

**KINETIC ANALYSIS OF NECK MUSCLE ASYMMETRY AMONG
ELITE SHOT-PUT THROWERS -AN OBSERVATIONAL STUDY**

By

CHIRAG S DASTIKOP

Dissertation Submitted to the

Odisha University of Health Sciences, Bhubaneswar, Odisha

In Partial Fulfilment Of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (MPT)

In

SPORTS

Under the Guidance of

DR. CHINMAYA KUMAR PATRA (PT)

Principal, ABSMARI



**ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH
INSTITUTE BHUBANESWAR, ODISHA**

2023-2025



Odisha University of Health Sciences, Bhubaneswar, Odisha

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled **Kinetic analysis of neck muscle asymmetry among elite shot-put throwers-An observational study** is a bonafide and genuine research work carried out by me under the guidance of Dr. Chinmaya Kumar Patra (PT), Principal Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha.

Date:

Signature of the candidate

Place: Odisha

Name: CHIRAG S DASTIKOP

University Registration No:23MP435047

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled “**Kinetic analysis of neck muscle asymmetry among elite shot-put throwers -An observational study**” is a bonafide research work done by **Chirag S Dastikop** in partial fulfilment of the requirement for the degree of **MPT - Master of Physiotherapy**.

Date

Place: Odisha

Seal & Signature of the Guide

Dr Chinmaya Kumar Patra (PT)

Principal

Department: Community physiotherapy

ENDORSEMENT BY THE HEAD OF THE DEPARTMENT

This is to certify that the dissertation entitled “**Kinetic analysis of neck muscle asymmetry among elite shot-put throwers -An observational study**” is a bonafide research work done by **Chirag S Dastikop** under the guidance of **Dr Chinmaya Kumar Patra (PT), Principal**, Abhinav Bindra Sports Medicine and Research Institute.

Date:

Place: Odisha

Seal & Signature of the HOD

Dr. Asifuzzaman Shahriyar Ahmed (PT)

Associate Professor

Musculoskeletal and Sports, ABSMARI

ENDORSEMENT BY THE PRINCIPAL

This is to certify that the dissertation entitled “**Kinetic analysis of neck muscle asymmetry among elite shot-put throwers -An observational study**” is a bonafide and research work carried out by **Chirag S Dastikop** under the guidance of **Dr. Chinmaya Kumar Patra (PT)**, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha.

Date:

Place: Odisha

Seal & Signature of the Principal

Dr. Chinmaya Kumar Patra (PT)

Principal, ABSMARI



ODISHA UNIVERSITY OF HEALTH SCIENCES

CERTIFICATE OF ACCEPTANCE

This is to certify that the dissertation entitled “**Kinetic analysis of neck muscle asymmetry among elite shot-put throwers -An observational study**” carried out by **Mr. Chirag S Dastikop**, bearing University Registration No. 23MP435047, has been **evaluated and accepted** by me as an **Examiner/ Evaluator**, appointed by the **Odisha university of health sciences, Bhubaneswar**, in partial fulfilment of the requirements for the award of the degree of **Master of Physiotherapy (MPT) in sports science**.

Date:

Signature of Examiner/ Evaluator

Place:

Name: _____

Institution: _____

Designation: _____

COPYRIGHT

Declaration by the Candidate

I hereby declare that the Odisha University of Health Sciences, Odisha shall have the rights to preserve, use and disseminate this dissertation / thesis in print or electronic format for academic / research purpose.

Date:

Signature of the Candidate

Place: Odisha

Name: CHIRAG S DASTIKOP

© Odisha University of Health Sciences, Odisha.

ACKNOWLEDGMENT

I would like to express my heartfelt gratitude to Almighty, my family and friends for their unwavering encouragement, understanding, and love. Their support has been a constant source of strength during this academic journey.

I extend my sincere gratitude and appreciation to the management and administration of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar, and those who have supported and guided me throughout the journey of this dissertation. Without their valuable contributions, this work would not have been possible.

I am also immensely grateful to Dr. Chinmaya Kumar Patra, the Principal, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your encouragement and belief in my abilities have been a source of motivation and confidence.

I would like to express my deepest gratitude to my dissertation guide, Dr. Chinmaya Kumar Patra sir, Principal, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your unwavering support, expert guidance, and insightful feedback have been instrumental in shaping this research. Your dedication to excellence in academia has inspired me to strive for higher goals in my academic pursuits.

Furthermore, I would like to extend special thanks to Dr. Deepak Kumar Pradhan sir for their valuable assistance and support throughout this research. Your expertise and constructive criticism have helped me refine my work and explore new dimensions in my study. I am also thankful to all the faculty members, staff, fellow students and subjects who have contributed to my academic growth and provided a stimulating environment for learning. I sincerely thank PHEEZE Company for their support and cooperation during my thesis. Their timely assistance greatly contributed to the successful completion of my work

In conclusion, this dissertation stands as a testament to the collaborative efforts of the individuals mentioned above, and I am deeply grateful for their contributions to my academic success.

Thank you.

Date:

Signature of the Candidate:

Place:

Name:

LIST OF ABBREVIATIONS USED

1. ABSMARI - Abhinav Bindra Sports Medicine and Research Institute.
2. sEMG – Electromyography.
3. SD - Standard Deviation.
4. SPSS - Statistical Package for social science.
5. MPT- Master of physiotherapy.
6. OUHS- Odisha university of health science.
7. SPSS- Stastical package of the social science.
8. Peak initial throw- preparatory or first double contact phase.
9. Peak during throw-over all peak during throw.
10. Post throw-release phase.

ABSTRACT

TOPIC: KINETIC ANALYSIS OF NECK MUSCLE ASSYMETRY AMONG ELITE SHOT PUT PLAYERS – AN OBSERVATIONAL STUDY

Background and Objective: Shot-put performance is driven by a highly coordinated kinetic chain, with a crucial yet underappreciated role played by the neck muscles. While lower body and trunk contributions are well studied, there is limited knowledge regarding phase-specific neck muscle asymmetry and its influence on throwing efficiency among elite shot-putters. **Objective:** The purpose of this study was to examine the presence and phase-wise pattern of neck muscle asymmetry comparing ipsilateral and contralateral activity—across different stages of the shot-put throw in elite athletes.

Methods: Twelve elite shot-put athletes (mean age 21.66 ± 2.53 years) underwent kinetic assessment via surface EMG, measuring upper trapezius activity on both sides during the initial, peak, and end phases of throwing. Electrode placements followed SENIAM guidelines, and synchronized video analysis ensured accurate phase determination. Paired t-tests analyzed inter-side muscle activity differences for each phase.

Interpretation and conclusion: Results revealed a clear right-sided dominance during the initial phase, likely reflecting hand dominance and unilateral training adaptations. At the peak of the throw, muscle activation was nearly symmetrical, implying integrated bilateral recruitment during explosive release. In the end phase, a subtle shift favored the non-dominant side, suggesting a compensatory stabilizing function. Though trends emerged, statistical significance was not achieved for any phase. These findings suggest that neck muscle asymmetry is dynamic and phase-dependent: initial dominance, symmetrical peak force, and

non-dominant stabilization at completion. Such modulation may support performance and injury prevention, highlighting the importance of phase-specific neck conditioning in elite shot-put training.

KEY WORDS: Neck muscle; Kinetics; Superficial neck muscle; Athletes; Elite athletes.

TABLE OF CONTENTS

SR. NO	CONTENTS	PAGE NO
1.	INTRODUCTION	1-9
2.	AIM AND OBJECTIVES	10-11
3.	HYPOTHESIS	12-13
4.	REVIEW OF LITERATURE	14-25
5.	METHODOLOGY AND PROCEDURE <ul style="list-style-type: none">➤ METHOD➤ INCLUSION CRITERIA➤ EXCLUSION CRITERIA➤ MATERIALS➤ OUTCOME MEASURE	26-34
6.	STASTICAL ANALYSIS	35-36
7.	RESULTS	37-43
8.	DISCUSSION	44-48
9.	CONCLUSION	49-51
10.	LIMITATION AND RECOMMENDATIONS FOR FUTURE STUDY	52-55
11.	SUMMARY	56-57
12.	STATEMENT OF FUNDING	58-59
13.	REFRENCES/BIBILOGRAPHY	60-66
14.	ANNEXURES	67-77

LIST OF TABLES

SR. NO	TABLES	PAGE NO
1.	Descriptive statistics of participants	38
2.	BMI classification of the athletes.	39
3.	Within group comparison right and left trapezius.	40

LIST OF FIGURES

SR. NO	FIGURES	PAGE NO
1.	Materials used.	28
2.	Strap placement and EMG testing.	31
3.	Phases of shot-put throwing.	33

LIST OF GRAPHS

SL. NO	GRAPHS	PAGE NO
1.	BMI classification of athlete.	
2.	With in group comparison right and left trapezius.	

INTRODUCTION

INTRODUCTION

Background

Shot put is a highly explosive track and field event in which elite athletes utilize their strength and technique in a coordinated manner to maximize performance, sequential muscular actions to propel a heavy sphere (shot put) with maximum force and speed. While the contribution of lower body and trunk musculature to shot put performance has been extensively documented ⁽¹⁾, the role of neck muscles particularly regarding symmetry and kinetic behavior remains underexplored. Yet the neck serves as a pivotal link, contributing to head stabilization, alignment of sensory systems and optimal force transfer throughout the throwing sequence. This movement relies heavily on the principles of the kinetic chain, which refers to the integrated, sequential activation of body segments to produce efficient and powerful motion. In shot put, the kinetic chain initiates from the ground up, beginning with force production in the legs (a closed kinetic chain action), progressing through the hips, torso, and shoulder girdle, and culminating in the final explosive arm extension and release (an open kinetic chain movement). The transformation of all these segments, it must be continually timed to preserve and optimize the force output in the segments. The delay in the kinetic chain leads energy leakage and poor throwing performance ⁽²⁾. The rotational well known by its complicated and explosive movement sequences, within in the area limitations of the throwing circle of the throwing circle of the shotput court ⁽³⁾. Excellence in this discipline rests upon a harmonious integration of three critical domains: an athlete's morphological profile (such as segmental mass distribution and lever arm lengths), motor abilities (including maximal strength, rate of force development, coordination, and balance), and the

technical finesse (fine skills) with which movements are performed ⁽⁴⁾. This technique uniquely combines both rotational and linear motion trajectories within a constrained area, demanding precisely timed inter-segmental coordination to maximize performance while minimizing unnecessary motion.

