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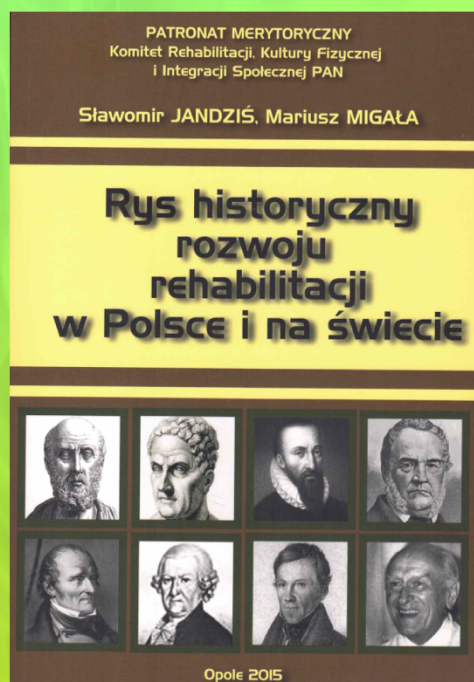


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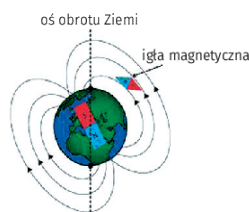
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# Effect of lower body, core and upper body kinematic chain exercise protocol on throwing performance among university shot put athletes: A pilot study

*Efekt protokołu ćwiczeń łańcucha kinematycznego dla dolnej części ciała, tułowia i górnej części ciała na wyniki pchnięcia kulą wśród uniwersyteckich kulomiotów: badanie wstępne*

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## Abstract

A coordinated sequence of movements is required to generate maximum power and velocity in shot put. Kinematic chains emphasize the interactions between various body segments during a movement. They suggest that force production and transfer are optimized by coordinating multiple joints and muscle groups. In previous research, the kinematic chain has been attributed to shot put performance. Few studies have examined the effects of a comprehensive kinematic chain exercise protocol on throwing performance among shot put athletes, particularly at universities. Pilot study investigating lower body, core, and upper body kinematic chain exercise protocol on university shot put athletes' throwing performance. A total of twenty-four young athletes specializing in shotput, with an average age of 19.87 years and a standard deviation of 1.31 years, were divided into two groups, namely the experimental group and the control group, using a random assignment method, the experimental group, consisting of 12 participants, underwent an 8-week kinematic chain training program alongside their regular training sessions. On the other hand, the control group, also consisting of 12 participants, only participated in their regular training sessions without any additional intervention. Pre- and post-training assessments were conducted to measure shotput throwing performance, preference for throwing style, and the participants' satisfaction with the exercise protocol, using a questionnaire. The athletes who took part in the kinematic chain program demonstrated a significant improvement in throwing distance compared to the control group ( $p = 0.01$ ). Additionally, the athletes in the experimental group reported higher levels of satisfaction with the exercise protocol ( $p = 0.005$ ). These findings indicate that incorporating an 8-week Lower Body, Core and Upper Body kinematic chain exercise protocol into regular training sessions can lead to more pronounced improvements in sport-specific throwing performance among young shotput athletes.

## Keywords

shotput athletes, kinematic chain exercises, shot put throwing style, core stability, throwing distance

## Streszczenie

Aby osiągnąć maksymalną moc i prędkość w pchnięciu kulą, wymagana jest skoordynowana sekwencja ruchów. Łańcuchy kinematyczne podkreślają interakcje między różnymi segmentami ciała podczas ruchu. Wskazują, że produkcja i transfer siły są optymalizowane poprzez koordynowanie wielu stawów i grup mięśniowych. W poprzednich badaniach łańcuch kinematyczny był przypisywany do wyników w pchnięciu kulą. Niewiele badań analizowało wpływ kompleksowego protokołu ćwiczeń kinematycznych na wyniki rzutu wśród lekkoatletów pchnięcia kulą, zwłaszcza na uniwersytetach.

