

**KINETIC ANALYSIS OF UPPER LIMB DURING CRICKET  
BATTING: AN OBSERVATIONAL STUDY**

**By**

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**of the requirements for the degree of**

**MASTER OF PHYSIOTHERAPY**

**IN**

**SPORTS**

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**BHUBANESWAR, ODISHA**

**2023-2025**

**Odisha University of Health Sciences**

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**Signature**

**Place :**

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## **LIST OF ABBREVIATIONS USED**

<b>1.</b>	Abhinav Brinda Sports Medicine and Research Institute (ABSMARI)	ABSMARI
<b>2.</b>	Surface electromyography	sEMG
<b>3.</b>	Standard Deviation	SD
<b>4.</b>	Surface Electromyography for the Non-invasive Assessment of muscles	SENIAM
<b>5.</b>	Statistical package of social science	SPSS
<b>6.</b>	Odisha University of health science	OUHS

# **ABSTRACT**

## **Background and Objective :**

Cricket batting requires highly coordinated neuromuscular pattern of activation, yet limited research has quantified stroke-specific upper limb muscle activation. The purpose of this study was to analyse the muscle activation pattern in cricket batsman during cricket strokes

## **Methods :**

Twenty male club-level cricketers (mean age  $22.3 \pm 3.0$  years) performed three strokes—cover drive, straight drive, and on drive—while sEMG recordings were obtained following SENIAM (Surface Electromyography for Non-invasive assessment of muscle) guidelines. Peak muscle activation was normalized to maximal voluntary contraction and analysed using one-way ANOVA.

## **Results :**

Triceps brachii activation was significantly greater during the straight drive ( $p < 0.001$ ), while the anterior deltoid peaked during the cover drive ( $p = 0.02$ ). Serratus anterior demonstrated highest activity in the straight drive, though not statistically significant. Biceps brachii activation was greatest in the on drive without significant difference.

## **Interpretations & Conclusion :**

Cricket batting involves stroke-specific neuromuscular recruitment, with distinct contributions of the triceps, anterior deltoid, serratus anterior, and

biceps. These findings support targeted conditioning and rehabilitation programs to optimize performance and reduce injury risk.

**Keywords :**

Cricket, Muscles, Kinetics, Strokes, Upper Extremity

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# **INTRODUCTION**

Cricket is a globally popular sport with rich traditions, strategic depth, and a competitive spirit that has attracted millions of participants and spectators worldwide<sup>[1]</sup>. Played on a large oval field with a 22-yard pitch, the game centres on the contest between the bowler delivering a hard leather ball and the batsman aiming to score runs with a flat wooden bat. Each team consists of 11 players: batsmen, bowlers, fielders, and a wicketkeeper who collectively contribute to the dynamic nature of the game<sup>[2,3]</sup>. Cricket demands a blend of physical skill, endurance, tactical awareness, teamwork, and rapid decision-making<sup>[4]</sup>. The sport is contested in three primary formats: Twenty20 (T20), One-Day Internationals (ODIs), and Test matches. T20 emphasizes quick scoring and aggressive shot-making within 20 overs, ODIs require balanced play over 50 overs, while Test cricket spans five days, demanding high levels of concentration, technical skill, and physical stamina<sup>[5]</sup>.

Batting is one of the most technically and psychologically demanding components of cricket. A batsman must counter diverse bowling strategies: fast, spin, swing, and seam deliveries while making split-second decisions under pressure<sup>[6]</sup>. Even with protective gear, batters face balls exceeding 140 km/h, requiring skillful balance between defensive techniques and attacking strokes<sup>[7,8]</sup>. A successful batting performance relies on technical execution, tactical awareness, and the efficient use of musculoskeletal forces.

The cricket bat swing is central to stroke execution and is generally divided into six phases: stance, backlift, stride and downswing, impact, and follow-through<sup>[7,9]</sup>. **Stance and Initiation:** Before ball release, the batsman prepares by observing the bowler's hand position and grip, using visual cues to anticipate

delivery type. <sup>[10]</sup> Backlift, At ball release, the bat is raised. An open-faced backlift enhances bat speed, whereas a closed one reduces it. Timing and judgment in this phase determine subsequent execution <sup>[7,11]</sup>. Stride and Downswing: Proper footwork and balance are crucial as the bat accelerates downward. A stable base and dynamic coordination optimize stroke precision <sup>[9,12]</sup>. Impact: The full bat face should meet the ball's middle to generate controlled force. Head position and timing are critical here <sup>[12]</sup>. Follow-Through: This reflects shot quality. A long follow-through often accompanies a powerful stroke, while shorter actions indicate defensive or checked shots <sup>[11]</sup>. Each phase integrates neuromuscular coordination, kinetic chain efficiency, and upper limb control. Understanding the role of upper limb muscles is key to analysing cricket batting. Muscles such as the deltoids, pectoralis major, latissimus dorsi, biceps brachii, triceps brachii, and teres major contribute at different stages of the bat swing <sup>[12,13]</sup>. During the stance phase, deltoids and biceps stabilize the bat and prepare for movement <sup>[14,15]</sup>. In the backlift, anterior deltoids, biceps, and pectoralis major elevate the bat, supported by the trapezius and latissimus dorsi <sup>[16,17]</sup>. The downswing relies on pectoralis major, latissimus dorsi, and teres major for power, with triceps generating elbow extension. Simultaneous antagonist control ensures precision <sup>[18,19]</sup>. At impact, pectoralis major and deltoids drive forward force, triceps extend the elbow, and scapular stabilizers maintain shoulder alignment <sup>[13,16]</sup>. The follow-through phase emphasizes deceleration, controlled mainly by posterior deltoids, biceps, and rotator cuff muscles <sup>[14,17]</sup>. This inter-muscular coordination enables efficient bat acceleration while minimizing injury risks.