The throw dynamically initiates through powerful activation of lower-body musculature, particularly the hip extensors and leg musculature, which generate initial torque and ground reaction forces ⁽⁵⁾. This force propagates proximally to the trunk and ultimately distally to the upper limb shot complex, culminating in the shot's release. Such a pattern exemplifies the proximal-to-distal kinetic chain, where in sequential, well-coordinated eccentric-to-concentric muscle actions facilitate efficient force build-up and magnification via stretch-shortening cycles ⁽⁶⁾. This mechanism is particularly essential in shot-putting, as it allows athletes to harness stored elastic energy and rapidly convert it into forward propulsion.

Biomechanical research has systematically segmented the rotational shot-put movement into six consecutive phases. Each phase plays a pivotal role in the cumulative development and transfer of mechanical energy, contributing to release velocity and throw distance:

1. Phase P1 – Preparation (First Double Support): The athlete positions both feet firmly at the rear of the circle, facing away from the sector. In this phase, foundational posture is established, and an initiating swing is generated to generate preliminary momentum ⁽⁷⁾.

2. Phase P2 – First Single Support (Entering the Turn): The athlete begins rotational movement, shifting support to one foot (typically the left), initiating angular acceleration ⁽⁷⁾.
3. Phase P3 – Flight Phase: This airborne transition occurs as the athlete transitions between supports near the center of the circle. Maintaining control during this phase is crucial for effective repositioning ⁽⁷⁾.
4. Phase P4 – Second Single Support: Upon ground contact with the right foot, the athlete plants firmly to prepare for the ensuing force application ⁽⁷⁾.
5. Phase P5 – Second Double Support: Both feet ground in front of the circle, forming the phase where the bulk of force transfer occurs, setting the stage for release ⁽⁷⁾.
6. Phase P6 – Release: The final explosive action, where the athlete propels the shot through the arm–hand complex, achieving optimal velocity and trajectory before rebalancing ⁽⁷⁾.

The above phases that mentioned are biomechanically individualistic energy developed in earlier phases are carried out till the end phases which helps in the sustained performance of the athlete ⁽⁸⁾. According to the complete kinematic review. The review says that to increase the shot-put distance and the release speed it depends on the success full energy transfer during all the phases of the shot-put the coaching should take on a comprehensive manner, sequential perceptive rather than isolating the phases of shotput ⁽⁸⁾. The intrinsic, combination of rapid rotational movement that are carried out with in the constricted space

arises, the considerable biomechanical challenges during the shot-put throw. It increases the demands for the dynamic balance, the spatial perception, segmental timing and precise postural control, the key principle of the human movement and the athlete should control the body orientation and conserve the linear momentum and it is more demanding than the gliding technique and this paragraph explains that how shot put is biomechanically challenged track and field event ⁽⁹⁾. Within the complex kinetic chain, the cervical musculature especially the sternocleidomastoid and upper trapezius, the above muscles stabilize the head and neck complex and maintains the visual alignment and it serves as a connection between the torso, shoulder girdle and upper limbs. Even minimal asymmetries in SCM or UT activation can introduce head tilt or misalignment albeit minor that may disrupt sensory integration (Visual and vestibular feedback), degrade movement efficiency, or predispose the athlete to injury ⁽¹⁰⁾. While direct shot-put research on neck asymmetry remains limited, studies in analogous high-speed, rotational sports and impact scenarios show that neck muscle strength and anticipatory activation significantly buffer head kinematics under load. This suggests a foundational role for cervical muscles in supporting both performance and injury resilience, warranting further attention within shot-put biomechanical analysis ⁽¹¹⁾.

Phase-Wise Interaction: Neck Muscle Activation and Asymmetry

Phase P1 – Preparation (Initial Stance, Double Support)

At the start, athletes plant both feet and engage in a controlled swing. The muscles contract nearly isometrically to stabilize the head, ensure forward gaze, and maintain alignment through rotational prep. Research in general population's reports that even during neutral tasks, SCM and UT display baseline asymmetries. For example, SCM symmetry index (SI)

hovers around 86 %, while UT symmetry is closer to 52 %, reflecting a left-side bias in activation. These latent imbalances may predispose athletes to asymmetric head positioning during the setup, potentially undermining balance or rhythm during the preliminary swing ⁽¹²⁾.

Phase P2 – Entering the Turn (Single Support Begins)

As the athlete shifts into rotation, beginning on the left foot, rapid angular momentum emerges. Neck muscles must counteract inertial forces from the turning trunk and sweeping limbs to maintain head posture. In unilateral sports such as baseball, repetitive motion drives morphological and functional changes in neck musculature often favoring one side. Similarly, rotational shot-put may amplify SCM/UT asymmetries during this phase. sEMG studies reveal that rotational arcs produce pronounced SCM asymmetry (up to 116 %), while UT remains better balanced (≈ 50 %). Sagittal motions like extension–flexion, by contrast, show superior symmetry (UT ≈ 42 %, SCM ≈ 72 %). The transition phase's rotational demand likely accentuates these disparities, potentially disrupting head stability or sensory feedback ⁽¹²⁾.

Phase P3 – Flight (Weight Transfer, Airborne Moment)

A brief airborne moment ensues as weight shifts from left to right foot. Head and neck control becomes more precarious without ground contact. Neck muscles must coordinate anticipatory stabilization a function that may be compromised by pre-existing asymmetries. External loading studies indicate that neck activation increases significantly when an athlete is aware of an incoming impact suggesting reactive muscle behavior is both context-dependent and vital to maintaining head control amid rapid movement. In the mid-flight phase, the neck must resist rotational overshoot, enabling precise reorientation

before landing ⁽¹²⁾.

Phase P4 – Second Single Support

Upon planting the right foot, homing into the second single support, neck musculature supports ground re-establishment and readies for subsequent force generation. Any lingering asymmetry could tilt head orientation, impair trunk–shoulder separation, or disrupt the impending double-support build-up ⁽¹²⁾.

Phase P5 – Second Double Support

With both feet grounded again, the athlete readies for maximal force production. This phase delivers upwards of 90 % of release velocity. Neck muscles must maintain head stability even as explosive forces reverberate through the body. Symmetric activation may uphold gaze and alignment, whereas imbalances could redirect force vectors or restrict accuracy ⁽¹²⁾.

Phase P6 – Release

The release stage embodies the kinetic chain's culmination. Here, dynamic deceleration follows force propagation. SCM and UT must engage to buffer head movement and preserve optimal orientation for release trajectory. Given reactive muscle behavior sensitivity to movement and anticipation, asymmetries during this phase may skew release mechanics or propagate cervical stress ⁽¹²⁾.

Asymmetry in Sports and Its Implications

While asymmetries in athletic performance, arising from unilateral demands, are frequently observed across various sports, the evidence regarding their influence on performance remains equivocal. Some research suggests that certain asymmetries may align with functional advantages, particularly in sports where limb dominance confers biomechanical

or proprioceptive benefits ⁽¹³⁾. However, a considerable body of evidence also links prolonged unilateral activity to bilateral force deficits and elevated risk of injury ⁽¹⁴⁾ ⁽¹⁵⁾. For example, adult female handball players exhibit more pronounced bilateral force imbalances compared to junior counterparts, potentially reflecting chronic unilateral loading patterns; in turn, strength asymmetries have been associated with both heightened injury prevalence and diminished performance outcomes.

A comprehensive systematic review of 31 studies examining lower limb functional asymmetry revealed that, while some studies report significant associations with injury risk, the overall quality of evidence is moderate to low, indicating that definitive conclusions remain out of reach. Moreover, asymmetries in lower-limb function may impair change-of-direction (COD) and sprint performance key factors in many sports though they appear to have limited impact on vertical jump capability. These findings imply that asymmetry as a structural trait does not straightforwardly dictate performance outcomes; rather, its effects may be context-dependent, varying across movement types and sports ⁽¹³⁾ ⁽¹⁷⁾.

Given this complexity, screening for asymmetry alone may not suffice to inform training or intervention strategies. Instead, such assessments should be interpreted as potential developmental markers “windows” during which neuromuscular training could yield meaningful gains. In support of this, targeted interventions, such as unilateral plyometric training, have demonstrated efficacy in reducing lower limb asymmetry ⁽¹²⁾. A recent meta-analysis of randomized controlled trials found that unilateral plyometric training significantly decreased asymmetry in various single-leg jump metrics (effect sizes: SLCMJ SMD = 0.51; SLBJ SMD = 0.56; SLLJ SMD = 1.24), with overall moderate effects (SMD

≈ 0.57). Conversely, complex or bilateral training approaches did not produce significant asymmetry reductions ⁽¹⁴⁾.

Translating this framework to neck muscle symmetry in shot-put, assessing bilateral balance across the shot-put phases becomes a meaningful diagnostic lens rather than a categorical remedy. While direct evidence for neck-specific asymmetry interventions is limited, analogous findings in rotational resistance training have shown substantial improvements in muscle symmetry and reactive strength—demonstrated by gains of approximately 46 N and large effect sizes (Hedges’s $d \sim 1.24$) ⁽¹⁵⁾. These results underscore the potential for phase-specific, unilateral training strategies (e.g., dynamic neck strengthening with rotation) to enhance neuromuscular efficiency and possibly mitigate asymmetry-related deficits ⁽¹⁴⁾ ⁽¹⁶⁾.

Measurement and Methodological Considerations

Understanding the phase-wise dynamics of neck muscle asymmetry in shot-put requires a methodologically rigorous biomechanical approach. Central to this process is the use of surface electromyography (sEMG), which when normalized through maximal voluntary contraction (MVC) allows for consistent and comparable quantification of muscle activation levels across individuals. It is important to analyze both the sternocleidomastoid and upper trapezius muscle both of which mostly help in the head stabilization and rotation control throughout the throw, to measure the asymmetry. Researchers frequently use symmetry index, which assesses and gives the data of imbalance between the right and left side of the limbs.

Phase-specific analysis of asymmetry necessitates careful segmentation of the shot-put movement. This is typically achieved by integrating synchronized video footage with

sensor-based motion capture, enabling precise delineation of the six recognized throwing phases (P1–P6). Muscle behavior can then be attributed accurately to each discrete phase, permitting fine-grained assessment of how symmetry evolves throughout the throw cycle. Complementing this dynamic analysis, baseline assessments both at rest and during controlled sagittal-plane tasks such as neck extension and flexion serve to establish reference symmetry values under non-throwing conditions ⁽¹⁸⁾.

It is essential to keep in account for the keen understanding between the static and dynamic circumstances as the muscular activation pattern in the cervical region will vary considerably depending on complex movement and velocity ⁽¹⁹⁾. In very nature the neuromuscular demands neck during the high-speed rotation through differs meaningfully from those during isolated testing ⁽²⁰⁾.

