1 [17]. 1:1 is the allocation ratio. All subjects provided informed, written consent prior to participation.

2.3. Participants:

Posters and fliers were given to potential participants in sports centers in Bengaluru and surrounding areas. Also, local social media channels, such as Facebook groups and What's app, were used to reach them. Shot-put athletes were included in this study if they met the following inclusion criteria: Healthy shot-put athletes – 2021 PAR-Q+ pre-participation evaluation questionnaire score of zero [18], Disabilities of the Arm, Shoulder and Hand (DASH) – Sports/Performing Arts Module score of 0%, [19] Male and female shot-put athletes, Minimum shot-put throwing distance (power position shot-put throwing): For Boys (with 6 kg shot put) – 8 mts and above, For Girls (with 4 kg shot put) – 6 mts and above, Athletes aged between 19 and 24 yrs, Athletes in and around Bangalore and Athletes willing to participate in the study sign the consent form and strictly follow the exercise protocol. Additionally, subjects reporting history of shoulder, waist, and chest surgery, a fracture or dislocation of the affected shoulder, inflammatory joint disease, fibromyalgia, elbow injuries, wrist and hand injuries, and shoulder trauma or current shoulder pathology (traumatic injury, glenohumeral joint dislocation, acromioclavicular joint separation), subjects reporting a history of recent upper limb trauma. History of recent trauma to the lower limbs: history of surgery for the hip, knee, and ankle; hip trauma; or present hip, knee, and ankle pathology, recent history of spine trauma, including lumbar, thoracic, and cervical trauma, as well as any ongoing pathology (such as IVDP, lumbar spondylosis, or cervical spondylitis). Athletes with severe musculoskeletal conditions, such as osteoarthritis, are unable to perform exercises were excluded [20].

2.4. Procedure:

Two consecutive days of evaluation sessions made up this randomized controlled experiment. University shot put participants were examined for inclusion and exclusion criteria on the first day [21]. Following that, participants completed the consent form and affirmed their desire to participate in part in the research. Following a two-day period, the subjects underwent another evaluation to determine baseline data, including height, weight, BMI, preferred throwing style, shot-put throwing distance, and shoulder muscle strength measured using a Hand-Held Dynamometer (HHD).

Randomization and Blinding:

Every participant of the two groups was divided up into an experimental and control group as random. The contents of the delivered training program were concealed from the assessors, an independent researcher who was not engaged in the assessment, data collecting, or statistical analysis carried out the participant randomization and blinding.

2.5. Outcome Measures

2.5.1. Baseline Characteristics

The following baseline characteristics were collected: age, height, weight.

BMI Measurement [22].

Body Mass Index (BMI) is a person’s weight in kilograms divided by the square of height in meters.

Shot-put throwing distances [23].

The power position is a crucial stance in the sport of shot put, directly preceding the actual throw. Mastering this position is essential for generating maximum force and achieving the greatest possible distance in the throw.

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Shoulder Muscle Strength [24].
Exercise Protocol Satisfaction Questionnaire [25].

2.6. Intervention: [20].

Table 1. Description of exercise Protocol.