Kinetic analysis offers quantitative insights into muscle function and

coordination during batting. Electromyography (EMG) is commonly used to monitor electrical activity in muscles like the deltoids, biceps, and triceps, providing temporal activation patterns during the swing <sup>[20,21]</sup>. Surface EMG, being non-invasive, is particularly suited for cricket biomechanics research <sup>[22]</sup>.

Complementary to EMG, motion capture systems with high-speed cameras record joint angles and limb trajectories, enabling three-dimensional stroke analysis <sup>[9,23]</sup>. Integration of EMG with motion capture provides a holistic view of neuromuscular activity and kinematics.

Force sensors, such as instrumented bats or force plates, quantify ground reaction forces and bat-ball impact loads, offering insights into joint stresses during batting <sup>[24,25]</sup>. Advanced biomechanical modelling software like OpenSim allows estimation of internal muscle forces and joint moments, further linking muscle kinetics with batting efficiency.<sup>[26]</sup> These approaches bridge performance analysis with injury prevention.

Muscle activation during batting is highly phase-specific. In the pre-delivery and backlift phases, moderate activation of deltoids, biceps, and trapezius supports bat positioning. During the downswing and impact, pectoralis major, latissimus dorsi, and triceps dominate, generating explosive bat speed <sup>[16,29]</sup>. Scapular stabilizers provide shoulder control, while biceps fine-tune trajectory.

Activation patterns also vary with stroke type. Straight drives emphasize pectoralis major and triceps, cut shots engage posterior deltoids and biceps, and pull shots rely on latissimus dorsi and trunk rotation <sup>[12,19]</sup>. Skilled batsmen demonstrate more economical activation, avoiding unnecessary contractions, while novices often display delayed or inconsistent patterns, leading to

inefficiency and injury risks [29,13].

Batting involves repetitive high-velocity swings that predispose players to overuse injuries. Common upper limb conditions include rotator cuff tendinopathy, biceps tendinitis, tennis elbow, and shoulder impingement [16]. These often arise from excessive loading during downswing and follow-through, particularly if muscle sequencing is inefficient.

Premature or imbalanced muscle activation, such as overuse of pectoralis major or latissimus dorsi, increases strain on the shoulder. Weak scapular stabilizers further exacerbate injury risk. Young or technically unrefined players are especially vulnerable due to inefficient kinetic chains [33,34].

Preventive strategies include biomechanically efficient technique training, targeted strength and conditioning of the shoulder girdle and forearm, and proprioceptive exercises to enhance neuromuscular control [19]. EMG monitoring during training can identify early fatigue or compensatory patterns, facilitating timely intervention [35].

Beyond injury prevention, kinetic insights can optimize performance. Power strokes depend on well-timed activation of the pectoralis major, triceps, and latissimus dorsi, while precision strokes rely on controlled activation of biceps and stabilizers [18]. Efficient transfer of ground reaction forces through the kinetic chain maximizes shot quality.

Training programs informed by kinetic analysis should emphasize functional strength, endurance, and neuromuscular coordination. Compound exercises such as push presses and rotational medicine ball throws replicate batting

demands <sup>[19,36]</sup>. High-repetition endurance training is particularly important for maintaining performance during extended innings.

Most importantly, individualized kinetic profiles allow coaches to correct inefficiencies. For instance, delayed triceps activation detected via EMG can be addressed with targeted drills, while uneven ground reaction forces can guide lower-limb strengthening <sup>[23,25]</sup>.

In summary, understanding and applying principles of muscle kinetics offers a powerful toolset for enhancing batting technique, power output, and accuracy, while also supporting long-term athletic development. As cricket continues to evolve with higher physical and technical demands, leveraging kinetic analysis not only bridges the gap between sports science and practice but also empowers players to reach their peak performance potential.

Despite the critical role that upper limb muscle function and kinetics play in cricket batting, there remains a notable gap in comprehensive research that systematically analyze these factors in real-world playing conditions, particularly across diverse stroke types and player skill levels. While previous studies have explored isolated aspects such as muscle activation or bat swing mechanics, few have integrated kinetic data with muscle function to provide a holistic understanding of the biomechanical demands placed on batsmen. Furthermore, the rapid evolution of cricket formats, including the rise of aggressive limited-overs styles, has heightened the physical and technical challenges faced by players, underscoring the urgent need for evidence-based insights into muscle coordination, injury prevention, and performance optimization. This study addresses these gaps by conducting a detailed

observational analysis of upper limb muscle kinetics during cricket batting, aiming to inform more effective training protocols, injury mitigation strategies, and coaching practices. The findings have practical value for players, coaches, and sports medicine professionals alike, contributing to enhanced player safety, improved stroke efficiency, and ultimately, elevated competitive performance in cricket at all levels.

## **AIMS & OBJECTIVE**

**Aim:**

To analyse the upper limb muscle activations during various cricket shots.

**Objective:**

To compare the upper muscle activation during various cricket shots using EMG analysis method.

# **HYPOTHESIS**

**Study Hypothesis:**

**Null Hypothesis:** There will be no difference of muscle activation pattern of upper limb on different batting shots.

**Alternate Hypothesis:** There will be significant difference of muscle activation pattern of upper limb on different batting shots.