Therefore, weaving together technical nuance and neck-muscle biomechanics reveals a compelling portrait: the rotational shot-put technique, with its six-phase sequence and rhythmic transitions, challenges throwers to maintain coordinated, dynamic equilibrium. Neck muscles though often overshadowed serve as critical stabilizers and sensory conduits, guiding head posture, gaze, and kinetic chain fidelity. Existing asymmetries, even if subtle, may impact movement flow from the initial setup through release. Conversely, phase-wise analysis of SCM and UT activation (via sEMG and SI) can illuminate when and how asymmetry emerges during preparation, transition, aloft flight, or force delivery.

Despite the extensive biomechanical profiling of lower limb and trunk involvement in shot-put performance, the cervical musculature particularly in terms of phase-specific asymmetry remains markedly underexplored. Existing research either marginally references neck dynamics or generalizes findings from non-throwing sports, leaving a clear

gap in our understanding of how SCM and UT function within the rotational shot-put context. Furthermore, no prior studies have systematically mapped neck muscle asymmetry across the six distinct throwing phases using kinetic markers such as sEMG-derived symmetry indices. This study aims to fill this void by offering a phase-wise kinetic analysis of neck muscle activation asymmetry among elite shot-put throwers. The findings have significant implications: practically, they may inform injury prevention protocols, contribute to more precise biomechanical assessments, and aid coaches in refining training interventions targeting cervical stability and symmetry. By identifying when asymmetry peaks and how it evolves throughout the throw, this study opens new avenues for optimizing neuromuscular coordination in one of athletics' most technically demanding events.

NEED OF THE STUDY

On synthesizing the available literature,

- Understanding of asymmetry in muscle activation on both side of the neck would help us identifying muscle imbalance and positional change in both static & dynamic posture leading to any kind of mechanical dysfunction or injury to neck and associated structures.
- Since there is no such literature available on the same from last 10 years the need arises to conduct a study to observe the asymmetry in neck muscle activation of both sides.
- Shot put being a power full overhead throwing sport where the impact on neck and

shoulder is considerably more, shot-put throwers are considered for the population of this study.

AIM AND OBJECTIVE OF THE STUDY

AIM OF THE STUDY

To compare the neck muscle activation between ipsilateral and contralateral sides of neck.

OBJECTIVES OF THE STUDY

The objective of this study is the EMG study of muscle activation pattern during shot put throwing and This study aims to investigate the EMG study of muscle activation pattern during shot put throwing.

1. To compare the EMG activity of neck muscle on both sides during rest.
2. To compare the EMG activity of neck muscle on both side peak activation while throwing.
3. To compare the EMG activity of neck muscle on both sides post throwing.

HYPOTHESIS

HYPOTHESIS:

Null hypothesis (H01)

H01: There will be no asymmetrical muscle activation between ipsilateral and contralateral neck during rest.

H02: There will be no asymmetrical muscle activation between ipsilateral and contralateral both side peak activation of neck while throwing.

H03: There will be no asymmetrical muscle activation between ipsilateral and contralateral neck post throwing.

Alternate hypothesis (H11)

H11: There will be asymmetrical muscle activation between ipsilateral and contralateral neck during rest.

H12: There will be asymmetrical muscle activation between ipsilateral and contralateral both side peak neck muscle activation while throwing.

H13: There will be asymmetrical muscle activation between ipsilateral and contralateral neck post throwing.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Methodology of literature review:

The articles were explored with appropriate keywords under relevant sections. The literature search was conducted from electronic databases PubMed and Google Scholar. Keywords included were selected for individual section with or without using Boolean operator AND, IN. The databases used were PubMed and Google scholar. The search was then narrowed by adding keywords. Articles other than the English language and human trials were excluded. The narrowed article titles and abstracts were screened. Excluded articles with quality less than 60% in JBI critical appraisal tools. The outcomes of the review are described in the following pages under the relevant section.

SECTIONS

- **Section 1:** To find relation between neck position and upper limb injury.
- **Section 2:** To find the Neck muscles activation in overhead throwers.
- **Section 3:** To find the most valid tool to assess the neck muscle asymmetry.

SECTION A

Title - To find relation between neck position and upper limb injury.

Objective – To investigate the relationship between neck position and upper limb injuries, focusing on biomechanical and neurodynamic mechanisms, in order to identify risk factors and guide preventive and rehabilitative strategies.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

Articles included in section A

- 1) Masumi Yoshimoto et.al (2024), Association of Head-Neck Rotation with History of Pitching-Related Elbow Pain in Youth Baseball Players. To determine whether the range of motion of head-neck rotation is associated with the history of pitching-related elbow pain in youth baseball players. Our cross-sectional analysis demonstrated that youth baseball players with a history of pitching-related elbow pain had limited head-neck rotation range of motion on the non-dominant side, and this was a significant factor associated with the history of pitching-related elbow pain.

- 2) Laurie Lee Devaney et.al (2020) Preseason Neck Mobility Is Associated with Throwing-Related Shoulder and Elbow Injuries, Pain, and Disability in College Baseball Pitchers. The primary purpose of this study was to prospectively investigate the relationship between measures of neck mobility and posture and the development of shoulder and elbow injuries, pain, and disability in college baseball pitchers across a single season, as quantified by both time loss and patient-reported outcomes. Preseason neck mobility measurements were associated with shoulder and elbow time-loss injuries and self-reported pain and disability in college baseball pitchers over the course of a season. The CFRT and cervical flexion range of motion demonstrated high sensitivity and NPV and therefore may be useful screening tools in developing a risk profile for individual pitchers.

INFERENCE OF SECTION A

Neck mobility measurements in college baseball pitchers were linked to shoulder and elbow injuries, self-reported pain, and disability, suggesting the Cervical flexion rotation test and cervical flexion range of motion as screening tools. This study found that youth baseball players with a pitching-related elbow pain history had a restricted head-neck rotation range of motion, a significant factor. After reading this article in this section we can conclude that there is significant correlation between neck mobility and shoulder injury and found that there is a relationship between neck and shoulder.

SECTION B

Title - to find the Neck muscles activation in overhead throwers.

Objective – Identify and describe the specific neck muscles that are activated during the different phases of an overhead throw. the degree of morphological asymmetry in the neck muscles.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

Articles included in section B

- 1) Gabriela Figas et al (2023) Symmetry of the Neck Muscles' Activity in the Electromyography Signal during Basic Motion Patterns This study aimed to analyse the activity of the upper trapezius (UT) and sternocleidomastoid (SCM) muscles at rest and during basic motions of the neck and to determine the symmetry of the muscle activation. Surface electromyography (EMG) was collected from UT and SCM bilaterally during rest, maximum voluntary contraction The study compared the activation of upper trapezius and sternocleidomastoid muscles during neck motions to assess symmetry. The extension-flexion movement was found to be the most symmetrical, indicating higher left side muscle activity. High activity at rest suggests improper upper body posture or incomplete relaxation.
- 2) Maly et al (2016) Unilateral and Ipsilateral Strength Asymmetries in Elite Youth Soccer Players with Respect to Muscle Group and Limb Dominance To identify the presence of strength asymmetries in young elite soccer players in relation to muscle group and limb preference (dominant vs. non-dominant limb). Our study found that more than 73.2 % of players have at least one strength asymmetry. More attention should be paid to knee flexors where we found strength asymmetry in 51.2 % of the tested players at the lowest velocity and in 41.5 % at the highest velocity. The non-dominant limb also deserves increased attention because its ipsilateral ratio was lower at each velocity compared to the dominant limb and strength asymmetries also achieved a higher percentage proportion. Maladaptive effects of body strength asymmetries.

INFERENCE OF SECTION B

According to physiological cross-sectional area (PCSA) is a measure of the number and size of muscle fibres available in a muscle and thus is an indicator of a muscle's potential for force production. By reading above article, we can conclude that both these muscles are primarily responsible for neck rotation when working unilaterally and for neck flexion (sternocleidomastoid) or extension (upper trapezius) when working bilaterally.

SECTION C

Title - To find the most valid tool to assess the neck muscle asymmetry.

Objective – To identify valid tool to assess asymmetry.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed.

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

Articles included in section C

- 1) Kamala Pashayeva et al (2021) The generalized information about the possibilities of assessing asymmetry and the prospects of research tools is presented. The important role of the choice of different methods for processing electromyographic signals, the results of which can be considered as an objective criterion for assessing the asymmetry of the muscles of the extremities, is noted, such as the asymmetry coefficient, a widely used parameter in statistical analysis, which characterizes the asymmetry of the statistical distribution. Also applied is the segmental method of studying the body to obtain estimates of the composition and differences between individual body segments. The isokinetic test method, which makes it possible to assess asymmetry in measuring muscle strength, relies on the randomness of the dynamic processes of the biological system. Use of nonlinear dynamics, the theory of dynamic chaos, and fractal analysis allows for determining the fractal properties of bio signals and from the classical methods used correlation analysis.

- 2) Sureshkumar Kamalakannan et al (2021) Feasibility and Acceptability of Pheeze: A Mobile Phone Based Wearable Prognostic Device for Physical Rehabilitation; Pheeze is a revolutionary device that captures, the range of motion (ROM) and Electromyogram (EMG) of the joints and muscles of the human body in real-time. Pheeze is a predictive device made up of two wearable modules, a supporting custom android application, and cloud-based processing services and data storage. The instrument is battery-powered and is rechargeable. The instrument is put on by the patient for therapy sessions. The two wearing modules are placed above and

below the joint to be monitored or checked for ROM and muscle activity. The surface EMG electrodes are placed on the particular muscle that is responsible for the motion of the joint. Both the ROM and the EMG are acquired by the phone app in real-time for immediate view on the phone's display screen. The acquired data is transferred to the cloud-based server where it is processed further and analyzed to determine the prognosis in terms of the consistency and control of the joint and muscle functions. The extensive results can also be downloaded as a report that can subsequently be distributed electronically or can be printed and appended to the patient reports and clinical case notes

INFERENCE OF SECTION C

One of the primary tools for this is electromyography (EMG), which measures muscle activity. The results from EMG can be objectively evaluated using a variety of statistical methods, with the asymmetry coefficient being a common metric. This coefficient is a statistical parameter that helps quantify the distribution's asymmetry, providing a clear way to compare the difference between, for example, the muscles of the left and right limbs. Measuring Range of Motion and muscle activity during therapy is crucial to set remedial goals for patients to achieve and recover during the continuum of care for persons with physical disabilities. However, standard techniques and tools are neither part of initial assessments nor the final discharge evaluation in the context of physical rehabilitation in most of the low and middle-income countries. This context warrants development of innovative strategies to establish therapeutic practice standards especially in terms of assessment of physical impairments such as limited ROM and muscle activity.