Pilotażowe badanie dotyczyło wpływu protokołu ćwiczeń kinematycznych dolnej części ciała, tułowia i górnej części ciała na wyniki rzutów lekkoatletów uniwersyteckich specjalizujących się w pchnięciu kulą. Dwadzieścia czterech młodych sportowców specjalizujących się w pchnięciu kulą, o średnim wieku 19,87 lat i odchyleniu standardowym 1,31 roku, zostało podzielonych na dwie grupy - eksperymentalną i kontrolną, za pomocą metody losowego przydzielania. Grupa eksperymentalna, składająca się z 12 uczestników, przeszła 8-tygodniowy program treningowy łańcucha kinematycznego obok regularnych sesji treningowych. Z kolei grupa kontrolna, również składająca się z 12 uczestników, uczestniczyła tylko w regularnych sesjach treningowych bez żadnej dodatkowej interwencji. Przed i po treningu przeprowadzono oceny wyników rzutów, preferencji stylu rzutu oraz satysfakcji uczestników z protokołu ćwiczeń za pomocą kwestionariusza. Sportowcy, którzy uczestniczyli w programie łańcucha kinematycznego, wykazali znaczącą poprawę w odległości rzutu w porównaniu z grupą kontrolną ( $p = 0,01$ ). Dodatkowo, sportowcy z grupy eksperymentalnej zgłaszali wyższy poziom satysfakcji z protokołu ćwiczeń ( $p = 0,005$ ). Wyniki te wskazują, że włączenie 8-tygodniowego protokołu ćwiczeń kinematycznych dolnej części ciała, tułowia i górnej części ciała do regularnych sesji treningowych może prowadzić do bardziej wyraźnych popraw w specyficznej dla sportu wydajności rzutu wśród młodych lekkoatletów pchnięcia kulą.

## Słowa kluczowe

ćwiczenia kinematycznego łańcucha, styl pchnięcia kulą, stabilność tułowia, odległość pchnięcia

## Introduction

Shot put, competitors push or throw a large metal ball (boys' weight is 5.4 kg; girls' weight is 4.4 kg) as far as they can with one hand. Strong quadriceps, hamstrings, and gluteus Maximus muscles are vital for shot putters to push off from the back of the circle and produce the initial thrust required to move the heavy metal shot across the circle. Shot-putters seek to achieve peak body acceleration while shooting through the triple extension of the leg joints and high torque output from the hip musculature during the power position with a release shot angle of 37-41° using either a gliding or rotational approach [1]. The optimal technique in shot putting entails a well-coordinated sequence of muscle contractions and relaxations, precisely timed to maximize the acceleration of the shot and attain the highest achievable release velocity [2]. In order to enhance their throwing effectiveness by increasing power and muscle mass, throwers dedicate a substantial amount of their training time to engaging in either traditional strength training or different forms of power training. In order to excel in shot-put, athletes must develop explosive strength, power, and master the appropriate throwing style. The standard conditioning regimen for shot put entails a systematic approach aimed at enhancing these vital components [3]. The kinetic chain, which describes the sequential activation and transfer of energy through numerous joints and body segments, is a key idea in throwing sports. For throwing actions to achieve their maximum power and effectiveness, a synchronised movement pattern is essential. Sequential Segmental Movement: In throwing sports, a variety of body segments must be sequentially activated and coordinated. The throw is released as a result of the movement which begins with the lower body, travels through the core and ends with the upper body and arm. The energy is gradually transferred from bigger, more strong muscle units to smaller, more specialized muscle groups creating a motion akin to a whip. Throwing acts are quicker and more effective as a result of the energy being activated and transferred sequentially, which increases the force produced. Kinetic chain workouts can improve the overall outcome and throwing efficiency in throwing sports training programmes. The primary goals of these workouts are to coordinate and strengthen the relevant muscle groups and movement patterns [4]. Coaches must modify their practises to ensure that their players are appropriately prepared for training and competition as the knowledge of training tactics continues to grow. Coaches of track and field throws are increasingly using ki-

nematic chains and heavy implements to improve shot put performance. Commonly, the distance the shot put implement – a spherical metal ball – travels when thrown is used to assess performance. The throwing circle's inside edge, which serves as the throw's beginning point, is measured from the point of impact (where the shot lands) when the distance is calculated. Typically, the measurement is given in metres or feet and inches [5].