## **REVIEW OF LITERATURE**

1. **Noorbhai et. al, (2024)** investigated batting back-lift techniques and highlighted the role of open versus straight back-lift positions. Their findings suggested that players using an open back-lift often generated greater bat speed and adaptability against fast bowlers. However, technique selection was also influenced by coaching traditions and player comfort, indicating both biomechanical and pedagogical dimensions of bat swing mechanics.
2. **Song et al. (2020)** studied scapular kinetic-chain exercises in overhead athletes and found improved activation of stabilizing muscles, such as serratus anterior and trapezius, which contributed to enhanced shoulder mechanics. These findings are transferable to cricket, where scapular control plays a central role in maintaining bat path stability and preventing shoulder overuse injuries.
3. **Stretch et. al, (2017)** reviewed batting mechanics in cricket, describing the bat swing as a coordinated sequence of stance, back-lift, downswing, impact, and follow-through. The study emphasized the importance of timing, footwork, and kinetic chain coordination in producing efficient and powerful strokes. Variations in swing technique were linked to differences in stroke effectiveness and susceptibility to injury.
4. **Pardiwala et. al, (2017)** provided an overview of cricket injuries, emphasizing that upper limb injuries are often linked to biomechanical inefficiencies in batting technique. They stressed the importance of strength conditioning and early detection of faulty muscle recruitment patterns to reduce overuse syndromes.

5. **Stretch et.al, (2017)** reviewed batting mechanics in cricket, describing the bat swing as a coordinated sequence of stance, back-lift, downswing, impact, and follow-through. The study emphasized the importance of timing, footwork, and kinetic chain coordination in producing efficient and powerful strokes. Variations in swing technique were linked to differences in stroke effectiveness and susceptibility to injury.
6. **Singla et. al, (2018)** assessed the reliability of electromyographic analysis of biceps brachii and triceps brachii in cricketers. The study demonstrated consistent activation patterns during batting tasks, supporting the role of EMG in quantifying muscle involvement and providing insight into functional contributions of these key upper limb muscles.
7. **Ahamed et. al, (2014)** analyzed electromyographic activity in overhead-throwing athletes and emphasized the contributions of deltoids, pectoralis major, and latissimus dorsi in forceful upper limb movements. The parallels to batting highlight the importance of coordinated recruitment of these muscles in producing high bat speed while minimizing strain.
8. **Taliep et. al, (2010)** examined the relationship between upper body muscle strength and batting performance. Their findings indicated that greater shoulder and arm strength correlated with improved bat swing speed and power generation, emphasizing the contribution of proximal-to-distal sequencing in batting strokes.
9. **Shaffer et. al, (1993)** conducted an electromyographic study of baseball

batting and identified activation sequences of upper limb muscles during swing phases. Although not cricket-specific, the methodology and findings demonstrate how EMG can be applied to map activation timing and intensity in cricket batting, providing comparative insights into kinetic chain efficiency.

## **METHODOLOGY**

- **Study design:** Observational study
- **Study setting:** Local Cricket academies in and around Bhubaneswar
- **Sampling method:** Purposive sampling.
- **Sample size:** 20 calculated via Formula method-  $(1.96)^2 \times \frac{4(0.05)^2}{(0.50)^2} + 15\% = 20$
- **Period of study:** 1 year

**Participants Characteristics :**

<b>Inclusion Criteria</b>	<b>Exclusion Criteria</b>
<ul style="list-style-type: none"> <li>• Players with minimum of 1 year of cricket coaching</li> <li>• Players who have played competitive cricket at club level.</li> <li>• Currently active players who practice for minimum 3-4 days a week</li> <li>• Gender: Male</li> <li>• Age: 18 above</li> </ul>	<ul style="list-style-type: none"> <li>• Recent fracture or any musculoskeletal condition strain, sprain, dislocation in less than 1 year.</li> <li>• Pain during performing the batting shots during the study</li> </ul>

**Table 1- Selection Criteria**

## **MATERIALS USED**

1. EMG
2. EMG Leads
3. Tablet Device
4. Cricket Bat
5. Leather Ball
6. Batting Cones

### **Outcome measure**

EMG – MVC (Maximal Voluntary Contraction)

# **PROCEDURE**

Approval from the IEC of Abhinav Bindra Sports Medicine and Research Institute (Annexure –C.1) was obtained. For data retrieval, Players were accessed and recorded to the Sports analysis in google drive.

Between May 2025 and July 2025 permission was taken from the Head Coaches of Multiple Cricket Academies in Bhubaneswar. A total of 29 players were assessed and 20 participants were considered, testing of the individuals was conducted on multiple days. On the day of testing Batsmen specific was completed. All participants were screened for inclusion and exclusion criteria by the principal investigator of the study and 20 participants were recruited, after thoroughly explaining the procedure, informed consent was obtained from all participants. Participants who met the inclusion criteria the following data were collected: age, height, gender, weight

EMG sensors and electrodes was placed on the athlete, skin preparation was done for the electrode placement according to SENIAM (Surface electromyography for the Non-invasive Assessment of muscles) guidelines. Electrodes were placed for each muscles based on the previous studies.

Patient Preparation: Patient clothing: comfortable sports attire, Playing surface cricket nets, cemented pitch. The sensors were placed on the body and the athlete were asked to perform the shot and Maximal voluntary contraction was recorded through the EMG device. Data were recorded using EMG device and Descriptive statistics was done for the demographic characteristics of the participants, Peak muscle activation was recorded through EMG for Kinetic analysis. The values were recorded and statistical analysis of the data was performed using SPSS version 27.



**Fig.1** – The cones are placed after asking the athlete to take a full stride, that point will be the point of contact with the ball.