Table 1: Description of exercise Protocol				
	Conventional training protocol		Kinematic chain exercise protocol	
Weeks	**Phase**	**Description**	**Phase**	**Description**
Week 1-2:	Foundation phase Focus on building a solid foundation of strength and movement patterns Strength Training:	Increase intensity by lifting weights. Aim for 3-4 sets of 4-8 reps. Focus on exercises like squats, lunges, Romanian deadlifts, bench presses, and pullups. Power Development: Include more advanced power exercises such as barbell cleans, snatch variations, and plyometric exercises like depth jumps and explosive pushups. Shot Put Technique: Continue practicing shot put technique drills	Foundation Phase Focus on building a solid foundation of strength and movement patterns.	Squat Variations: Perform barbell squats, goblet squats, and Bulgarian split squats to strengthen the lower body. Aim for 3-4 sets of 4-8 reps. Medicine Ball Throws: Include exercises like overhead medicine ball slams, rotational throws, and chest passes to develop power and explosive strength. Core Stability: Incorporate exercises like planks, side planks, and Russian twists to develop core stability and rotational strength.
Week: 3-4:	Strength and power focus Continue to build strength while increasing power output Strength Training:	Maintain strength gains by continuing with heavy compound exercises. Aim for 3-4 sets of 6-10 reps. Power Development: Emphasize explosive movements such as power cleans, snatches, and jump squats. Shot Put Technique: Allocate more time for technical skill work. Practice shot put throws with lighter implements to refine release technique and improve speed of movement.	Strength and Power Focus Continue to build strength while increasing power output.	Deadlift Variations: Include exercises like conventional deadlifts, trap bar deadlifts, and Romanian deadlifts to strengthen the posterior chain. Aim for 3-4 sets of 6-10 reps. Kettlebell Swings: Perform kettlebell swings to develop explosive hip power. Plyometric Exercises: Incorporate box jumps, depth jumps, and bounding to improve power output.
Weeks: 5-6:	Power and explosiveness Shift the focus towards explosive power and increased speed Strength Maintenance:	Maintain strength gains by reducing volume but maintaining intensity. Aim for 2-3 sets of 8-12 reps. Power Maintenance: Continue with explosive exercises, but reduce volume. Technique: Focus on finetuning technique, performing shot put throws with competition weight implements. Incorporate competition specific scenarios and mental preparation.	Dynamic movements and stability	Lunge Variations: Include walking, reverse, and lateral lunges to improve lower body strength and stability. Aim for 3-4 sets of 8-12 reps. Medicine Ball Rotational Throws: Perform exercises like rotational shot-put throws with a medicine ball to enhance power and rotational strength. Single Leg Balance Exercises: Incorporate single leg deadlifts, single leg squats, and pistol squats to improve stability and balance.
Weeks: 7-8:	Peaking phase Taper the training to optimize performance for competitions	Throughout the entire 8-week protocol, it is important to prioritize proper warmups, cooldowns, and recovery strategies such as stretching, foam rolling, and adequate rest.	Integration and peaking phase Clean and Snatches:	Include barbell cleans and snatches to develop explosive power and coordination throughout the kinetic chain. Aim for 3-4 sets of 8-12 reps. Overhead Press Variations: Perform exercises like overhead barbell presses, dumbbell presses, and push presses to strengthen the upper body.

	Shot Put Specific Drills: Allocate more time for practicing shot put throws with competition weight implements. Focus on technique, coordination, and timing.

2.7. Data Analysis:

The statistical software SPSS version 28.0 was used for the analyses. Minimum, maximum, mean values and standard deviation of the baseline clinical characteristics of the participants were calculated and reported with p values. The normality of the data was evaluated using various graphical and formal statistical methods, including histograms, Q-Q plots, z-scores of kurtosis and skewness, and lastly the Kolmogorov–Smirnov test. Repeated measure ANOVA for with in group analysis and independent-sample t-tests for between group analysis to find the change in shot-put throwing distance, muscle strength and Exercise Protocol Satisfaction Questionnaire. Lastly, associations between Height and BMI (dependent variables), and Shot-put Throwing Distance (independent variables) were analyzed using Pearson's correlation coefficient tests. P-values < 0.05 were considered statistically significant.

3. Results

Seventy-Five subject, Male; Forty-eight and Female; Twenty-seven completed this study. There were three dropouts in this study. The baseline characteristics of the participants are shown in Table 2.

Table 2. Mean Standard deviation & p value for baseline Data.

Table 2 Baseline characteristics of the randomized study participants (N = 80)					
Characteristics [a]	Control Group (n=38)	*μ & σ*	Experimental Group (n=37)	*μ & σ*	p[b]
Age (years)					
Male	25	20.6 ±1.44	25	19.5±1.57	0.9488
Female	15	20.6 ±1.49	15	19.15±1.53	0.9554
Gender					
Male	25		25		
Female	15		15		
Height (mts)					
Male	25	1.68±0.01	25	1.69 ±1.57	0.5384
Female	15	1.60±0.02	15	1.68±0.01	0.9097
Weight(kg)					
	25	75.3±3.24	25	76.3±2.50	0.1892
	15	58.9±5.34	15	56.9±5.15	0.6236
BMI (kg/m^2)					
	25	26.56±0.71	25	26.77±0.40	0.1829
	15	22.4±2.20	15	22.1±2.15	0.5472
Throwing Distance(mts)					
Male	25	9.2±0.61	25	9.1±0.59	0.4971
Female	15	6.9±0.25	15	6.95±0.20	0.9497
Shoulder Muscle Strength(kg)					
FLX	25	21.93±1.22	25	21.29±1.28	0.3384
	15	19.14±1.00	15	19.79±1.20	0.0690
EXT	25	16±2.98	25	16±1.66	0.1415
	15	13±1.97	15	13.5±1.28	0.2819
ER	25	10±2.41	25	11±1.64	0.4605
	15	8±2.27	15	8.5.5±2.27	0.1205

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IR	25	12±2.08	25	11.5±1.93	0.3186
	15	11±1.56	15	11.5±1.55	0.7286
EPSQ	38	97±14.18	37	92.17±14.52	0.1787

Abbreviations; ER External Rotation; IR Internal Rotation; FLX Flexion; EXT Extension: mts metres; kg Kilogram; BMI Body Mass Index., EPSQ Exercise protocol satisfaction questionnaire
[a] Continuous data are expressed as mean (standard deviation), categorical data as number, [b]p values are associated with the while Wilcoxon rank sum test and two-sample t-test are used for continuous variables. μ Mean; σ Standard Deviation, p=0.05 significance level.