METHODOLOGY AND PROCEDURE

METHODOLOGY

- 1) Study population: Shot put players.
- 2) Study design: Cross-sectional study design.
- 3) Sampling technique: Universal sampling.
- 4) Sampling criteria:
 - INCLUSION CRITERIA
 - a. The age between 18-28 years.
 - b. Gender both male and female both.
 - c. Elite athletes (athlete competing at national and international level).
 - d. Participants must be able to perform 3 consecutive repetitions.
 - EXCLUSION CRITERIA
 - a. Any ongoing pain or under lying medical issue.
 - b. Any surgery to the upper limb in last six months.
 - c. Any existing health condition like musculoskeletal, cardiovascular and respiratory conditions.
 - d. If the pain arises at the time of testing.
- 5) Sample size: 15.
- 6) Study setting: Kalinga Stadium, Bhubaneswar.
- 7) Study duration: 5 Months.
- 8) Ethical clearance: 2 Months.
- 9) Sample selection: 1 Month.
- 10) Data collection: 1 Month.
- 11) Statistical analysis, results, discussion: 1 month.

MATERIALS USED

- EMG device
- EMG leads
- Tab
- Shot put (4kg,5kg,6kg,7kg)
- Tripod stand
- Two mobile phones

OUTCOME MEASURES

- EMG device,
- MVC - Maximum voluntary contraction of Trapezius muscle on both sides of the neck using a portable EMG device i.e. Pheeze manufactured by Startoon labs private limited.
- Peak muscle activation values were recorded and used for analysis.



Figure 1: Materials used.

PROCEDURE

Approval from IEC of Abhinav Bindra sports medicine and research institute (annexure c.1) was obtained. For data retrieval, players were assessed and recorded to sports analysis in google drive.

PHASE 1

Between June 2025 and July2025 permission was taken from the head coach, Athletics project Odisha DSYS: Kalinga stadium, Bhubaneswar for the recruitment of subjects (i.e. shot-put throwers).

PHASE 2

A total of 15 players were assessed and 12 participants and baseline data was taken in order to analyze.

PHASE 3

Testing of an individual subject was conducted on 4 separate days. A minimum of 24-72 hours of rest before testing for the complete recovery.

The following were confirmed for the pre-test check list before testing;

1. No maximal resistance exercises within 24 hours.
2. No large meal within 2 hours of testing.
3. No caffeine/pre workout within 12 hours.
4. Subjects' indication for adequate recovery.

On the testing day the standardized shot-put specific warm-up drills was completed,

followed by baseline testing of the back throw test (over head back word throw) & standing throw test, the tests were chosen by the coach opinion.

PHASE 4

All the participants were screened for inclusion and exclusion criteria by the principal investigator of the study and 12 participants was recruited; after thoroughly explaining the procedure, informed consent was obtained from all the participants. Participants who met the inclusion criteria the following baseline data were collected: age, gender, height and weight.

PHASE 5

- EMG sensors and electrode was placed on the athlete and mobile cameras were placed in sagittal view and posterior view during this phase. Skin preparation will be done for electrode placement according to SENIAM guidelines (22). Electrodes will be placed for each muscle according to the previous studies.

Patient preparation:

- I. Patient clothing: Men: tight-fit pants/shorts and t-shirts.

Women: tight fit pants/short.

- II. Body landmarks: 1st strap of the EMG sensor on the forehead of the athlete and 2nd strap of EMG sensors on the xiphisternal level above the chest.



Figure2: Strap placement and EMG testing.

- III. Surface: cemented throwing circle, a wooden stop board.
- IV. Material required: Mobile camera, digital camera tripods, EMG sensors.
- V. Distance of camera:
 - Sagittal and Frontal view: 3 meters.
 - Height of the camera: 5 meters.

PHASE 6

The athlete was instructed to change into suitable clothing and sensors were placed on the body and athlete was instructed to throw on the cue of start.

PHASE 7

The athlete was instructed to perform throws, which was recorded through mobile cameras for the analysis of phases and maximum voluntary contraction of muscle was recorded through EMG.

Adverse event: there was no adverse event happened while performing test.

PHASE 8

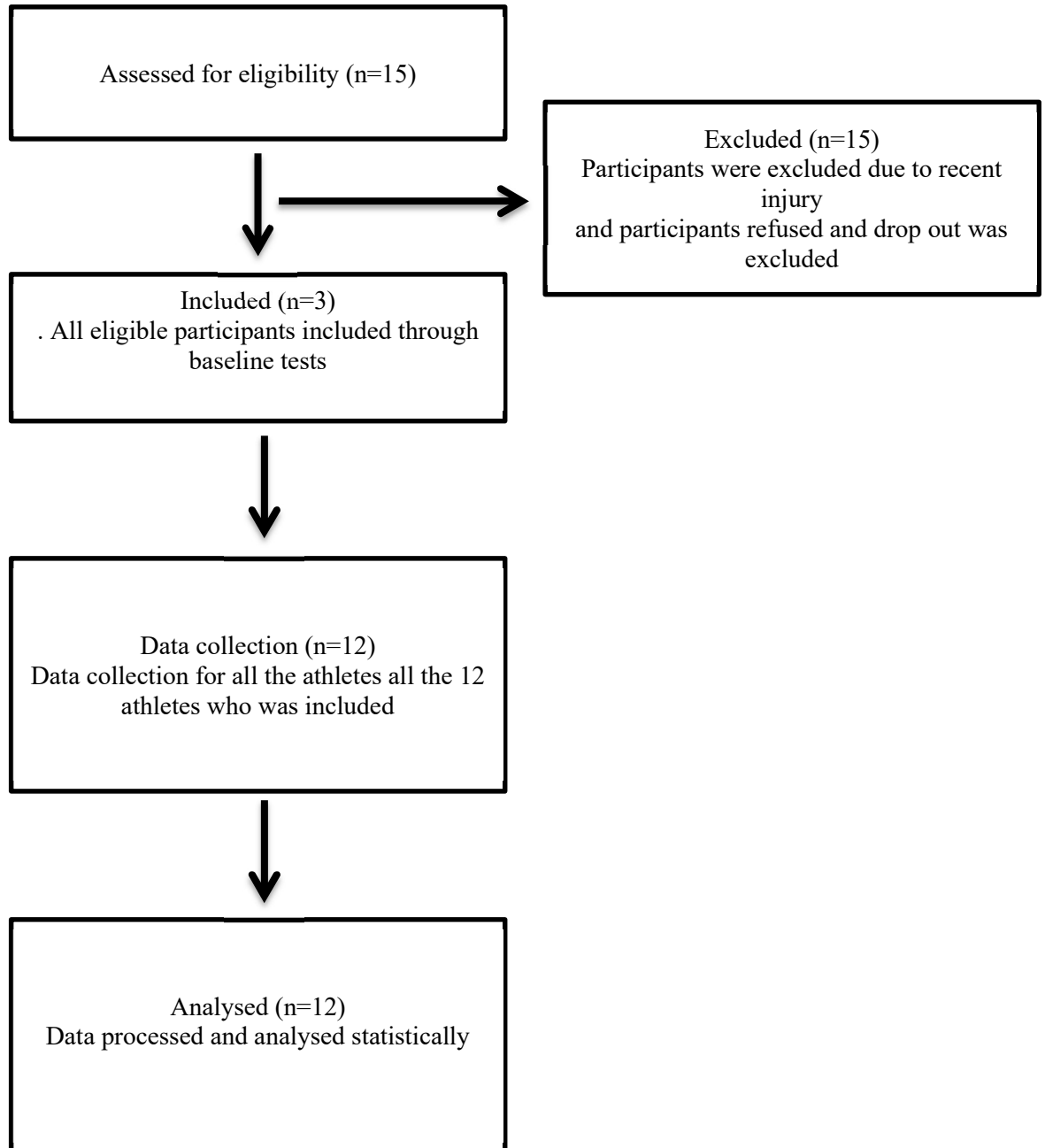
Data analysis;

Data was recorded using EMG device and phases were analyzed using the camera recording. Descriptive analysis was done for demographic characteristics of participants. Phase wise activation of initial throw, peak during throw and post throw activation was recorded with EMG for kinetic analysis. The values were recorded for 3 phases and statistical analysis of the data was performed for all 12 participants using SPSS version 22.



Figure 3: Phase of shot-put throwing.

METHODOLOGY FLOW CHART



STATISTICAL ANALYSIS

STATISTICAL ANALYSIS

The data was analyzed using IBM Crop. Released 2017. IBM SPSS statistics for windows, version 25.0. Armonk, NY: IBM CROP. In the descriptive statistics that is mean, standard deviation, minimum, maximum and frequency distribution was calculated to summarize the demographic data the age, gender, height, weight and BMI. The Inferential statistics was done to examine within-subject differences in trapezius muscle activation (left vs. right side) across three phases of the shot-put throw (Initial, Peak, and End). The paired t-test was used for the comparisons since the same participants contributed values for both sides and in addition the correlation coefficients (r) were computed to assess the relationship between left and right trapezius activity during all the phases of shot-put throwing.