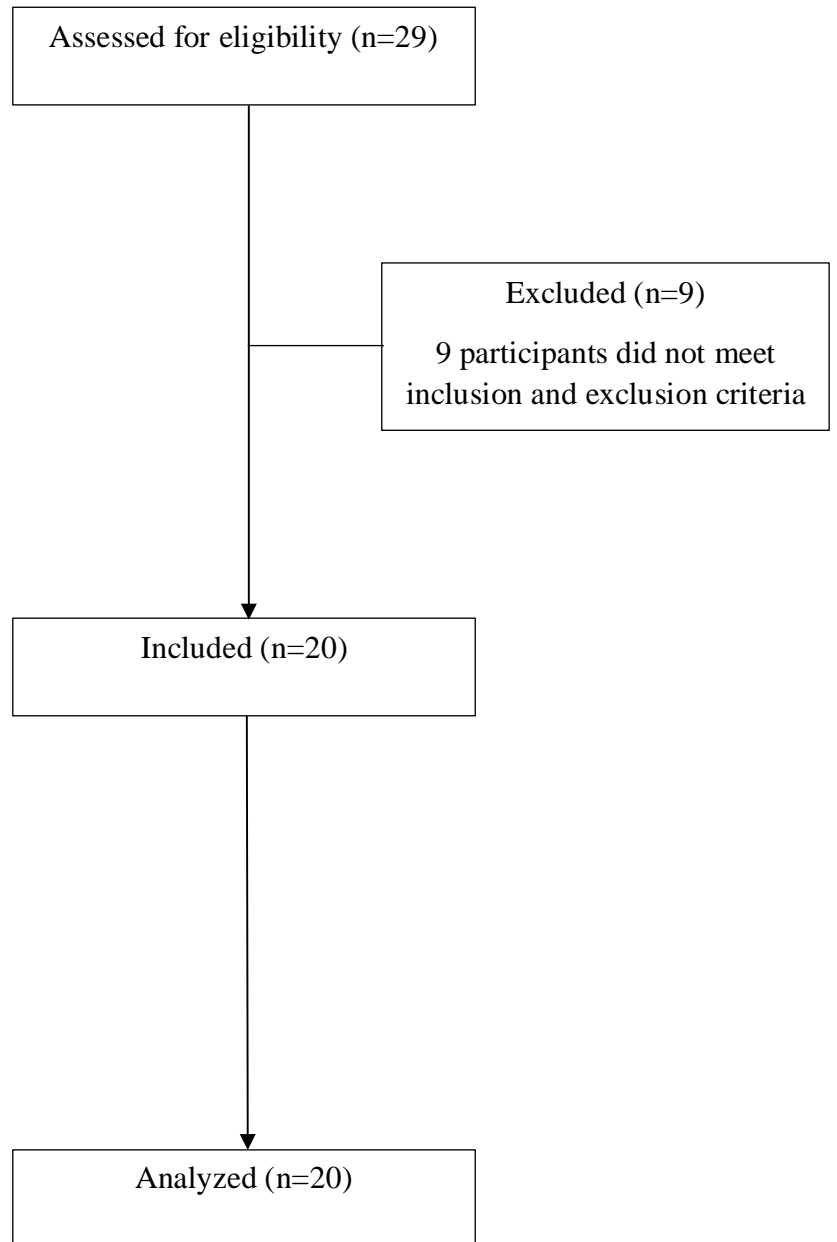


**Fig. 2 – Placement of the cone**



**Fig. 3 & 4 – The batsman performs the drives and EMG activation is recorded.**

## FLOW CHART



# **STATISTICAL ANALYSIS**

Statistical analysis was performed using IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 27.0.1.0 Armonk, NY: IBM Corp. The descriptive statistics was done to find the normality of the data using Shapiro-Wilk test. Interferential statistics was done to find out mean, standard deviation and significance using 1 way ANOVA.

## **RESULT**

The present study title “Kinetic analysis of Upper limb muscles during cricket batting : An Observational Study” among Cricket Batsmen had obtained 20 required sample as per the availability of the participants for which all 29 participants were screened for inclusion and exclusion criteria, 9 participants did not meet inclusion and exclusion criteria, 20 participants were recruited for the study and 20 participants completed the EMG testing hence result analysis done for 20 participants.

Variable	Mean ± SD	Shapiro–Wilk (p-value)
<b>Age (years)</b>	22.35 ± 3.030	.198
<b>Height (cm)</b>	76.050 ± 6.134	.029
<b>Weight (kg)</b>	178.700 ± 7.197	.986
<b>BMI (kg/m<sup>2</sup>)</b>	23.890 ± 2.307	.008

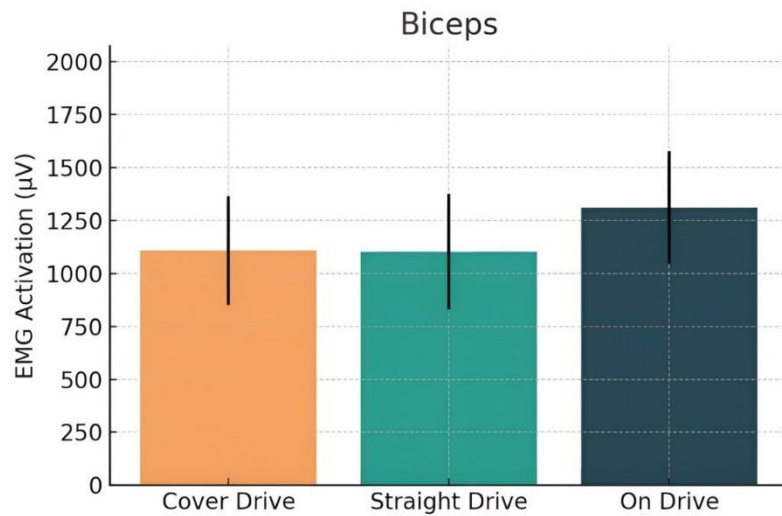
**Table 2- Descriptive Statistics**

The study included a total of 20 cricket batsmen, comprising all males. The mean age of the participants was  $22.35 \pm 3.03$  years, with the P-value of (.198). The mean height was  $178.08 \pm 7.197$  cm with P-value of (p = .986). The average weight of the participants was  $76.050 \pm 6.134$  kg,(0.29), and the mean Body Mass Index (BMI) was  $23.890 \pm 2.307$  with P-value of (p=.008).