Table 2 explains detailed analysis and insights into the mean, standard deviation, and statistical significance (p-values) of each variable, at the start of the study allowing for a comprehensive understanding of the differences between the control and experimental groups and homogeneity between the groups. Age and Gender.

Both the control and experimental groups had similar age distributions, with no significant differences observed between the two groups for both males ($p = 0.9488$) and females ($p = 0.9554$). The gender distribution was also balanced, with 25 males and 15 females in both the control and experimental groups.

Physical Characteristics

Height: There was no significant difference in height between males ($p = 0.5384$) and females ($p = 0.9097$) in the control and experimental groups. Weight: The weight of participants in both groups also showed no significant variation for males ($p = 0.1892$) and females ($p = 0.6236$). BMI: Similarly, the Body Mass Index (BMI) did not significantly differ between the control and experimental groups for both males ($p= 0.1829$) and females ($p = 0.5472$).

Physical Performance

Throwing Distance: The throwing distance for both males ($p = 0.4971$) and females ($p=0.9497$) did not exhibit significant differences between the control and experimental groups.

Shoulder Muscle Strength:

Flexion (FLX): While there was no significant discrepancy for males ($p = 0.3384$), females showed a marginally significant difference ($p = 0.0690$) between the control and experimental groups. Extension (EXT): There was no significant difference observed for both males ($p = 0.1415$) and females ($p = 0.2819$). External Rotation (ER): No significant disparity was noted for both males ($p = 0.4605$) and females ($p = 0.1205$). Internal Rotation (IR): Both males ($p = 0.3186$) and females ($p = 0.7286$) did not show significant differences.

EPSQ (Exercise Protocol Satisfaction Questionnaire): The participants' satisfaction with the exercise protocol did not significantly differ between the control and experimental groups ($p = 0.1787$). The results indicate that at baseline, there were no significant differences in the characteristics and performance measures between the control and experimental groups, ensuring a balanced starting point for the study.

Table 3. presents the scores of patients in various outcome measures, including throwing distance and shoulder muscle strength, at different time points (0th week, 8th week, and 10th week) for both control group (CG) and experimental group (EG). The table also includes the mean and standard deviation (SD) values for baseline measurements and changes from baseline, as well as the results of repeated measures ANOVA on the change from baseline, including the F-statistic and p-values.

Table 3 Patients' scores in all the outcome measures

Assessment (Max/Healthy Value)	Groups	Baseline value, Mean (SD)	Change from baseline, Mean (SD)	Repeated Measures ANOVA on change from baseline

		0^{th} week	8^{th} week	10^{th} week	F	P
Male (n=25)						
Throwing Distance(mts)	CG	9.2 ±0.61	10.44±0.47	10.54±0.41	64.44	0.001
	EG	9.11 ±0.59	10.9±0.28	10.81 ±0.43	157.34	0 .001
Shoulder Muscle Strength(kg)						
FLX	CG	21.93±1.22	23.42±5.53	20.17±4.40	88.61	0.017
	EG	21.29±1.28	24.74±4.42	21.59±5.39	53.14	0.001
EXT	CG	16±2.98	20.04±2.79	19.14±2.79	1208.8	0.031
	EG	16±1.66	20.06±2.18	16.96 ±2.18	2165.87	0.042
ER	CG	10±2.41	14.82±4.43	12.82±4.90	7591.79	0.001
	EG	11±1.64	16.88±2.49	14.88±2.89	3940.6	0.001
IR	CG	12±2.08	14.82±6.84	12.82±6.87	7591.79	0.020
	EG	11.5±1.93	16.88±6.15	14.88±5.95	39406	0.001
Female (n=15)						
Throwing Distance(mts)	CG	6.9±0.25	7.34±0.22	7.55±0.15	28.28	0.038
	EG	6.95±0.20	7.41±0.21	7.56±0.20	45.53	0.001
Shoulder Muscle Strength(kg)						
FLX	CG	19.14±1.00	22.32±10.61	19.16±11.52	22.69	0.003
	EG	19.79±1.20	24.66±3.71	20.44 ±5.02	44.59	0.001
EXT	CG	13±1.97	15.7±6.57	14.77±6.57	1017.25	1.000
	EG	13.5±1.28	16.1±8.06	14.6±8.06	1295	0.001
ER	CG	11.23±2.27	15.3±3.90	13.3±4.51	6011.38	0.012
	EG	12.23.5±2.27	18.27±4.72	16.27±5.51	8113.95	0.027
IR	CG	11±1.56	15.3±6.75	13.3±6.75	6011.38	0.04
	EG	11.5±1.55	18.27±10.12	16.27±10.12	8113.95	0.023