RESULT

RESULTS

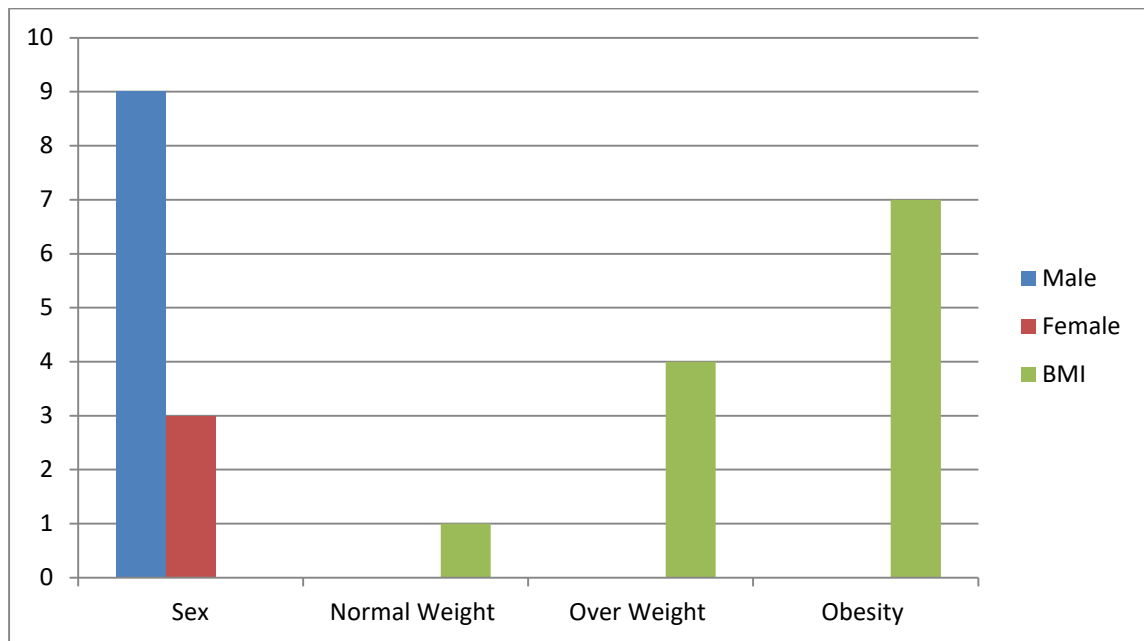
The present study titled the Kinetic analysis of neck muscle asymmetry among elite shot-put throwers had obtained 15 required sample as per the availability of the participants for which all 15 participants were screened for inclusion and exclusion criteria, 3 participants did not meet inclusion criteria and were excluded, 12 participants were recruited for the study and 12 participants completed the EMG testing hence result analysis done for 12 participants.

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	12	19	28	21.67	2.535
GENDER					
Male	09				
Female	03				
HEIGHT	12	129	185	172.08	16.065
WEIGHT	12	58	155	100.42	26.565

The above presents the descriptive statistics of the 12 participants. The mean age was 21.67 years (SD = 2.54) and with ages ranging from 19 to 28. The sample included 7 males and 3 females. Participants' height was ranged from 129 cm to 185 cm, with a mean of 172.08 cm (SD = 16.07), while weight ranged from 58 kg to 155 kg, averaging 100.42 kg (SD = 26.57).

Table 2: BMI of the Participants				
	Frequency	Percent	Valid Percent	Cumulative Percent
Normal	1	8.3	8.3	8.3
Over Weight	4	33.3	33.3	41.7
Obesity	7	58.3	58.3	100.0
Total	12	100.0	100.0	

The above displays the Body Mass Index (BMI) classification of the 12 participants. The majority (58.3%) were categorized as obese, followed by 33.3% classified as overweight, and only 8.3% falling within the normal BMI range. These results indicate a high prevalence of excess body weight among the sample.



Graph 1: BMI classification of athletes.

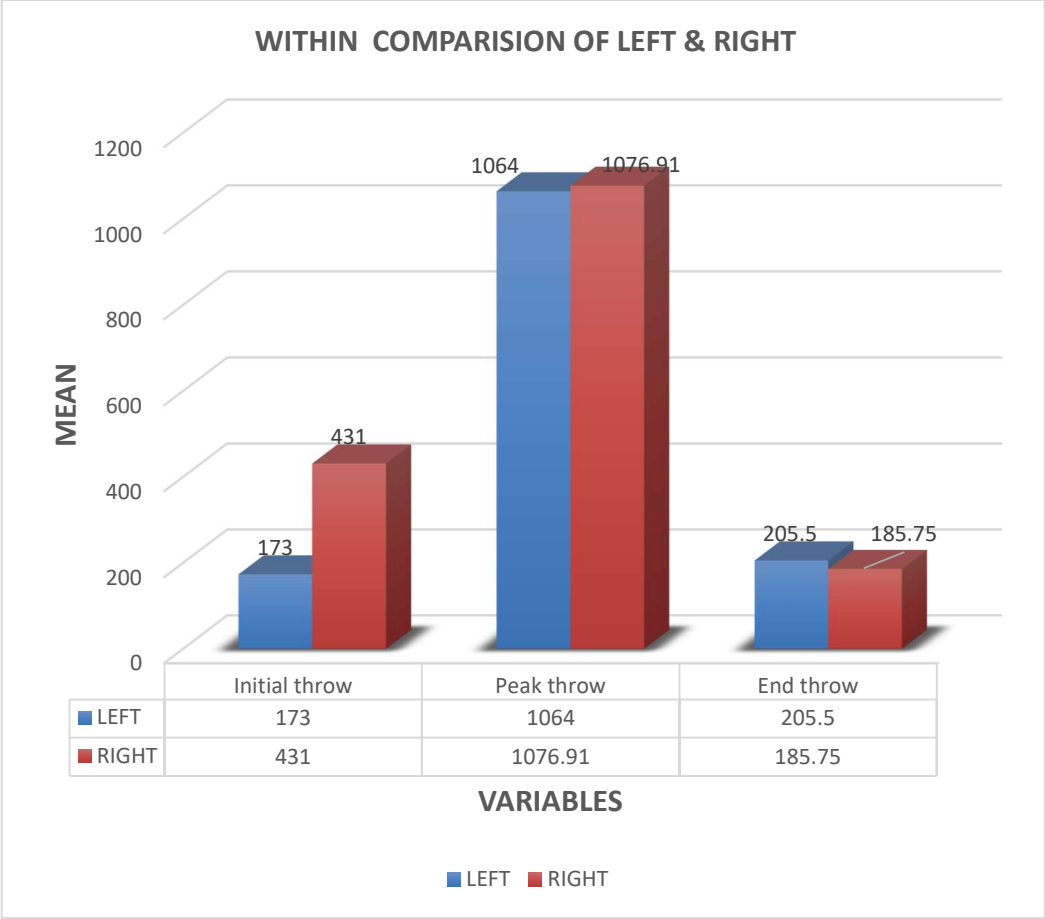
TABLE 3: WITHIN COMPARISON OF LEFT & RIGHT TRAPEZIUS

Variables	Left Trapezius MEAN ± SD	Right trapezius MEAN±SD	MEAN Difference	r	t	p
Initial throw	173±93.54	431±490.387	-258	.432	-1.952	.077
Peak throw	1064±407.5	1076.91±440.4	-12.833	.418	-.097	.924
End throw	205.5±328.618	185.75±238.884	19.75	.245	.192	.851

At the initial throw, the left side had a mean value of 173 ± 93.54 , while the right side showed a much higher mean of 431 ± 490.39 . This resulted in a mean difference of -258, indicating higher values on the right. Although the correlation coefficient (r) was 0.432, the t-value was -1.952, and the associated p-value was 0.077. This suggests a trend toward significance, but it did not reach conventional statistical significance ($p > 0.05$).

During the peak throw, the left side recorded a mean of 1064 ± 407.50 , while the right side had a very similar mean of 1076.91 ± 440.40 , leading to a minimal mean difference of -12.83. The correlation coefficient was 0.418, the t-value was -0.097, and the p-value was 0.924, indicating no statistically significant difference between sides during the peak throw phase.

Finally, in the end throw phase, the mean value for the left side was 205.5 ± 328.62 , slightly higher than the right side, which had a mean of 185.75 ± 238.88 . The mean difference was 19.75, with a correlation coefficient of 0.245, a t-value of 0.192, and a p-value of 0.851. This again suggests no significant difference between the left and right sides at the end of the throw.



Graph 2: Within comparison right and left trapezius.

The bar graph titled “Within Comparison of Left and Right trapezius” presents a visual representation of the mean values for three key phases of shot-put throwing: that is Initial Throw, Peak Throw, and End Throw, comparing the performance of the left and right sides. Each phase has illustrated using paired bars blue for the left side and orange for the right providing a clear side-by-side comparison of performance within the same individuals.

In the Initial Throw phase, the graph shows a noticeable difference between the two sides. The right side demonstrates a significantly higher mean value (431) compared to the left side, which recorded a mean of only 173. This sharp contrast suggests that participants tended to initiate the throw with greater force or control on their right side. This may be reflective of hand dominance, with many individuals naturally favoring their right side for tasks requiring precision and power. The large gap at this phase could indicate better neuromuscular coordination, reaction timing, or initial force generation on the dominant side.

Moving into the Peak Throw phase, the difference between the sides narrows considerably. Here, the left side achieved a mean of 1064, while the right side was only slightly higher, with a mean of 1076.91. The bars in this section of the graph appear almost identical in height, indicating that by the time maximum throw performance is reached, both sides are functioning at a nearly equivalent level. This result suggests that despite early-phase asymmetries, the body may naturally balance itself during the full execution of the throw. The equalization at this stage may be due to increased involvement of the entire kinetic chain engaging core muscles, legs, and upper body symmetrically thereby reducing the advantage of the dominant side.

In the End Throw phase, a subtle shift is observed. Interestingly, the left side recorded a slightly higher mean (205.5) compared to the right side (185.75). While the difference is minor, it is nonetheless notable, particularly because it represents a reversal from the initial phase where the right side dominated. This reversal might be attributed to fatigue setting in more prominently on the dominant side, or possibly better control during the deceleration phase by the non-dominant side. Alternatively, it may suggest that while one side initiates the throw more forcefully, the other may compensate during the follow-through or recovery phase.

Taken together, the graph offers a compelling illustration of how side-to-side performance varies across different stages of the throw. The initial advantage of the right side is evident, but this asymmetry diminishes as the throw progresses, with near parity at peak performance, and a slight left-side advantage by the end. This dynamic pattern may point to the body's intrinsic ability to self-correct or compensate for imbalances during complex motor tasks.

DISCUSSION

DISCUSSION

This study examined that the neck muscle asymmetry in elite shot-put throwers across three critical phases: the initial throw, the peak throw, and the end throw. Results showed clear right-sided predominance at initiation, near-symmetry at peak performance, and a subtle left-sided predominance at the end. At initiation, the right side exhibited higher mean values (431 ± 490.39 vs. 173 ± 93.54), suggesting a dominant-side advantage during preparatory force generation. Although not statistically significant ($p = 0.077$), the trend was consistent. By the peak throw phase, left and right activation was nearly equal (1064 ± 407.5 vs. 1076.91 ± 440.4 , $p = 0.924$), highlighting bilateral recruitment during maximal output. At the end phase, a slight but non-significant reversal (205.5 ± 328.62 vs. 185.75 ± 238.88 , $p = 0.851$) suggested compensatory or stabilizing roles of the non-dominant side. Anthropometric analysis revealed typical shot-put profiles: high body mass (100.41 ± 16.06 kg), elevated BMI (34.19 ± 7.94), and significant variation in height ($p = 0.002$), consistent with sport-specific demands. These findings emphasize that neck muscle asymmetry is dynamic, phase-dependent, and functionally significant.