	Cover Drive (S1)	Straight Drive (S2)	On Drives (S3)	p-value	Effect Size	95% CI
Biceps	1108.95±25 6.077	1101.7500± 273.603	1311.900±2 63.863	0.22	1.25	.001- .272
Triceps	1201.9500± 313.713	1607.600± 276.002	1493.2500± 312.628	.000	.254	.068- .407
Serratus Anterior	986.2000± 336.905	1228.400± 398.254	1137.1500± 401.252	0.135	.068	.000- .198
Anterior Deltoid	1377.0500± 175.461	1090.600± 285.1687	1129.3500± 293.333	.002	.190	.029- .344

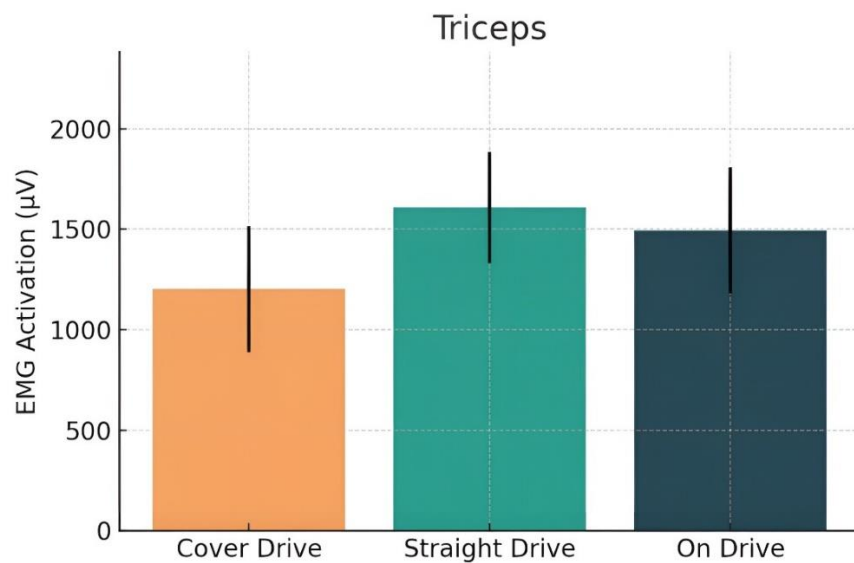
**Table 3- Inferential Statistics**

The following table reveals activation patterns of the four muscles during three different batting strokes.



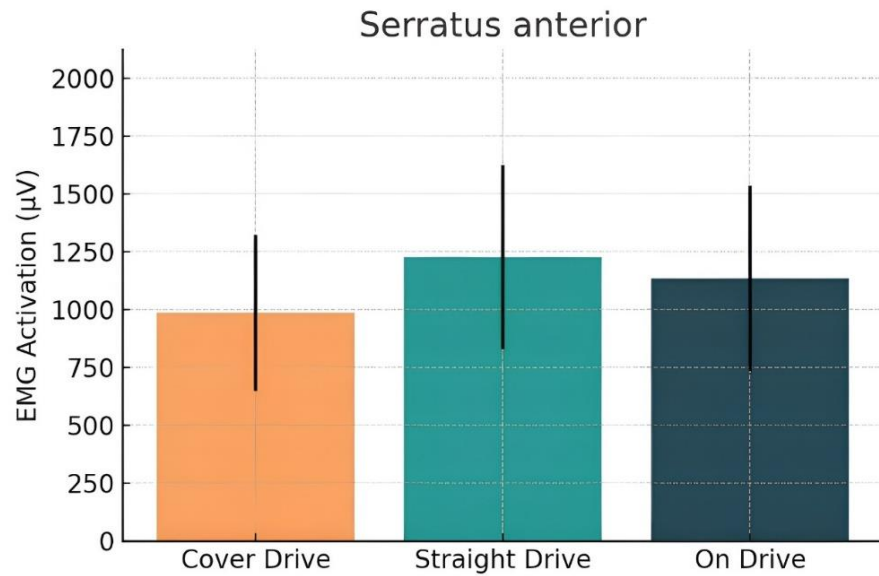
**Graph - 1**

Biceps brachii shows high activation during the on drive ( $1311.90 \pm 263.86 \mu\text{V}$ ), and followed by the cover drive ( $1108 \pm 256.08 \mu\text{V}$ ), Straight drive ( $1101.75 \pm 273.60 \mu\text{V}$ ). The differences were not statistically significant, P value=0.22.