Abbreviations; kg; Kilogram, FLX; Flexion, EXT; Extension, ER; External Rotation, IR; Internal Rotation, mts; metre, ANOVA; Analysis of variance; F-statistic, CG; Control Group, EC; Experimental Group
μ Mean; σ Standard Deviation, *p=0.05 significance level.

Male Participants Throwing Distance:

Both the control and experimental groups showed significant improvements over time, with the experimental group demonstrating a greater increase (p = 0.001).

Shoulder Muscle Strength: Flexion (FLX): Both groups showed improvements, with the experimental group a more substantial increase (p = 0.017). Extension (EXT): Significant improvements were noted in both groups, with the experimental group having a higher improvement (p = 0.031). External Rotation (ER): Remarkable enhancements were observed in both groups, with the experimental group showing greater improvements (p = 0.001). Internal Rotation (IR): Both groups exhibited improvements, notably with the experimental group showing a more notable increase (p = 0.020).

Female Participants Throwing Distance:

Significant improvements were observed in both the control and experimental groups, with a slightly higher increase in the experimental group (p = 0.038).

Shoulder Muscle Strength: Flexion (FLX): Both groups demonstrated improvements, with the experimental group displaying a more considerable increase (p = 0.003). Extension (EXT): Significant improvements were seen in both groups, with the experimental group showing a higher enhancement (p = 0.001). External Rotation (ER): Substantial enhancements were noted in both groups, with the experimental group exhibiting greater improvements (p = 0.012). Internal Rotation (IR): Notable improvements were observed in both groups, particularly with the experimental group showing a more significant increase (p = 0.04). Figure 2.The results emphasize that the intervention had a positive impact on both male and female participants in terms of throwing distance and shoulder muscle strength. The experimental group generally exhibited greater improvements compared to the control group for most of the outcome measures, indicating the effectiveness of the intervention in enhancing physical performance and strength in both genders.

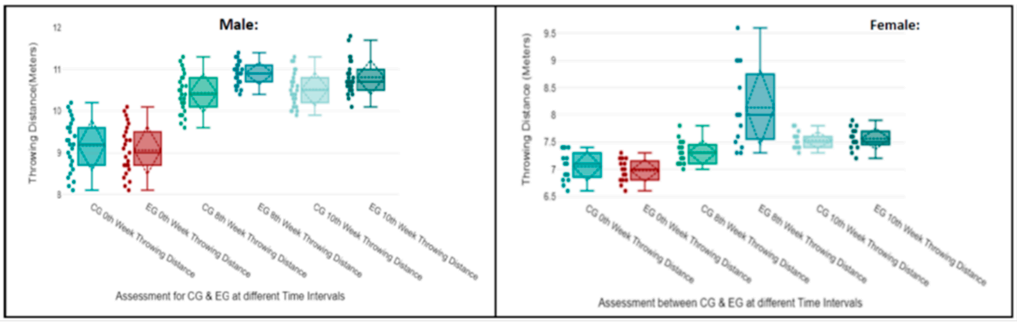

Figure 2. Throwing Distance for Male & Female subjects**.**

Table 4. Presents the results of between-group analysis for patients' outcome measures in various assessments, including throwing distance and shoulder muscle strength, for both control group (CG) and experimental group (EG), as well as for females. Patients' Outcome Measures between Groups Analysis.