Important tools in the fields of exercise research and fitness training include exercise programmes and questionnaires. They support adherence by assessing hazards, personalising fitness programmes, defining goals, keeping track of progress, and doing research. Individuals can maximise the advantages of exercise while lowering the risks by making use of these tools [6]. To our current understanding, there has been no prior investigation conducted by other researchers on the impact of lower body, core and upper body kinematic chain training regimen shot put performance, despite the fact that coaches have noticed the tendency. Additionally, prior information regarding the other nations of university, national and elite shot putters has been gathered. In contrast no studies have looked at university athletes from India. The purpose of this study was to compare the effects of a lower body, core and upper body kinematic chain exercise protocol to traditional training on shot put performance. Shot putters who trained with the lower body, core and upper body kinematic chain exercise routine were predicted to perform better in shot put competitions. The findings of this research may assist trainers in refining their strengthening and conditioning strategies and provide more accurate predictions regarding shot-put performance among athletes at Dayananda Sagar University.

## Methods

### Study population, recruitment and eligibility criteria

Twenty-four 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  $\alpha = 0.05$ , according to a power analysis using G\*POWER 3.1 [7]. All participants provided written informed consent before participation. The Institutional Review Board at the College of Physiotherapy, Dayananda Sagar University, approved the protocol, and the study was registered at the clinical trial registry of India (CTRI/2022/07/044196). University shot putters with 1–6 years of track and field experience were participants. They were free of any musculoskeletal injuries within the past six months.

Table 1. Inclusion and exclusion criteria

| Variables                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Mean (SD)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Healthy shot-put athlete's – 2021 PAR-Q+ pre-participation evaluation questionnaire score of zero [8]</li><li>• Disabilities of the Arm, Shoulder and Hand (DASH) – Sports/Performing Arts Module score of 0% [9]</li><li>• Male and female shot-put athletes.</li><li>• Minimum shot-put throwing distance (power-position shot-put throwing)</li><li>• For Boys (with 6 kg shot put) – 8 mts and above</li><li>• For Girls (with 4 kg shot put) – 6 mts and above</li><li>• Athletes aged between 19 and 24 yrs.</li><li>• Athletes in and around Bangalore.</li><li>• Athletes willing to participate in the study sign the consent form and strictly follow the exercise protocol.</li></ul> | <ul style="list-style-type: none"><li>• History of recent upper limb trauma: shoulder trauma or current shoulder pathology (traumatic injury, glenohumeral joint dislocation, acromioclavicular joint separation, a history of shoulder, waist and chest surgery, fracture or dislocation of the affected shoulder, inflammatory joint disease, fibromyalgia, elbow injuries, wrist and hand injuries)</li><li>• History of recent lower limb trauma: hip trauma or current hip, knee &amp; ankle pathology, a history of hip, knee and ankle surgery,</li><li>• History of recent spinal trauma: cervical, thoracic &amp; lumbar trauma or current pathology (cervical spondylosis, lumbar spondylosis, IVDP etc.).</li><li>• Sever musculoskeletal diseases like osteoarthritis restrain athletes from performing [10, 11].</li></ul> |