The present study tested three null hypotheses regarding neck muscle asymmetry across different phases of the shot-put throw. The null hypothesis H_{01} , which proposed no asymmetrical activation between ipsilateral and contralateral neck muscles at rest, was rejected. The data revealed the trend toward dominant-side predominance during the initial throw, supporting the alternate hypothesis H_{11} . Although the p-value (0.077) did not cross the conventional threshold, the consistent right-sided dominance indicated functional asymmetry at initiation.

In contrast, the null hypothesis H0₂ was accepted, as results demonstrated that there was no significant asymmetry during the peak throw phase. This finding supports the notion that elite athletes achieve bilateral balance when maximal force generation is required, leading to the rejection of the alternate hypothesis H1₂. Similarly, the null hypothesis H0₃ was accepted for the post-throw phase, since no significant asymmetry was observed despite a slight mean predominance on the non-dominant side, rejecting the alternate hypothesis H1₃.

In summary, only H1₁ was supported, while H1₂ and H1₃ were not, emphasizing that neck muscle asymmetry is phase-specific emerging at initiation but resolving during peak and follow-through phases. The phase-specific nature of asymmetry found in this study aligns with recent sports science literature. Rahnama et al. (2025) reported greater non-dominant splenius capitis thickness and stronger neck extensors in baseball pitchers, indicating compensatory adaptations on the non-dominant side, which resonates with our finding of left-sided predominance in the end phase ⁽²⁹⁾. Similarly, Acik et al. (2023) observed no significant asymmetry in neck flexor strength or thickness among pitchers, paralleling our symmetry at peak throw ⁽³⁰⁾. Furthermore, Hashimoto et al. (2023) showed that upper limb muscle cross-sectional area strongly correlated with shot-put performance, indirectly supporting the idea that performance depends on coordinated bilateral recruitment despite early-phase asymmetries ⁽³¹⁾. By contrast, Ikeda et al. (2023) found greater lean mass in the dominant arm of overhead throwers, highlighting long-term morphological dominance ⁽³¹⁾. Gowda et al. (2024) showed that kinematic chain exercises improved shoulder strength and reduced asymmetries in shot-put athletes, suggesting that targeted training can diminish persistent imbalances ⁽³²⁾. Finally, Jiao et al. (2025) demonstrated that the non-throwing

arm contributes significantly to balance during the completion phase of the glide shot-put, supporting our interpretation of non-dominant cervical muscle involvement at the end of the throw⁽³³⁾.

Majority of the studies in the literature show that though dominance is a common phenomenon functional demands are to be addressed which necessitates the bilateral balance or even non-dominant compensation that is added by this study. However, symmetry during the peak throw states the principle of kinetic chain integration which indicates that to achieve optimal output one requires the use of both sides of the neck muscles that help stabilize the head, maximize the alignment and protect from energy breakdown. Also, the left-sided predominance during end phase suggests compensatory mechanisms. Usually, the fatigue experienced by players is attributed to the role of dominance that helps in stabilizing as well and isn't dysfunctional but the body's way to safeguard against cervical overload while achieving deceleration. Initiation of muscle activity at the dominant helps in gaining explosive momentum while the activity on the non- dominant side prevents from injury which helps in optimal performance. The physiological basis for this observation is attributed to the motor unit recruitment, bilateral cortical activation at peak effort, and proprioceptive stabilization during deceleration. The head stabilized by the neck acts as a link between vestibular and visual systems, that also contribute in synchronous movements at upper and lower limbs. Hence it can be stated that slightest of the asymmetries in the cervical region affect the shot- put throw. The observations from this study can be used in various settings like that of training and rehabilitation and athlete development and awareness programs. Strength and Conditioning coaches may focus on improving the dominant side strength by drills like medicine ball throws, stressing on the bilateral coordination through Olympic lifts and resisted rotational

exercises. The physiotherapists may use these findings to screen the athletes and focus on improving the non-dominant side stabilization and dominant side explosive power for rehabilitating the affected individuals. Further having a higher BMI and mass provide strength that facilitate uneven loading patterns. Height variances may influence cervical stabilization demands as taller athletes may experience amplified asymmetries due to longer lever arms, whereas shorter athletes rely more on explosive cervical control. While planning a training protocol one must take into account the sex differences as men tend to have a greater unilateral strength, that influences dominant-side initiation, and women on the other hand often display greater levels of endurance and flexibility, that facilitates compensatory or symmetrical activation. The study hence provides deeper insights regarding the asymmetry that it should not be wrongly looked upon but the functional modulation during various phases help regulate the elite athletes to use it to an advantage. It clearly demonstrates that training may be focused on not reducing the asymmetries but help the athletes to use it to stabilize the non- dominant side and improve the explosive power on the dominant side.

CONCLUSION

CONCLUSION

The current research gives us the new insights on the active role of the neck muscle asymmetry among the phases of the shotput throw, after analyzing the kinetic patterns during the initial peak to end peak. It is seen that the asymmetry is phase dependent and dominant side plays important role in initiation all through the peak phase, the maximum force was critical interpretation was emerged and there was minute shift toward, non-dominant side at the end phase. And last for the coaches, athletes, and physiotherapists, all of these patterns highlight the need for training programs that boosts dominant-side power, bilateral coordination, and develop non-dominant endurance and control.

The anthropometric characteristics of the cohort, particularly high body mass and BMI, reflect the demands of shot-put but also raise questions about how structural factors interact with neuromuscular strategies to influence asymmetry.

In conclusion, the study underscores the critical yet often overlooked role of cervical musculature in throwing performance. Neck muscle asymmetry in shot-put is dynamic, adaptive, and functionally significant, offering fertile ground for further investigation and practice application in elite sport.

LIMITATIONS AND SCOPE FOR FUTURE STUDY

LIMITATIONS AND SCOPE FOR FUTURE STUDY

Limitations-While the present study provides valuable insights into the kinetic analysis of neck muscle asymmetry among elite shot-put throwers, several limitations must be acknowledged to properly contextualize the findings. First, the relatively small sample size ($n = 12$) limits the statistical power and generalizability of the results. Although trends toward significance were observed, particularly in the initial throw phase, the possibility of Type II errors cannot be excluded. A larger cohort would strengthen the reliability of the conclusions and allow for more robust subgroup analyses, including sex-specific comparisons.

Second, the observational design of the study restricts the ability to establish causal relationships between neck muscle asymmetry and performance outcomes. While asymmetries were identified across different phases of the throw, it remains unclear whether these imbalances directly influence performance, represent adaptive strategies, or serve primarily as protective mechanisms against injury. Experimental or longitudinal designs would be better suited to address these causal questions.

Third, the study focused exclusively on kinetic measures without incorporating complementary modalities such as electromyography (EMG), imaging, or motion capture analysis. While kinetic data provide a strong foundation for understanding force dynamics, they do not fully capture the underlying neuromuscular activation patterns or morphological characteristics contributing to asymmetry. This limits the depth of interpretation regarding the specific roles of individual cervical muscles and the coordination strategies employed.

Another limitation relates to the heterogeneity of the sample in terms of anthropometric

variables, particularly height, which showed significant variation. These differences may have influenced cervical mechanics and the distribution of forces across throw phases, complicating direct comparisons between athletes. Moreover, the imbalance in gender representation, with only three female participants, precludes meaningful sex-based analyses.

Finally, external factors such as training history, throwing technique (glide vs rotation), and injury status were not controlled in this study. Each of these elements could significantly influence neck muscle kinetics and asymmetry patterns. Without accounting for them, the findings, though valuable, must be interpreted with caution and seen as exploratory rather than definitive.

Scope of future study-Building on the findings of this study, future research should seek to address the limitations while expanding the scope of inquiry into neck muscle asymmetry in shot-put athletes. A key priority is the inclusion of larger and more diverse samples to enhance statistical power and allow for stratified analyses across sex, age, and technique variations. By incorporating athletes from different competitive levels, researchers could also examine whether the observed phase-dependent asymmetry patterns are unique to elite performers or represent broader adaptations across the athletic spectrum. Methodologically, future studies should integrate multimodal assessments to provide a more comprehensive picture of asymmetry. And radiographic techniques namely ultra sound or MRI would help and reveling structural asymmetries in the muscle thickness and physiological cross-sectional area and 3D motion capture system may help to find the cervical mechanics with whole bodies kinematic categorical section and gives us the information about this and how neck muscle contributes to kinetic chain transfer in

muscles.

A longitudinal research is needed to investigate how asymmetry that develop eventually with training level, competition level and rehabilitation phase and should clarify that the asymmetries a stable trial or an adaptive process, modifiable factor .And the encouraging directions involves comparative analysis across throwing domines in the athletics like javelin, discuss, and hammer throw, where the cervical stabilization has a crucial role, it helps to identify the asymmetry in overhead throwing sports.

SUMMARY

SUMMARY

The study examined that the neck muscle asymmetry among the elite shot-put throwers by analyzing the activity of the upper trapezius muscles right and left across the 3 phases that are initial, peak during throw, end phase using the surface EMG. And the above research reveals that there is highest activation in the dominant side in initial phase, the activation was symmetrical in peak throw with minimal Stastical difference.

And there was slight increase activation in non-dominant side at the end phase of throwing. All of these phase dependent asymmetries indicate functional adaptations that supports the injury prevention and performance.

The above gives us information that targets neck muscle training helps in in injury prevention and performance.

STATEMENT OF FUNDING

STATEMENT OF FUNDING

- 1) **Source of Funding:** there was no source of funding for this study.
- 2) **Nature of Funding:** the study was self-supported, with no external financial assistance.