Table 4 Patients' outcome measures between the group analysis			
Male (n=25)			
Assessment (Max/Healthy Value)	CG Mean (SD)	EG Mean (SD)	P Value
Throwing Distance(mts)	10.43±0.47	10.90±0.28	0.000*
Shoulder Muscle Strength(kg)			
FLX	23.42±5.53	24.74±4.42	0.042*
EXT	20.04±2.79	20.06±2.18	0.975
ER	14.82±4.43	18.88±2.49	0.004*
IR	14.82±6.84	18.88±6.15	0.060
Female (n=15)			
Throwing Distance(mts)	7.30±0.22	8.13±0.72	0.052*
Shoulder Muscle Strength(kg)			
FLX	22.32±10.61	24.66±3.71	0.042*
EXT	15.7±6.57	16.1±8.06	0.507
ER	15.3±3.90	16.27±4.72	0.003*
IR	15.3±6.75	16.27±10.12	0.041*
EPSQ	98.98± 14.15	164.43± 9.91	0.022

Abbreviations; kg; Kilogram, FLX; Flexion, EXT; Extension, ER; External Rotation, IR; Internal Rotation, mts; metre, ANOVA; Analysis of variance; F-statistic, CG; Control Group, EC; Experimental Group, EPSQ; Exercise Protocol Satisfaction Questionnaire
μ Mean; σ Standard Deviation, *p=0.05 significance level.

Male Participants

Throwing Distance: The experimental group showed a statistically significant improvement in throwing distance compared to the control group (p = 0.000).

Shoulder Muscle Strength: Flexion (FLX): The experimental group had a significantly higher mean strength in flexion compared to the control group (p = 0.042). Extension (EXT): There was no significant difference in extension strength between the two groups (p = 0.975). External Rotation

(ER): The experimental group exhibited significantly greater external rotation strength than the control group (p = 0.004). Internal Rotation (IR): Although not statistically significant, there was a trend towards higher internal rotation strength in the experimental group (p = 0.060).

Female Participants

Throwing Distance: A trend towards improvement was noted in throwing distance for the experimental group compared to the control group, with a p-value of 0.052.

Shoulder Muscle Strength: Flexion (FLX): The experimental group showed significantly higher flexion strength than the control group (p = 0.042). Extension (EXT): There was no significant difference in extension strength between the control and experimental groups (p = 0.507). External Rotation (ER): The experimental group had significantly greater external rotation strength than the control group (p = 0.003). Internal Rotation (IR): A significant improvement in internal rotation strength was observed in the experimental group compared to the control group (p = 0.041).

EPSQ (Exercise Protocol Satisfaction Questionnaire):

Participants in the experimental group reported significantly higher satisfaction levels with the exercise protocol compared to the control group, as indicated by a p-value of 0.022.

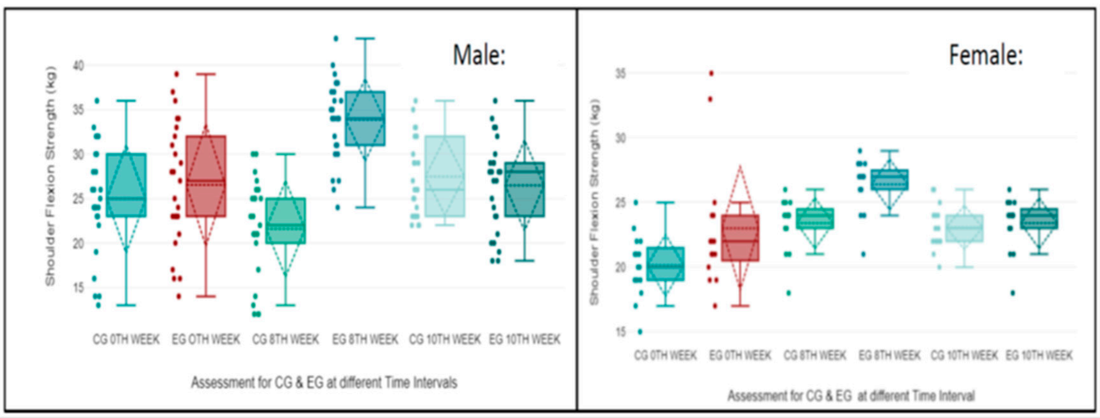

Figure 4. Between-group analysis for Shoulder Flexion Strength: Male & Female**.**