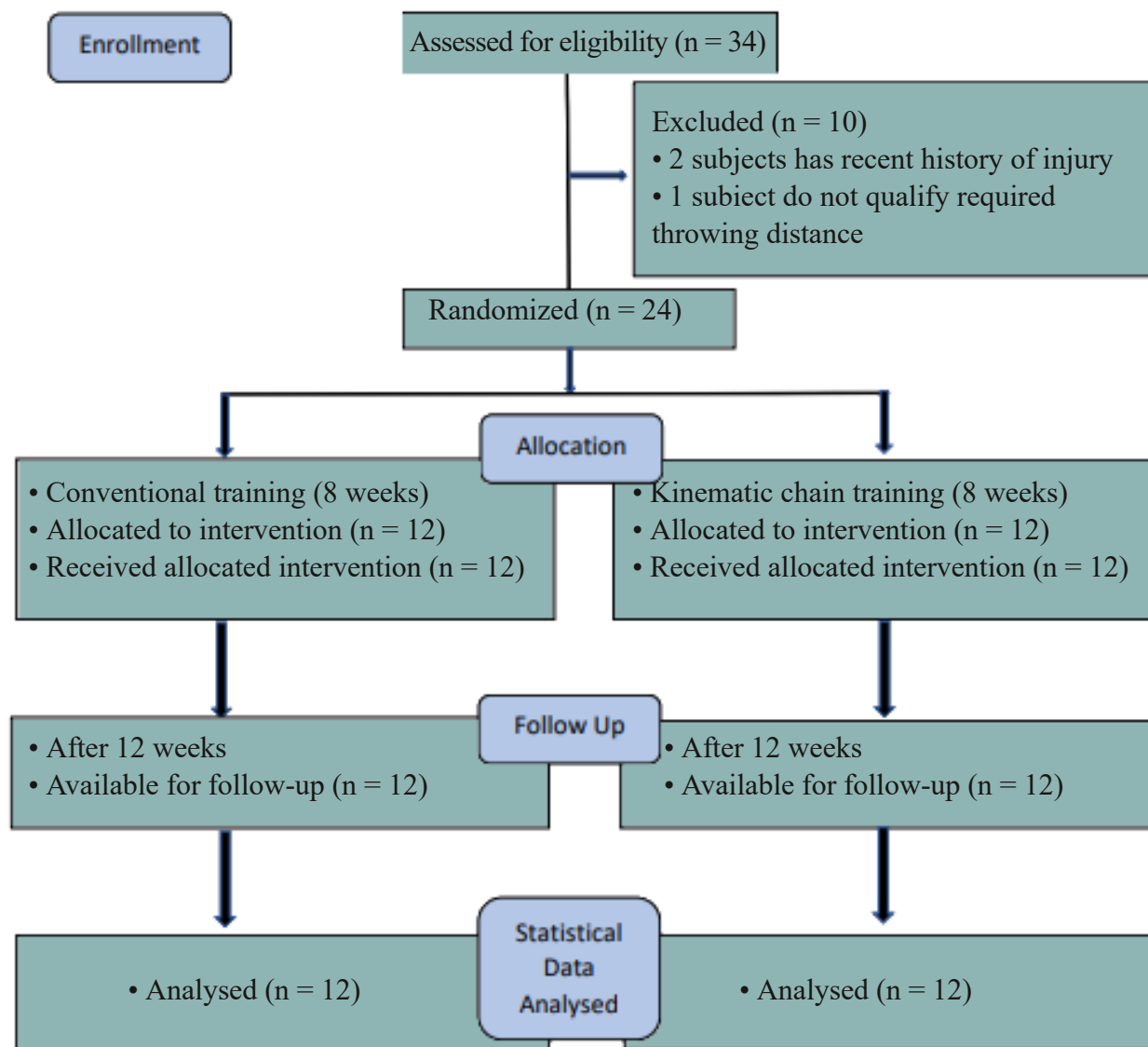


Figure 1. Main screens of the PregEx application

The participants completed pre-participation evaluations. Athletes were tested using the gym and training area at Dayanand Sagar University. Testing was done in one of three campus gyms and a training area with identical equipment. Before the test, participants completed a brief questionnaire on their training experience and involvement in other sports. Additionally, weight and height measurements were made down to the nearest tenth of a kilogramme and centimetre, respectively. The BMI was noted [12]. Finally, each training regimen was briefly explained to the participants before they could ask any questions or request more information.

#### Shot put performance (throwing distance)

For the throwing area, a suitable location was selected that prioritized safety and openness, ensuring there were no obstacles or hazards that could interfere with the shot put. The designated throwing area was clearly delineated by lines to demarcate the allocated space for throwing. The sector is made up of an arc, two lines that branch off of it and a fan-shaped area. The measuring tape should be set up either exactly behind or along the throwing sec-

tor's centreline. Make sure it is straight and firmly secured. Warm-up: To get your body ready for the throw go through a complete warm-up programme that includes dynamic stretches and mobility drills. A shot put of appropriate weight and size was selected to match the age group of the participants, put yourself in the throwing position by standing with your feet shoulder width apart at the back of the throwing circle. With your throwing hand hold the shot put against your neck and beneath your jaw. Starting the throw drive your legs quickly to start the throw, then channel the force through your body, keeping your balance and stability turn your body while extending your arm to release the shot put at the ideal time. Take a throw distance measurement: Take note of where the shot-put first touches the ground after it lands. Measure the distance from the centreline of the throwing sector or the designated starting point to the shot put's landing area using the measuring tape. For an accurate measurement, make sure the measuring tape is taut and straight. Throwing range was measured as follows: Take note of the measurement in metres. To ensure consistency, three warm-up throws were allowed, and the best performance out of the three attempts was selected [13].