BIBLIOGRAPHIC REFERENCES

BIBLIOGRAPHIC REFERENCES

- 1) Saeterbakken AH, Stien N, Andersen V, Scott S, Cumming KT, Behm DG, Granacher U, Prieske O. The Effects of Trunk Muscle Training on Physical Fitness and Sport-Specific Performance in Young and Adult Athletes: A Systematic Review and Meta-Analysis. *Sports Med.* 2022 Jul;52(7):1599-1622. doi: 10.1007/s40279-021-01637-0. Epub 2022 Jan 21. PMID: 35061213; PMCID: PMC9213339.
- 2) Kanakapura Chananke Gowda VK, Subramanian SS, Mustafa Gaowgzeh RA, Ahmed Alsenany S, Abdelaliem SMF, Saeed Alabdullah AA, Afnan AM. Effect of Kinematic Chain Exercise Protocol on Throwing Performance and Shoulder Muscle Strength among University Shot Put Athletes-A Randomized Controlled Trial. *J Clin Med.* 2024 Aug 23;13(17):4993. doi: 10.3390/jcm13174993. PMID: 39274203; PMCID: PMC11396099.
- 3) Coh M, Stuhec S, Supej M. Comparative biomechanical analysis of the rotational shot put technique. *Coll Antropol.* 2008 Mar;32(1):249-56. PMID: 18494211.
- 4) Kato T, Maeda K, Mizushima J, Maeda A. Investigation of a Theoretical Model for the Rotational Shot Put Technique. *J Appl Biomech.* 2024 Nov 13;40(6):528-536. doi: 10.1123/jab.2023-0233. PMID: 39504951.
- 5) Landolsi M, Labiadh L, Zarrouk F, Maaref K, Ghannouchi S, Tabka Z, Lacouture P. Kinematic analysis of the shot-put: A method of assessing the mechanical work of the hand action force. *Eur J Sport Sci.* 2018 Oct;18(9):1208-1216. doi: 10.1080/17461391.2018.1478449. Epub 2018 Jun 5. PMID: 29869946.

- 6) Schofield M, Cronin JB, Macadam P, Hébert-Losier K. Rotational shot put: a phase analysis of current kinematic knowledge. *Sports Biomech.* 2022 Mar;21(3):278-296. doi: 10.1080/14763141.2019.1636130. Epub 2019 Aug 1. PMID: 31368410.
- 7) Landolsi, Mounir & LAZHAR, LABIADH & Zarrouk, Faysal & Maaref, K. & Ghannouchi, Slaheddine & Tabka, Zouhair & Lacouture, Patrick. (2018). Kinematic analysis of the shot-put: A method of assessing the mechanical work of the hand action force. *European Journal of Sport Science.* 18. 1-9. 10.1080/17461391.2018.1478449.
- 8) Schofield, Michael & Cronin, John & Macadam, Paul & Hébert-Losier, Kim. (2019). Rotational shot put: A phase analysis of current kinematic knowledge. *Sports Biomechanics.* 21. 10.1080/14763141.2019.1636130.
- 9) Kato T, Maeda K, Mizushima J. Comparison between rotational and glide techniques in shot put based on the performance analysis of competitions. *J Phys Educ Sport.* 2023 May;23(5):1156–64. doi:10.7752/jpes.2023.05144.
- 10) Eckner JT, Oh YK, Joshi MS, Richardson JK, Ashton-Miller JA. Effect of neck muscle strength and anticipatory cervical muscle activation on the kinematic response of the head to impulsive loads. *Am J Sports Med.* 2014 Mar;42(3):566-76. doi: 10.1177/0363546513517869. Epub 2014 Jan 31. PMID: 24488820; PMCID: PMC4344320.
- 11) Waring KM, Smith ER, Austin GP, Bowman TG. Exploring the Effects of a Neck Strengthening Program on Purposeful Soccer Heading Biomechanics and Neurocognition. *Int J Sports Phys Ther.* 2022 Oct 2;17(6):1043-1052. doi: 10.26603/001c.38327. PMID: 36237655; PMCID: PMC9528716.
- 12) Figas G, Hadamus A, Błażkiewicz M, Kujawa J. Symmetry of the Neck Muscles' Activity in the Electromyography Signal during Basic Motion Patterns. *Sensors*

- (Basel). 2023 Apr 21;23(8):4170. doi: 10.3390/s23084170. PMID: 37112509; PMCID: PMC10140881.
- 13) Helme M, Tee J, Emmonds S, Low C. Does lower-limb asymmetry increase injury risk in sport? A systematic review. *Phys Ther Sport*. 2021 May;49:204-213. doi: 10.1016/j.ptsp.2021.03.001. Epub 2021 Mar 8. PMID: 33770741.
- 14) Sun W, Li H, Qu L, Zhou Y, Cao X, Wang K, Li K. Unilateral plyometric training effectively reduces lower limb asymmetry in athletes: a meta-analysis. *Front Physiol*. 2025 Apr 9;16:1551523. doi: 10.3389/fphys.2025.1551523. PMID: 40271209; PMCID: PMC12014563.
- 15) Kalata M, Maly T, Hank M, Michalek J, Bujnovsky D, Kunzmann E, Zahalka F. Unilateral and Bilateral Strength Asymmetry among Young Elite Athletes of Various Sports. *Medicina (Kaunas)*. 2020 Dec 10;56(12):683. doi: 10.3390/medicina56120683. PMID: 33321777; PMCID: PMC7764419.
- 16) Versteegh TH, Dickey JP, Emery CA, Fischer LK, MacDermid JC, Walton DM. Evaluating the Effects of a Novel Neuromuscular Neck Training Device on Multiplanar Static and Dynamic Neck Strength: A Pilot Study. *J Strength Cond Res*. 2020 Mar;34(3):708-716. doi: 10.1519/JSC.0000000000003091. PMID: 30946260.
- 17) Fox KT, Pearson LT, Hicks KM. The effect of lower inter-limb asymmetries on athletic performance: A systematic review and meta-analysis. *PLoS One*. 2023 Jun 8;18(6):e0286942. doi: 10.1371/journal.pone.0286942. PMID: 37289826; PMCID: PMC10249853.
- 18) Figas G, Hadamus A, Błażkiewicz M, Kujawa J. Symmetry of the Neck Muscles' Activity in the Electromyography Signal during Basic Motion Patterns. *Sensors*

(Basel). 2023 Apr 21;23(8):4170. doi: 10.3390/s23084170. PMID: 37112509; PMCID: PMC10140881.

- 19) Rahnema L, Acik C, Dy C, Keslacy S. Unilateral baseball pitching: morphological and functional adaptations in the neck muscles. *Front Sports Act Living*. 2025 Feb 10;7:1452412. doi: 10.3389/fspor.2025.1452412. PMID: 39995574; PMCID: PMC11847819.
- 20) Pashaei M, Babakhani F, Banihashemi K. Evaluation of surface electromyography of selected neck muscles during the whiplash mechanism in aware and unaware conditions due to safe punching in kickboxing. *BMC Musculoskelet Disord*. 2023 May 30;24(1):429. doi: 10.1186/s12891-023-06563-y. PMID: 37254094; PMCID: PMC10227954.
- 21) Pashayeva K, Abdullayev N. Methods and Tools for Assessing Muscle Asymmetry in the Analysis of Electromyographic Signals [Internet]. *Complementary Therapies. IntechOpen*; 2022. Available from: <http://dx.doi.org/10.5772/intechopen.103061>
- 22) Hermens HJ, Freriks B, Merletti R, Hägg G, Disselhorst-Klug C, Rau G. European recommendations for surface electromyography (SENIAM)—results of a European project. *J Electromyogr Kinesiol*. 1999;9(5):321-2.
- 23) Yoshimoto M, Kawabata M, Miyata T, Sato Y, Naoi D, Ashihara M, Suzuki N, Ikoma C, Tatsuki H, Kuratsubo R, Watanabe H, Kusaba Y, Watanabe D. Association of Head-Neck Rotation With History of Pitching-Related Elbow Pain in Youth Baseball Players. *Orthop J Sports Med*. 2024 Feb 23;12(2):23259671241229079. doi: 10.1177/23259671241229079. PMID: 38405009; PMCID: PMC10894543.

- 24) Devaney LL, Denegar CR, Thigpen CA, Lepley AS, Edgar C, DiStefano LJ. Preseason Neck Mobility Is Associated With Throwing-Related Shoulder and Elbow Injuries, Pain, and Disability in College Baseball Pitchers. *Orthop J Sports Med.* 2020 May 18;8(5):2325967120920556. doi: 10.1177/2325967120920556. PMID: 32523967; PMCID: PMC7235677.
- 25) Figas G, Hadamus A, Błażkiewicz M, Kujawa J. Symmetry of the Neck Muscles' Activity in the Electromyography Signal during Basic Motion Patterns. *Sensors (Basel).* 2023 Apr 21;23(8):4170. doi: 10.3390/s23084170. PMID: 37112509; PMCID: PMC10140881.
- 26) Maly T, Zahalka F, Mala L. Asimetría de fuerzas unilateral e ipsilateral en jugadores de fútbol de élite juveniles con respecto al grupo muscular y a la dominancia de miembros. *Int J Morphol.* 2016;34(4):1339-44.
- 27) Pashayeva K, Abdullayev N. Methods and Tools for Assessing Muscle Asymmetry in the Analysis of Electromyographic Signals [Internet]. *Complementary Therapies. IntechOpen*; 2022. Available from: <http://dx.doi.org/10.5772/intechopen.103061>.
- 28) Kamalakannan S, Battina V, Susurla S, Kondpapi M, Pogula V. FEASIBILITY AND ACCEPTABILITY OF PHEEZEE™: A MOBILE PHONE-BASED WEARABLE PROGNOSTIC DEVICE FOR PHYSICAL REHABILITATION. *Int J Pharm Technol.* 2021 Jun;13:32343-53.
- 29) Rahnama L, Acik C, Dy C, Keslacy S. Unilateral baseball pitching: morphological and functional adaptations in the neck muscles. *Front Sports Act Living.* 2025 Feb 10;7:1452412. doi: 10.3389/fspor.2025.1452412. PMID: 39995574; PMCID: PMC11847819.
- 30) Acik, Ceren; Keslacy, Stefan; Dy, Christine; and Rahnama, Leila (2023) "Neck Flexors Bilateral Symmetry in Baseball Pitchers: A Unilateral Perspective," *International Journal of*

- 31) Ikeda, Y., Kurokawa, S., & Watanabe, K. (2023). Distal muscle cross-sectional area correlates with shot put performance. *Journal of Strength and Conditioning Research*, 37(6), 1221–1229.2023 Nov;160:111819. doi: 10.1016/j.jbiomech.2023.111819. Epub 2023 Sep 26. PMID: 37783186.
- 32) Kanakapura Chananke Gowda, VK, Subramanian, SS, Mustafa Gaowgzeh, RA, Ahmed Alsenany, S, Abdelaliem, SMF, Saeed Alabdullah, AA, et al. Effect of Kinematic Chain Exercise Protocol on Throwing Performance and Shoulder Muscle Strength among University Shot Put Athletes—A Randomized Controlled Trial. *J Clin Med*. 2024;13(17):4993. doi: 10.3390/jcm13174993.
- 33) jiao, J., Yang, T., Ma, Y., & Yang, G. (2025). Kinematic Characteristics of the Non-Throwing Arm During the Completion Phase of the Glide Shot Put in Elite Female Athletes: A Case Study. *Applied Sciences*, 15(3), 1397. <https://doi.org/10.3390/app15031397>

ANNEXURES

ANNEXURE A (1): IEC CERTIFICATE



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/155

Date: 09/05/2025

APPROVAL LETTER APPENDIX- VIII

To,

CHIRAG S DASTIKOP
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Kinetic analysis of neck muscle asymmetry among elite shot-put throwers -an observational study

Protocol ID.: ABS-IEC-2025-PHY-042

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Chirag S Dastikop**

With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 24/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	24/04/2025
2	Informed Consent Form	24/04/2025
3	Undertaking form PI	24/04/2025
4	CRF	24/04/2025
5	COI from the Investigators	24/04/2025

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

The following members were present at meeting held on 24-04-2025




1

📍 Utkal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101

☎ +91-63707-03654

✉ iec@absmari.com

ANNEXURE A (2): IEC COMMITTEE MEMBER



ABSMARI

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/155

Date: 09/05/2025

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
4	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
5	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
6	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

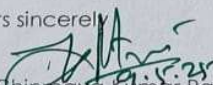
This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.