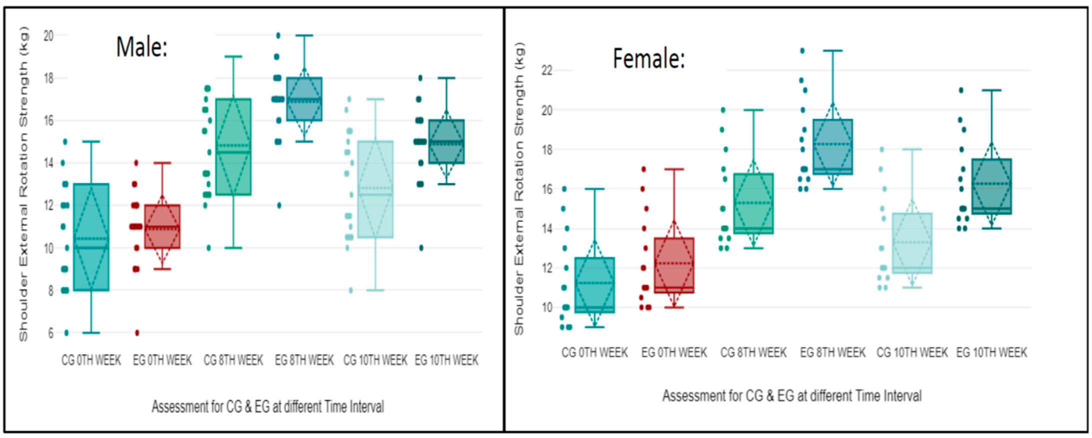

Figure 5. Between-group analysis for Shoulder Extension Strength Male & Female.

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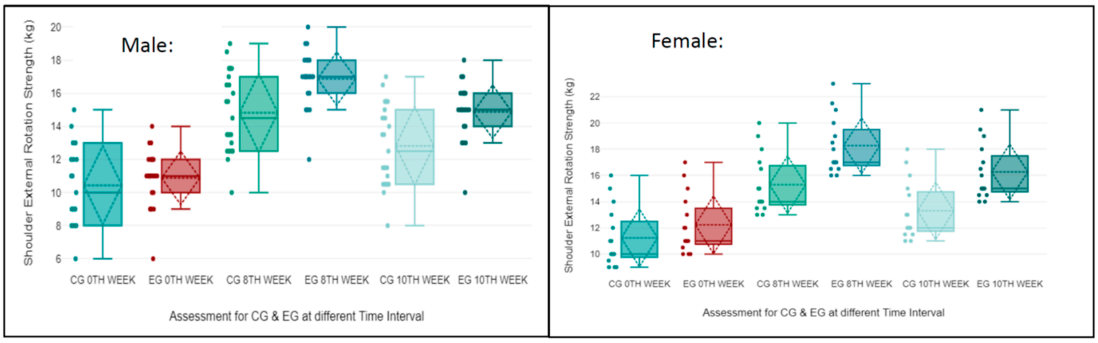

Figure 6. Between-group analysis for Shoulder External Rotation Strength: Male & Female.

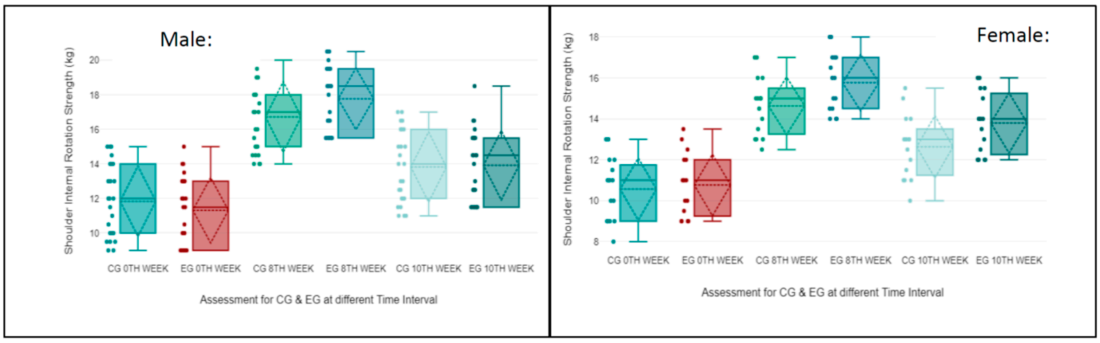

Figure 7. Between-group analysis for Shoulder Internal Rotation Strength: Male & Female.

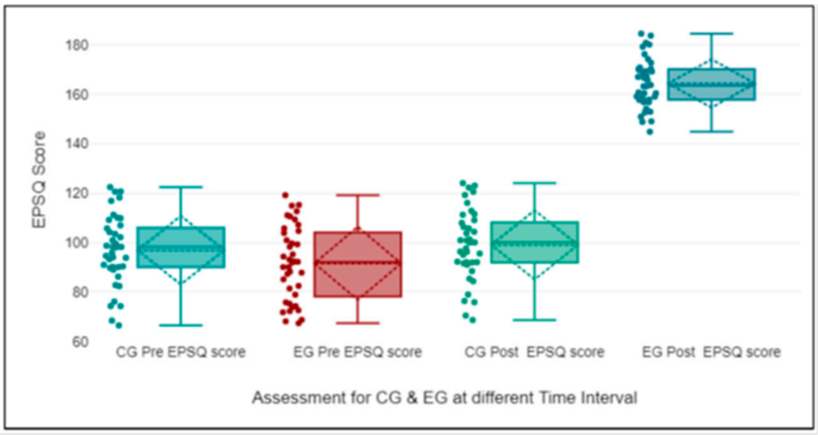

Figure 8. Between-group analysis for Pre-& Post EPSQ Score.