### Randomization and blinding

The randomization procedure will be conducted by an independent researcher who is unaware of the specific parameters of the stud. A computer-generated sequence of random numbers will be utilized for the randomization process [14] to assign the participants at random to one of the two therapies (Kinematic chain exercise group and conventional exercise control group). Following the allocation and taking baseline measurements, the randomization will take place. During the course of the study this sequence will be documented in a password-protected Excel table and kept secret from collaborators. The group allocation to the physical therapists or the participants cannot be concealed due to the large differences between the various exercise programmes. Although outcome assessors and data analysts will not be involved in participant recruitment, treatment assignment or administration (interventions), they will be blinded to treatment allocations. Subjects will be given instructions not to disclose their intervention to outcome assessors..

### Interventions

The intervention will span a total of 48 sessions, with each session lasting 1 hour. These group-based sessions will be conducted on a weekly basis for a duration of 12 weeks, taking place either at the gymnasium or the sports courts. In order to ensure a fair comparison, both training groups will have an equal number of training sessions and session duration. Certified and experienced physical trainers, with an average experience of 5-10 years, will lead these groups. The exercise dosage patterns will be based on the current recommendations provided by the American College of Sports Medicine [15]. The gradual increase in intensity throughout each training session will serve as a motivational strategy for the participants.

### Conventional training protocol [16, 17]

Each conventional training session will begin with a set of gentle stretching exercises lasting 10 min, designed to target the major muscle groups.

**Table 2. Conventional training protocol**

| <b>Weeks 1-2: Foundation phase</b><br><b>Focus on building a solid foundation of strength and movement patterns</b>                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strength Training: Perform compound exercises with moderate to heavy weights, aiming for 3-4 sets of 8-12 reps. Include exercises like squats, deadlifts, bench presses, overhead presses, and rows. |
| Power Development: Incorporate explosive exercises to develop power. Include exercises like medicine ball throws, kettlebell swings, and box jumps. Perform 3 sets of 6-8 reps.                      |
| Shot Put Technique: Practice shot put technique drills and work on improving form and coordination. Focus on footwork, hip rotation, and release technique.                                          |
| <b>Weeks 3-4: Strength and power focus</b><br><b>Continue to build strength while increasing power output</b>                                                                                        |
| Strength Training: Increase intensity by lifting heavier weights. Aim for 3-4 sets of 6-10 reps. Focus on exercises like squats, lunges, Romanian deadlifts, bench presses, and pull-ups.            |
| Power Development: Include more advanced power exercises such as barbell cleans, snatch variations, and plyometric exercises like depth jumps and explosive push-ups. Perform 3 sets of 4-6 reps.    |
| Shot Put Technique: Continue practicing shot put technique drills. Incorporate video analysis to identify areas for improvement and refine technique accordingly.                                    |
| <b>Weeks 5-6: Power and explosiveness</b><br><b>Shift the focus towards explosive power and increased speed</b>                                                                                      |
| Strength Training: Maintain strength gains by continuing with heavy compound exercises. Aim for 3-4 sets of 4-8 reps.                                                                                |
| Power Development: Emphasize explosive movements such as power cleans, snatches, and jump squats. Perform 3 sets of 3-5 reps.                                                                        |
| 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.                         |
| <b>Weeks 7-8: Peaking phase</b><br><b>Taper the training to optimize performance for competitions</b>                                                                                                |
| Strength Maintenance: Maintain strength gains by reducing volume but maintaining intensity. Aim for 2-3 sets of 4-6 reps.                                                                            |
| Power Maintenance: Continue with explosive exercises, but reduce volume. Perform 2-3 sets of 2-4 reps.                                                                                               |
| Shot Put Technique: Focus on fine-tuning technique, performing shot put throws with competition-weight implements. Incorporate competition-specific scenarios and mental preparation.                |
| Throughout the entire 8-week protocol, it is important to prioritize proper warm-ups, cooldowns, and recovery strategies such as stretching, foam rolling, and adequate rest.                        |



### Kinematic chain training protocol [6, 18–20]

Each session will begin with 10 min of stretching of the major

muscle groups. Subsequently, participants will complete four series of brisk walking for 10 min, followed by 1 min of recovery.