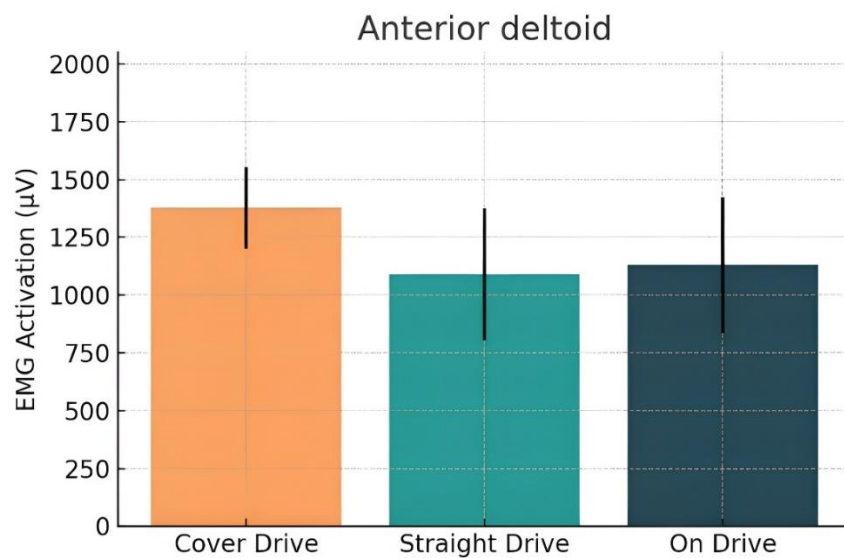
**Graph - 2**

Triceps brachii activation peaked during the on drive ( $1607.60 \pm 276.00 \mu\text{V}$ ) which is significantly higher comparing to cover drive ( $1201.95 \pm 313.71 \mu\text{V}$ ) and on drive ( $1493.25 \pm 312.63 \mu\text{V}$ ). The p-value  $< 0.01$ .



**Graph - 3**

Serratus anterior activation peaked during the straight drive ( $1228.40 \pm 398.25 \mu\text{V}$ ), followed by on drive ( $1137.15 \pm 401.25 \mu\text{V}$ ) and cover drive ( $986.20 \pm 336.91 \mu\text{V}$ ) with p-value = 0.135.



**Graph - 4**

Anterior deltoid showed maximum activation during the cover drive ( $1377.05 \pm 175.46 \mu\text{V}$ ), followed by straight drive ( $1090.60 \pm 285.17 \mu\text{V}$ ) and on drive ( $1129.35 \pm 293.33 \mu\text{V}$ ). The differences were statistically significant ( $P_{\text{value}}=0.02$ ).

This EMG analysis revealed the distinct activation pattern across the three cricket strokes. Biceps brachii showed the highest mean activation during the drive, followed by cover drive and straight drive, though the differences were not statistically significant. Triceps brachii showed significantly greater activation in the straight drive compared to the cover drive and on drive. Serratus anterior activation peaked in the straight drive, followed by the on drive and cover drive, yet it showed no statistical significance. Anterior deltoid showed maximal activation during the cover drive and with significantly lower values in the straight drive and the on drive, which is statistically significant. These results confirm stroke-specific recruitment patterns among the upper limb muscles during cricket batting.

## **DISCUSSION**

This study examines upper limb muscles (Biceps, Triceps, Serratus anterior, Anterior Deltoid), their activation pattern during different cricket strokes (cover drive, straight drive, on drive) using surface EMG. The study included 20 club level cricket male cricket batsman, who met the inclusion criteria of having 1 or more years of formal coaching and competitive playing experience.

The novelty of study is in that it integrates stroke specific EMG analysis of multiple upper limb muscles (Biceps, triceps, serratus anterior , anterior deltoid), thereby offering an understanding about the activation and recruitment patterns of muscles during different batting shots. The findings demonstrate stroke specific variations in the recruitment pattern of the above mentioned muscles , Triceps Brachii activity peaked during straight drive, Anterior deltoid activation was the highest during the cover drive and Biceps Brachii showed maximum activation during the on drive, while Serratus anterior was most active during the straight drive.

While some differences were statistically significant (Triceps Brachii and Anterior Deltoid), Biceps Brachii and Serratus anterior were statistically not significant, which highlights the complex and specific demands of the cricket strokes. Overall the study provides practical insights for Physiotherapists, Coaches, and Strength and conditioning experts with clear understanding of the different muscle recruitment patterns for each cricket strokes which might lead to good injury prevention protocols and performance enhancement strategies based the findings of this study.

The initial alternate hypothesis proposed that there would be difference in the muscle activation pattern on different cricket strokes, was accepted, as the

results confirm significant variations in the activation of Triceps Brachii and Anterior Deltoid and with clear difference in the activation patterns of Biceps Brachii and Serratus anterior during the three cricket shots as well. The findings shows that the triceps brachii was more active during the straight drive, indicating its role in generating forceful elbow extension. Similarly, the anterior deltoid high activation during cover drive indicates its role in shoulder flexion and guiding the bat through a forward trajectory.

Comparable evidence can be taken from cricket bowling and other overhead sports, studies have found biceps brachii activation is phase specific in cricket bowling<sup>[46]</sup> and revealed differential activation patterns of three heads triceps brachii depending on the bowling phase<sup>[48]</sup>. These studies suggests task specific recruitment pattern of the muscles, which further supports this study. Furthermore, studies on baseball batting have shown phase wise difference in the upper limb muscle recruitment depending on the swing type<sup>[48]</sup>. This strengthens the rationale that batting strokes are highly dependent on coordinated yet sports specific muscle activity.

The gross outcomes of the study highlights the differences in the activation pattern of the upper limb muscles across different cricket strokes. Triceps activation peaked in the straight drive, this is consistent with the cricket bowling studies where the triceps has been shown to generate high activation during high velocity arm movements<sup>[49]</sup>. The anterior deltoids highest activity in cover drive reflects its role in shoulder flexion and guiding the bat along the batting arc.

Serratus Anterior peaked during straight drive, this signifies its role in scapular stabilization during impact on the ball. EMG studies in cricket bowling<sup>[49]</sup> and

scapular muscle activation work in push up plus variations highlight the serratus anterior as the key stabilizer during forceful protraction<sup>[50]</sup>. This supports the interpretation that serratus anterior contributes to straight drive execution.