The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely,



Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar
ABSMARI ETHICS COMMITTEE



2

**Utkal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101**

+91-63707-03654

iec@absmari.com

ANNEXURE B: INFORMED CONSENT

Study Title: Kinetic analysis of neck muscle asymmetry among elite shot-put throwers-
An observational study

Study Number: ABS-IEC-2025-PHY-042

Subject 's Name: _____ Subject 's Initials: _____

Date of Birth / Age: _____

Address of the Subject _____ Qualification _____

Occupation: Student/Self-Employed/ Service/Housewife/Others (Please tick as appropriate)

Annual Income of the subject _____ if

applicable Name and address of the nominee(s) and his relation
to the subject _____ (For the
purpose of compensation in case of trial related death).

- (i) I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions.
- (ii) I understand that my participation in the study is voluntary and that I am free to
- (iii) withdraw at any time, without giving any reason, without my medical care or legal rights being affected.
- (iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s)
- (v) I agree to take part in the above study
- (vi) I agree and give my consent to take part in the video analysis

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:

Date: ____/ ____/ ____

Signatory 's Name: _____

Signature of the Investigator:

Date:

Study Investigator 's Name: Chirag S Dastikop

Signature of the Witness: _____ Date: ____/ ____/ ____

Name of the Witness: _____

ANEXXURE C: CASE REPORT FORM

Name of the participant:

Date:

Age:

Gender:

Dominance:

Height:

Weight:

BMI:

**ANNEXURE D: Anatomical Landmarks for straps and electrode
placement**

1st Strap of EMG sensor	Fore head of athlete.
2nd Strap of EMG sensor	Xiphisternal level above the chest.
EMG electrode placement	On the bulk of the muscle

ANNEXURE E: MASTER CHART

ATHLETE	AGE	GENDER	HEIGHT	RT INITIAL THROW	RT PEAK DURING THROW	RT POST THROW	WEIGHT	LT PRE THROW	LT PEAK DURING THROW	LT POST THROW	BMI
1	21	M	175	1299	1644	86	102	227	1559	117	33.3
2	19	M	176	1573	1627	291	89	245	1132	203	28.7
3	20	M	178	345	928	158	93	139	775	84	29.4
4	22	M	179	267	998	81	90	287	566	85	30.9
5	20	F	129	557	1806	907	85	248	1518	325	51.1
6	22	F	168	212	447	195	75	338	1656	1215	26.6
7	24	M	176	206	996	140	88	126	1246	102	28.4
8	20	F	153	63	717	113	58	126	396	102	24.8
9	23	M	185	252	1356	137	155	148	1090	137	45.3
10	22	M	179	151	669	62	122	68	749	11	38.1
11	19	M	182	168	662	49	130	77	808	55	39.2
12	28	M	185	79	1073	10	118	47	1274	30	34.5

ANEXXURE F: BROCHURE OF PHEEZE EMG

Let Technology Talk for Your Professional Skills

FDA LISTED

A SCIENTIFIC WAY TO REPORT

Pheeze is the world's first smart physiotherapy toolkit that monitors and measures the range of motion, surface EMG bio-feedback and other parameters during a patient's recovery. It is an easy-to-use wearable device that connects to your mobile phone or tablet using our Pheeze app. One can generate reports and track daily, weekly and monthly progress.

PATIENT FRIENDLY
Provide an engaging experience to your patients.

PHEEZE-O-THERAPIST
Become a Pheeze therapist and get exclusive access to our pool of patients.

ESSENTIAL TOOLKIT
A necessary and a multi-faceted tool for home therapy sessions.

ADDITIONAL REVENUES
Increase your revenues by 20% with Pheeze reports.

TELE-CONSULTATION
Stay connected with your patients anytime, anywhere.

WHY PHEEZE?
One of the major changes in physiotherapy is documentation of health records. Hence there is a need for a standardised system to measure the outcome of physiotherapy. Our most engaging clinical solution is a very effective way to know your patient's recovery and change or improve on your practices.

MONITOR PROGRESS

GAMIFICATION THEMES



WHY SHOULD PHYSIOTHERAPISTS CHOOSE PHEEZE?

More reports are a better way for physiotherapists to monitor the patient's condition to the referring doctor, hence reduce operational costs using accurate clinical notes, track and document results in real-time reports, easily useful in counselling the patient.

CERTIFICATIONS

PHEEZE FOR HOSPITALS

Pheeze will help you create an engaging session in the hospital. It will help you keep track of the recovery on timely basis.

HOME THERAPY WITH PHEEZE

Specialities

- Orthopaedics
- Neurology
- Spine Injuries
- Sports Injuries
- Trauma
- Cardio Pulmonary Rehab
- Paediatrics
- Geriatric Care
- Women Health

Why us?

Startoon Labs is a medical device company founded by IIT and IIM alumni and headquartered in Hyderabad, India, Telangana, funded by BIRAC, Department of Biotechnology, Government of India and registered as MSME. Pheeze received many awards and accolades at various events by Medical, IIT, CANOTECH, Samsung, IIM Calcutta and IIT Kharagpur etc.

Headquarters

Startoon Labs Pvt. Limited
Plot No. 10, First Floor, Paigah Colony, Sanjar Patel Road, Secunderabad - 500003, Telangana, India

+91 879 089 8481
+91 913 392 3826
www.startoonlabs.com

ANEXXURE G: TURNITIN AI REPORT

Chirag S Dastikop

KINETIC ANALYSIS OF NECK MUSCLE ASSYMETRY AMONG ELITE SHOT PUT PLAYERS – AN OBSERVATIONAL STUDY

Quick Submit
Quick Submit
Odisha University of Health Sciences

Document Details

Submission ID	13348661911	43 Pages
Submission Date	Sep 23, 2025, 10:46 AM GMT+5:30	6,751 Words
Download Date	Sep 23, 2025, 10:54 AM GMT+5:30	39,875 Characters
File Name	TRY_AMONG_ELITE_SHOT_PUT_THROWERS-AN_OBSERVATIONAL_STUDY_1.docx	
File Size	67.9 KB	

turnitin Page 1 of 43 - Cover Page Submission ID: 13348661911

turnitin Page 2 of 43 - AI Writing Overview Submission ID: 13348661911

*% detected as AI

AI detection includes the possibility of false positives. Although some text in this submission is likely AI-generated, scores below the 20% threshold are not surfaced because they have a higher likelihood of false positives.

Caution: Review required.
It is essential to understand the limitations of AI detection before making decisions about a student's work. We encourage you to learn more about Turnitin's AI detection capabilities before using the tool.

Disclaimer: Our AI writing assessment is designed to help educators identify text that might be prepared by a generative AI tool. Our AI writing assessment may not always be accurate. Our AI model may produce either false positive results or false negative results. It should not be used as the sole basis for adverse actions against a student. It takes further scrutiny and human judgment or consultation with an organization's application of its specific academic policies to determine whether any academic misconduct has occurred.

Frequently Asked Questions

How should I interpret Turnitin's AI writing percentage and false positives?
The percentage shown in the AI writing report is the amount of qualifying text within the submission that Turnitin's AI writing detection model determines was either likely AI-generated text from a large language model or likely AI-generated text that was likely reworded using an AI paraphrase tool or word spinner.


False positives (incorrectly flagging human-written text as AI-generated) are a possibility in AI models.

AI detection scores under 20%, which we do not surface in new reports, have a higher likelihood of false positives. To reduce the likelihood of misinterpretation, no score or highlights are attributed and are indicated with an asterisk in the report (%*).

The AI writing percentage should not be the sole basis to determine whether misconduct has occurred. The reviewer/instructor should use the percentage as a means to start a formative conversation with their student and/or use it to examine the submitted assignment in accordance with their school's policies.

What does "qualifying text" mean?
Our model only processes qualifying text in the form of long-form writing. Long-form writing means individual sentences contained in paragraphs that make up a longer piece of written work, such as an essay, a dissertation, or an article, etc. Qualifying text that has been determined to be likely AI-generated will be highlighted in cyan in the submission, and likely AI-generated and then likely AI-paraphrased will be highlighted purple.

Non-qualifying text, such as bullet points, annotated bibliographies, etc., will not be processed and can create disparity between the submission highlights and the percentage shown.



ANEXXURE H: PLAGRISM REPORT

Chirag S Dastikop

KINETIC ANALYSIS OF NECK MUSCLE ASSYMETRY AMONG ELITE SHOT PUT PLAYERS – AN OBSERVATIONAL STUDY

Quick Submit
Quick Submit
Odisha University of Health Sciences

Document Details

Submission ID
trncid::1:3348661911

Submission Date
Sep 23, 2025, 10:46 AM GMT+5:30

Download Date
Sep 23, 2025, 10:54 AM GMT+5:30

File Name
TRY_AMONG_ELITE_SHOT_PUT_THROWERS-AN_OBSERVATIONAL_STUDY_1.docx

File Size
67.9 KB

43 Pages
6,751 Words
39,975 Characters

turnitin Page 1 of 47 - Cover Page

Submission ID - trncid::1:3348661911

turnitin Page 2 of 47 - Integrity Overview

Submission ID - trncid::1:3348661911

4% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text
- Cited Text
- Small Matches (less than 8 words)

Match Groups

- 20 Not Cited or Quoted 4%
Matches with neither in-text citation nor quotation marks.
- 0 Missing Quotations 0%
Matches that are still very similar to source material.
- 0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation.
- 0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks.

Top Sources

- 3% Internet sources
- 2% Publications
- 0% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.