**Table 3. Kinematic chain exercise protocol**

|                                                                                                                                                                                                                                                                                                                                                                                                             |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| A kinetic chain exercise protocol for shot put athletes aims to strengthen and optimize the coordination of the entire kinetic chain involved in the shot-put movement. This includes the legs, hips, core, and upper body. The following 8-week program is designed to enhance shot put performance by focusing on developing strength, power, stability, and coordination throughout the kinematic chain. |  |
| <b>Weeks 1-2: Foundation Phase</b><br><b>Focus on building a solid foundation of strength and movement patterns.</b>                                                                                                                                                                                                                                                                                        |  |
| Squat Variations: Perform barbell squats, goblet squats, and Bulgarian split squats to strengthen the lower body. Aim for 3-4 sets of 8-12 reps.                                                                                                                                                                                                                                                            |  |
| Medicine Ball Throws: Include exercises like overhead medicine ball slams, rotational throws, and chest passes to develop power and explosive strength. Perform three sets of 6-8 reps.                                                                                                                                                                                                                     |  |
| Core Stability: Incorporate exercises like planks, side planks, and Russian twists to develop core stability and rotational strength. Aim for 2-3 sets of 12-15 reps.                                                                                                                                                                                                                                       |  |
| <b>Weeks 3-4: Strength and Power Focus</b><br><b>Continue to build strength while increasing power output.</b>                                                                                                                                                                                                                                                                                              |  |
| 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. Aim for three sets of 10-12 reps.                                                                                                                                                                                                                                                                                              |  |
| Plyometric Exercises: Incorporate box jumps, depth jumps, and bounding to improve power output. Perform three sets of 6-8 reps.                                                                                                                                                                                                                                                                             |  |
| <b>Weeks 5-6: Dynamic movements and stability</b>                                                                                                                                                                                                                                                                                                                                                           |  |
| 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. Aim for three sets of 6-8 reps.                                                                                                                                                                                                                           |  |
| Single-Leg Balance Exercises: Incorporate single-leg deadlifts, single-leg squats, and pistol squats to improve stability and balance. Aim for 2-3 sets of 10-12 reps per leg.                                                                                                                                                                                                                              |  |
| <b>Weeks 7-8: Integration and peaking phase</b>                                                                                                                                                                                                                                                                                                                                                             |  |
| Cleans and Snatches: Include barbell cleans and snatches to develop explosive power and coordination throughout the kinetic chain. Aim for 3-4 sets of 4-6 reps.                                                                                                                                                                                                                                            |  |
| Overhead Press Variations: Perform exercises like overhead barbell presses, dumbbell presses, and push presses to strengthen the upper body. Aim for 3-4 sets of 6-10 reps.                                                                                                                                                                                                                                 |  |
| Shot Put Specific Drills: Allocate more time for practising shot put throws with competition-weight implements. Focus on technique, coordination, and timing.                                                                                                                                                                                                                                               |  |
| Throughout the 8-week program, it is essential to incorporate appropriate warm-up and cool down routines, including dynamic stretching and mobility exercises. Additionally, prioritize adequate rest, recovery, and proper nutrition to support the training demands.                                                                                                                                      |  |

**Table 4. Weekly planner**

| Conventional protocol                                                            | Kinematic chain exercise protocol                                |
|----------------------------------------------------------------------------------|------------------------------------------------------------------|
| <b>Monday</b>                                                                    |                                                                  |
| Warm-up: Dynamic stretching and mobility exercises.                              | Warm-up: Dynamic stretching and mobility exercises.              |
| Conventional protocol (Strength Training, Power Development, Shot Put Technique) | Kinematic chain exercise protocol                                |
| Cool-down: Static stretching and foam rolling                                    | Cool-down: Static stretching and foam rolling                    |
| <b>Tuesday</b>                                                                   |                                                                  |
| Warm-up: Dynamic stretching and mobility exercises                               | Warm-up: Dynamic stretching and mobility exercises.              |
| Conventional protocol (Strength Training, Power Development, Shot Put Technique) | Kinematic chain exercise protocol                                |
| Cool-down: Easy jog or light aerobic activity followed by static                 | Cool-down: Easy jog or light aerobic activity followed by static |