Table 5. The results indicate strong positive correlations between both height and BMI with the throwing distance among the shot-put thrower athletes. A correlation coefficient (r) close to 1 suggests a strong positive linear relationship between the variables. In this context, it implies that as the height or BMI of the athlete's increases, their throwing distance also tends to increase.

Table 5 Correlations between Height, BMI and Thawing Distance in male and female shot-put thrower athletes.

Correlations between Height and Thawing Distance:			
Sample size	Height (mts) Means and SD	Throwing Distance(mts) Means and SD	Pearson correlation coefficient (r)
n=40	1.6705± 0.042	8.55± 1.14	0.8055
Correlations between BMI and Thawing Distance:			
	BMI (kg/mts²)	Throwing Distance(mts) Means and SD	Pearson correlation coefficient (r)
n=40	26.09± 2.39	8.55± 1.14	0.7598

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Preferred Throwing style :			
	Male (n=50)	Female (n=30)	%
Gliding	15	24	31.98
Rotational	35	6	68.02

mts; metres, BMI; Body Mass Index, SD; standard deviation.

Figure 9. Correlation between throwing distance and height.

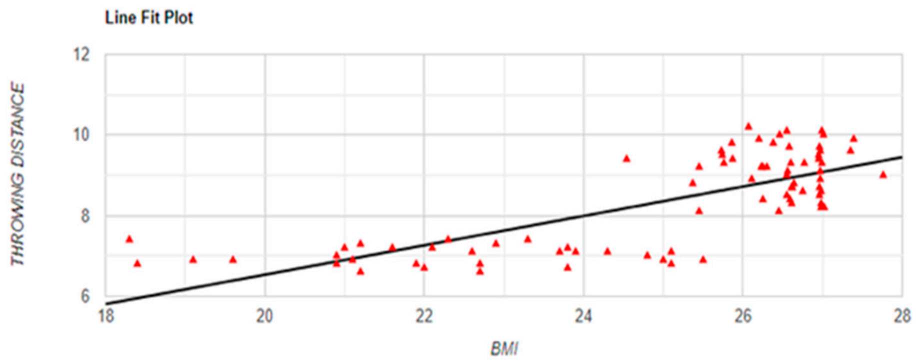

Figure 10. Correlation between throwing distance and BMI.

Male Athletes: The majority (70%) of male athletes prefer the rotational throwing style, while a smaller proportion (30%) prefers the gliding style. This suggests that rotational technique is more popular among male athletes in the survey.

Female Athletes: In contrast, the majority (80%) of female athletes prefer the gliding throwing style, while a smaller proportion (20%) prefers the rotational style. This indicates a strong preference for the gliding technique among female athletes in the survey. (Figure 11)

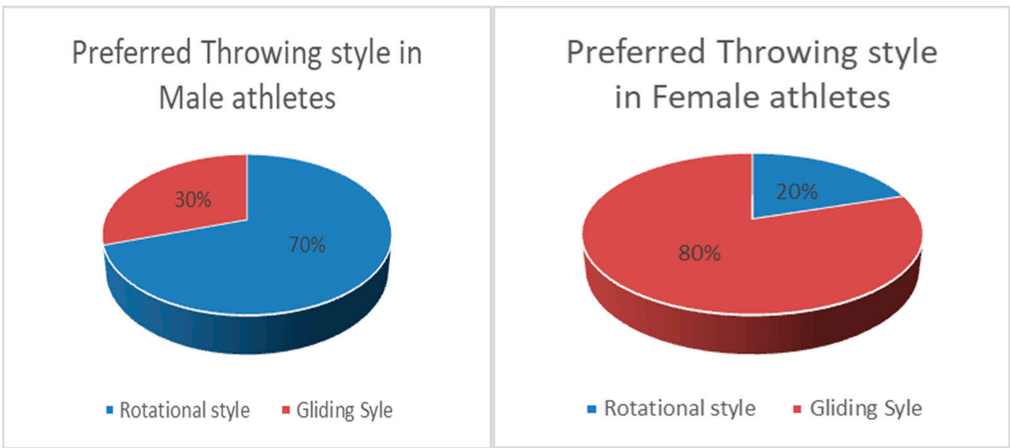

Figure 11. Preferred throwing style among athletes.