Biceps brachii was most active during the on drive, which is likely related to its role in the stabilizing the elbow joint, comparable findings have been reported in baseball studies where biceps was recruited to adjust the bat angle during controlled bat swings<sup>[48]</sup>.

Overall these results emphasize that batting strokes are not uniform but involve a complex muscular integration.

## **CONCLUSION**

This study provides key insights into the stroke specific muscle activation of upper limb muscles (Biceps, Triceps, Serratus anterior, Anterior Deltoid) during cricket batting using surface electromyography.

Analysis of the muscle activation pattern of the upper limb muscles during cricket batting revealed that Triceps Brachii was most active during the straight drive shot, Anterior deltoid peaked during the cover drive shot, Serratus anterior peaked during the straight drive and biceps brachii showed maximal activity In the on drive. These findings highlight that batting involves different neuromuscular strategies depending on the stroke. The results are consistent with previous EMG studies in Cricket and different sports , hence strengthening the evidence.

**LIMITATIONS & FUTURE**  
**RECOMMENDATIONS**

Several limitations must be acknowledged, all participants were male club level cricket batsman. This restricts the generalizability of the findings to elite or female players. The study focused on only three strokes (Cover, Straight, On drive) leaving out other strokes such as pull, cut, sweep

While the Surface EMG is highly validated, it is susceptible to cross talk and electrode placement variability, the technical challenges must be considered.

The study was conducted in practice nets under controlled conditions, which may not fully replicate the demands of live match play

Future Research should include elite professionals, female cricketers and even junior players and also incorporating wider ranges of shots.

Integrating EMG with 3D motion capture and force plates further enhances the understanding of the kinetics and kinematics.

## **SUMMARY**

This observational study investigated the muscle activation pattern of upper limb muscles during different batting strokes using a Surface Electromyography.

Twenty male club level cricketers with a minimum of one year of formal coaching and club level year experience participated. Electrodes were placed on the biceps brachii, triceps brachii, serratus anterior, and anterior deltoid according to SENIAM (Surface electromyography for the Non-invasive assessment of muscles) guidelines and muscle activation was recorded during three cricket shots: Cover drive., Straight drive, On drive.

Results demonstrated distinct activation patterns.

Triceps brachii peaked significantly during the straight drive, anterior deltoid most active in the cover drive, serratus anterior was the greatest in straight drive, while biceps brachii showed peak activation during the on drive

The findings highlights the importance of batsman specific rehabilitation and performance training and to enhance batting efficiency and reduce injury risk.

## STATEMENT OF FUNDING

Source of Funding – N/A

Nature of Funding – N/A

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**ANNEXURE**

## 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/2025/142

Date: 02/05/2025

**APPROVAL LETTER**  
**APPENDIX - VIII**

To,

**PRAJWAL H**  
ABSMARI  
273, PAHAL, BHUBANEWAR-752101

**Protocol Title: Kinetic analysis of upper limb muscles during cricket batting -An Observational Study.**

**Protocol ID:** ABS-IEC-2025-PHY-057

**Subject:** Approval for the conduct of the above referenced study

Dear **Mr./Ms./Dr. PRAJWAL H**

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 25/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	25/04/2025
2	Informed Consent Form	25/04/2025
3	Undertaking form PI	25/04/2025
4	CRF	25/04/2025
5	COI from the Investigators	25/04/2025

The following members were present at meeting held on 25-04-2025

<b>MEMBERS</b>
<b>Dr. Smaraki Mohanty</b> Clinician
<b>Dr. Satyajit Mohanty</b> Scientific Member
<b>Mr. Shib Shankar Mohanty</b> Legal Expert
<b>Ms. Annie Hans</b> Social Scientist
<b>Ms. Subhashree Samal</b> Lay Person
<b>Mr. Deepak Ku. Pradhan</b> Scientific Member
<b>IEC-SECRETARIAT</b>
<b>Mr. Gouranga Ku. Padhy</b> <b>Mr. Susant Ku. Raychudamani</b>



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## ANNEXURE A (2): IEC COMMITTEE MEMBER



# 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/2025/142

Date 02/05/2025

MEMBERS
<b>Dr. Smaraki Mohanty</b> Clinician
<b>Dr. Satyajit Mohanty</b> Scientific Member
<b>Mr. Shib Shankar Mohanty</b> Legal Expert
<b>Ms. Annie Hans</b> Social Scientist
<b>Ms. Subhashree Samal</b> Lay Person
<b>Mr. Deepak Ku. Pradhan</b> Scientific Member
IEC-SECRETARIAT
<b>Mr. Gouranga Ku. Padhy</b> <b>Mr. Susant Ku. Raychudamani</b>

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. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

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, 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



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## **ANNEXURE B: INFORMED CONSENT**

**Study Title:** Kinetic Analysis of upper limb muscles during cricket batting:  
An Observational Study

**Study Number:** ABS-IEC-2025-PHY-057

**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 withdraw at any time, without giving any reason, without my medical care or legal rights being affected.
- iii. 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).
- iv. I agree to take part in the above study.
- v. 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:** \_\_\_\_\_