| Conventional protocol                                                            | Kinematic chain exercise protocol                                           |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>Wednesday</b>                                                                 |                                                                             |
| Rest and recovery                                                                | Rest and Recovery                                                           |
| <b>Thursday</b>                                                                  |                                                                             |
| Warm-up: Dynamic stretching and mobility exercises                               | Warm-up: Dynamic stretching and mobility exercises                          |
| Conventional protocol (Strength Training, Power Development, Shot Put Technique) | Kinematic chain exercise protocol                                           |
| Cool-down: Easy jog or light aerobic activity followed by static stretching      | Cool-down: Easy jog or light aerobic activity followed by static stretching |
| <b>Friday</b>                                                                    |                                                                             |
| Warm-up: Dynamic stretching and mobility exercises                               | Warm-up: Dynamic stretching and mobility exercises                          |
| Conventional protocol (Strength Training, Power Development, Shot Put Technique) | Kinematic chain exercise protocol                                           |
| Cool-down: Static stretching and foam rolling                                    | Cool-down: Easy jog or light aerobic activity followed by static stretching |
| <b>Saturday</b>                                                                  |                                                                             |
| Warm-up: Dynamic stretching and mobility exercises                               | Warm-up: Dynamic stretching and mobility exercises                          |
| Conventional protocol (Strength Training, Power Development, Shot Put Technique) | Kinematic chain exercise protocol                                           |
| Cool-down: Easy jog or light aerobic activity followed by static stretching      | Cool-down: Easy jog or light aerobic activity followed by static stretching |
| <b>Sunday</b>                                                                    |                                                                             |
| Rest and recovery                                                                | Rest and Recovery                                                           |

Exercise progression within the program is achieved by systematically increasing the difficulty and intensity of exercises as time progresses. This gradual progression ensures safe and effective training, preventing training plateaus and optimizing outcomes. It is important to customize the progression based on individual goals and skill levels.

Instruments: The participants will be assessed at three different times. First before beginning the intervention; second immediately after the end of the intervention (8 weeks) and third 2 weeks after the end of the intervention.

Primary outcome  
Shotput throwing distance

Secondary outcomes  
Exercise protocol satisfactory questioner

### Statistical analysis

Using time (baseline and post intervention – primary end point) as the within-group factor and group (conventional and kinematic chain exercises protocol) as the between-group factor, two-way analysis of covariance [21] tests will be used to compare how the study interventions affect the primary and secondary outcomes based on an intention-to-treat sample. Using time (baseline, post intervention and 12-week follow-up) as the within-group component and group (conventional and kinematic chain workouts protocol) as the between group factor two-way ANCOVA tests will also be utilised to assess how the study treatments affect the outcomes. The analysis will take gender into account [22]. The data will be evaluated with the use of SPSS software, version 24.0, with the significance level (p) set at 0.05 (two tailed analyses).

### Results

Participants' characteristics are presented in Table 5. There were six males and three females who participated in the study.

**Table 5. Means and standard deviations summary statistics for participants**

|                                | Control group (N = 12) |         | Experimental group (N = 12) |         | p-value |
|--------------------------------|------------------------|---------|-----------------------------|---------|---------|
|                                | Mean (range)           | ± SD    | Mean (range)                | ± SD    |         |
| Age [years]                    | 19.666 (19-22)         | ± 1.154 | 20.753 (19-22)              | ± 1.484 | 0.17871 |
| Height [cm]                    | 172.333 (165-182)      | ± 6.853 | 176.083 (169-182)           | ± 3.872 | 0.88328 |
| BMI [kg/m <sup>2</sup> ]       | 22.975 (17.2-26.2)     | ± 1.522 | 22.333 (17.2-28.7)          | ± 3.642 | 0.71894 |
| Pre-throwing distance [meters] | 8.216 (7.5-9.6)        | ± 0.65  | 8.55 (8-9.6)                | ± 0.45  | 0.21178 |



**Table 6. Pre and post 12-week changes in shotput throwing distance within groups**

| Assessment                    | Group        | Mean $\pm$ SD      | p (pre-test-post-test) | Mean $\pm$ SD      | p (post-test-follow-up) | Mean $\pm$ SD      | p (pre-test-follow-up) |
|-------------------------------|--------------|--------------------|------------------------|--------------------|-------------------------|--------------------|------------------------|
| Shotput Throwing Distance [m] | Control      | 8.517 $\pm$ 0.8437 | 0.033342               | 8.983 $\pm$ 0.9365 | 0.00001                 | 8.683 $\pm$ 0.9286 | 0.00289                |
|                               | Experimental | 9.029 $\pm$ 0.6708 | 0.000016               | 9.775 $\pm$ 0.5803 | 0.00040                 | 9.296 $\pm$ 0.9091 | 0.00001                |