4. Discussion

With a focus on throwing distance, shoulder muscular strength, and exercise protocol satisfaction, the study's findings offer important insights into the impact of particular rehabilitation or exercise regimens on patient outcomes. Comparing the experimental group (EG) to the control group (CG), the experimental group (EG) demonstrated a statistically significant increase in throwing distance. This outcome could potentially be attributed to the Kinematic chain activation used in the EG, which might have been more successful in improving the muscle strength and coordination needed for throwing-related activities. According to a research by Cools et al. (2021), throwing ability can be greatly impacted by customized sport-specific rehabilitation programs [26]. The efficacy of the experimental procedure designed especially for female athletes, who may have different physiological responses or injury healing patterns than male athletes, is demonstrated by the considerable difference in throwing distance between EG and CG among female athletes. This is consistent with research by Vrublevskiy et al. (2020), which indicates that male and female patients receiving shoulder rehabilitation exhibit different adaption and improvement patterns [27]. Strength within Shoulder Muscles; External Rotation (ER) and Internal Rotation (IR) The lack of significant variations between CG and EG for ER and IR among male subjects suggests that the experimental technique may not have been effective at enhancing the strength of those movements as it was for other motions. This could be a result of the particular exercises selected for the EG, which might have highlighted different facets of shoulder functionality [28]. The multimodal approach required for thorough shoulder rehabilitation is discussed in a paper by Ellen Becker, Todd S. Aoki, and Ryoki (2020), which emphasizes the significance of focusing on different muscle groups for overall shoulder strength and stability. FLX and Extension, The EG's FLX & EXT mean values were significantly higher, indicating that the experimental exercises were beneficial to these particular motion patterns [29]. This could be attributed to the targeted strengthening of the internal rotator muscles and posterior chain. The fact that IR has improved in female subject is particularly significant because it affects throwing mechanics and shoulder stability. Researchers Wight et al. (2022) discovered that athletes with shoulder injuries might get markedly better results with customized rehabilitation regimens that prioritize IR strength [30]. Questionnaire on Exercise Protocol Satisfaction (EPSQ) Presumably as a result of better reported benefits or the customized nature of the exercises, the higher mean EPSQ score in the EG reflects greater satisfaction with the exercise regimen [31,32]. The significance of patient satisfaction and its relationship to adherence to rehabilitation exercises and overall outcome efficacy has been emphasized in a study conducted by Collado-Mateo et al. (2021). The correlation coefficient (r) being close to 1 suggests a strong positive linear relationship between height and throwing distance, as well as between BMI and throwing distance. A correlation coefficient close to 1 indicates that there is a strong tendency for the variables to move in the same direction; in this case, as height or BMI increases, the throwing distance also tends to increase [32]. This finding implies that taller athletes and those with higher BMI measurements generally achieve greater throwing distances in shot-put. Taller athletes likely benefit from longer lever arms and increased muscle mass, providing them with more power and momentum to propel the shot-put further. Similarly, athletes with higher BMI might possess greater muscle strength and mass, contributing to their ability to throw the shot-put over longer distances [33]. The preferred throwing style differs between male and female athletes surveyed. While rotational technique is more popular among male athletes, the gliding technique is favored among female athletes. These findings may have implications for coaching strategies and training programs tailored to different gender groups in shot-put events [13,34].

5. Conclusions

The results of the study, the experimental training regimen significantly improved the subjects' throwing distance, key shoulder muscle strength attributes, particularly among females, and internal rotation and extension measurements. This emphasizes the significance of developing tailored, gender-specific rehabilitation plans that consider each participant's specific needs and physiological traits. Further research should examine the particular components of the experimental procedure that most significantly influenced these results, with an emphasis on optimizing rehabilitative tasks to achieve specific improvements in patient satisfaction and shoulder function.

Author Contributions: VKC and S.S: designed the research, conducted the research analyzed the data, wrote the first draft, RAMG, SAA,: SMFA, AASA, SSA: research analyzed the data, wrote the drafts and all authors contributed to the manuscript; and VKC had primary responsibility for the final content. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was conducted in accordance with the Dayananda Sagar University and was approved by the Institutional Ethics Committee of the University (Committee (IEC/IRB/DSU/FAC/2023/001) obtained approval for this experiment, before the study began; the protocol was registered at Clinical Trials Registry-India (CTRI/202309057242).

Informed Consent Statement: Written Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The data that support the findings of this study are available upon request from the corresponding author, VKC.

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Conflicts of Interest: The authors declare no conflicts of interest.

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