**Signature of the Witness:** \_\_\_\_\_

**Date:** \_/\_\_\_/\_\_\_

**Name of the Witness:** \_\_\_\_\_

## ANNEXURE C: MASTER CHART

Athlete	Height		Weight		Biceps (CD)	Triceps(CD)	Serratus(CD)	AD (CD)	Biceps(SD)	Triceps(SD)	Serratus(SD)	AD(SD)	Biceps(OD)	Triceps(OD)	Serratus(OD)	AD(OD)
	Age (cm)	(kg)	BMI													
1	20	173	76	25.39	604	1684	1240	1329	489	1431	1024	1685	556	1389	1796	924
2	20	194	62	16.47	966	1482	1528	1402	1905	1812	1746	1522	1558	1945	1028	1356
3	24	181	82	25.03	677	926	1218	975	871	1641	995	405	1525	1645	1240	484
4	19	176	79	25.5	1598	1837	1596	956	1334	2087	1547	1012	1722	1551	919	987
5	21	168	76	26.93	722	1525	1181	1617	690	1811	1600	1025	1734	1474	918	1091
6	22	188	79	22.36	1659	1203	1211	1687	1071	1759	1805	1271	1035	1658	2053	1242
7	27	175	74	24.16	1275	667	312	1311	1334	2087	1547	990	1722	1551	919	712
8	18	182	77	23.24	1137	748	387	1345	1276	702	245	678	1153	638	235	550
9	28	178	69	21.78	1339	515	304	1657	1042	1522	230	570	1260	634	280	478
10	19	179	78	24.34	1051	1201	957	1356	1119	1547	1235	1151	1282	1542	1187	1342
11	25	176	84	27.12	1169	1228	1008	1398	1072	1602	1272	1123	1315	1587	1212	1365
12	22	187	74	21.15	1110	1185	970	1375	1090	1520	1240	1160	1240	1530	1222	1326
13	26	179	82	25.59	1129	1202	977	1407	1120	1589	1267	1143	1274	1575	1202	1335
14	21	181	79	24.11	1067	1195	960	1360	1118	1572	1232	1172	1270	1565	1198	1317
15	24	175	72	23.51	1130	1258	997	1387	1132	1612	1276	1156	1305	1607	1238	1367
16	20	185	81	23.66	1081	1222	936	1377	1021	1536	1275	1132	1223	1557	1176	1325
17	23	178	71	22.41	1126	1241	985	1412	1106	1598	1263	1163	1284	1591	1273	1347
18	27	172	74	25.01	1118	1254	1002	1418	1093	1573	1253	1153	1271	1619	1223	1378
19	22	183	83	24.78	1095	1218	968	1371	1061	1561	1245	1146	1248	1590	1215	1321
20	19	180	78	24.07	1126	1248	987	1401	1111	1590	1271	1155	1261	1617	1209	1340

# ANNEXURE D: PHEEZEE – Brouchure



Let Technology Talk for Your Professional Skills



**FDA LISTED**

## A SCIENTIFIC WAY TO REPORT

Pheezee 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 Pheezee app. One can generate reports and track daily, weekly and monthly progress.

**PATIENT FRIENDLY**  
Provide an engaging experience to your patients

**PHEEZEE-O-THERAPIST**  
Become a Pheezee therapist and get exclusive access to our pool of patients

**ESSENTIAL TOOLKIT**  
A necessary and a must-have toolkit for home therapy sessions

**ADDITIONAL REVENUES**  
Increase your revenues by 20% with Pheezee reports

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

### WHY PHEEZEE?

One of the major challenges in physiotherapy is documentation of health records. Hence there is a need for a standardized 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 improvise on your practices

### MONITOR PROGRESS



### GAMIFICATION THEMES




### WHY SHOULD PHYSIOTHERAPISTS CHOOSE PHEEZEE?

Health records are a better way for physiotherapists to evaluate the patient's condition to the referring doctor, hence reduce operational costs using accurate clinical notes. 5 out of 5 physiotherapists found the reports, simple, useful in accelerating the patient.

### CERTIFICATIONS



### PHEEZEE FOR HOSPITALS

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

### HOME THERAPY WITH PHEEZEE

Physiotherapy always...



## 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 IT and IIM alumni and headquartered in Hyderabad, India, Bangalore. Funded by IIMC, Department of Biotechnology, Government of India and registered as MSME. Pheezee received many awards and accolades at various events by Medical, IIP, CAHOTECH, Samruaj, IIM Calcutta and IIT Kharagpur etc.

### Headquarters

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

+91 879 089 8481  
+91 914 992 5436  
www.startoonlabs.com



# ANNEXURE E: TURNITIN PLAGARISM REPORT

**Prajwal Harish**

## **KINETIC ANALYSIS OF UPPER LIMB MUSCLES DURING CRICKET BATTING – An Observational Study**

- Quick Submit
- Quick Submit
- Odisha University of Health Sciences



### Document Details

Submission ID	trn:old::1:3347589207	30 Pages
Submission Date	Sep 22, 2025, 4:00 PM GMT+5:30	3,523 Words
Download Date	Sep 22, 2025, 4:13 PM GMT+5:30	21,609 Characters
File Name	IMB_MUSCLES_DURING_CRICKET_BATTING_-_AN_OBSERVATIONAL_STUDY.docx	
File Size	578.6 KB	

## **3% Overall Similarity**

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

### Filtered from the Report

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

### Match Groups

- 9** Not Cited or Quoted **3%**  
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.

# ANNEXURE F: TURNITIN AI REPORT

Prajwal Harish

## KINETIC ANALYSIS OF UPPER LIMB MUSCLES DURING CRICKET BATTING – An Observational Study

1

Quick Submit  
Quick Submit  
Odisha University of Health Sciences

### Document Details

Submission ID  
trn:oid::1:3347589207

Submission Date  
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30 Pages  
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turnitin Page 1 of 32 - Cover Page

Submission ID trn:oid::1:3347589207

turnitin Page 2 of 32 - AI Writing Overview

Submission ID trn:oid::1:3347589207

### \*% 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 (i.e., our AI models may produce either false positive results or false negative results), so it should not be used as the sole basis for adverse actions against a student. It takes further scrutiny and human judgment in conjunction 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 revised 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.