Note: Values are presented as means  $\pm$  standard deviations (SD); p = statistical significance

**Table 7. Exercise protocol satisfactory questioner at 8<sup>th</sup> week.**

|                    | Mean $\pm$ SD    | p value                                                                                  |
|--------------------|------------------|------------------------------------------------------------------------------------------|
| Control Group      | 32.41 $\pm$ 4.46 | The t-value is -3.77294. The p-value is 0.000524. The result is significant at p < 0.05. |
| Experimental Group | 37.66 $\pm$ 1.82 |                                                                                          |

## Discussion

Not much is known about the connections between shot-put performance and the lower body, core, upper body and kinematic chain workout routine. This study compared university athletes shot-put performance and satisfaction for exercise routine between experimental protocol and standard training. Although it has long been recognised that strength is a crucial element of performance in track and field throwing events, including the shot put [23, 24], and the findings of the current investigation serve as further evidence of this, it is not well known how the individual lifts relate to performance during a competitive season. First we noted in the study that both the conventional and experimental groups significantly increased their shot put throwing distance at the eight-week mark ( $p = 0.002$  and  $p = 0.001$ ) and they continued to improve at the twelve-week mark ( $p = 0.010$  and  $p = 0.003$ ) (2012) Terzis et al. Second, we found that every athlete who took part in the study completed the exercise programme satisfactorily after the eighth week of training. According to the findings ( $t = -3.77$  &  $p = 0.0005$ ) athletes who completed the kinematic chain exercise protocol reported considerably greater levels of protocol satisfaction than those who completed the conventional exercise protocol [25]. Technical proficiency varies greatly between novice and expert throwers. Strength can sometimes take precedence over the development of skill, but it can also be a limiting element [26]. According to university-level research that took coaching instruction into account athletes have access to enough technical training to improve [27]. Beyond asking competitors how long they had competed in the shot put, the study's scope did not take technical instruction into account. However, it's possible that college athletes lack of dedicated throwing coach [6]. Since technical training is not always available, this study suggests that university athletes may improve shot put performance by implementing a kinematic chain activation workout routine that focuses on strength, power, core stability and plyometric activities [28]. Furthermore stronger more powerful athletes are more likely to pick up technique more quickly than weaker athletes when technical training is made available to them [29]. The findings of this study provide valuable insights into the effectiveness of kinematic chain exercise as a

training approach for shot put athletes. The kinematic chain exercise group's improved performance results show that these exercises are superior to more traditional exercises that separate specific muscle groups because they emphasise the integration of movements throughout the entire kinetic chain [30, 31]. These discoveries have applications for shot put athletes' coaches and trainers. Kinematic chain exercises may improve performance results and athletic achievement when incorporated into training regimens. Coaches should think about including exercises that emphasise the sequential passage of forces from the lower body to the upper body encouraging the integration of movements across numerous joints and muscle groups.

## Conclusion

The results of this study provide preliminary evidence that kinematic chain exercises can improve throwing performance among university shotput athletes. These findings indicate the benefits of incorporating a comprehensive training program targeting the kinematic linkages involved in shot put throwing. A larger sample size and longer intervention period are needed to validate these findings and investigate the mechanisms behind the observed performance gains.

## Limitations

The limited sample size of this study may restrict the generalizability of the findings to a larger population of athletes. Additionally, the small sample size did not allow for gender-specific analysis in the study. In future studies a comprehensive screening process could be implemented to assess the ability levels and training backgrounds of athletes, coaches or both. This would enable researchers to investigate the quadratic relationship between strength and shot-put performance as well as determine the optimal strength-to-body weight ratio necessary for achieving the best shot-put performance while minimizing variations in skill levels. The ability to throw the shot put is a multifaceted, sophisticated skill that calls for athletic development as well as mastery. This study discovered that the kinematic chain workout routine for the lower, middle and upper bodies improves shot

put performance. Consequently, the activation of the inclusion kinetic chain. By extending the throwing distance a training programme may improve shot put performance while also improving protocol acceptance and satisfaction. These activities should be used in training by coaches and athletes.

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