CORRELATION BETWEEN INITIAL MOMENTUM AND OPTIMUM RELEASE ANGLE WITH DYNAMIC BALANCE IN ELITE JAVELIN THROWERS: AN OBSERVATIONAL STUDY

By

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IN

BIOMECHANICS

Under the guidance of

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ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE
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LIST OF ABBREVIATIONS USED

- 10-m – 10 meter
- 2-D – Two Dimensional
- 3-D – Three Dimensional
- 30-m – 30 meter
- 35-m – 35 meter
- 5-m – 5 meter
- ABSMARI – Abhinav Bindra Sports Medicine and Research Institute
- BMI – Body Mass Index
- IEC – Institutional Ethics Committe
- MSS – Maximum Sprinting Speed
- NMT – Neuro Muscular Training
- SPSS – Statistical Package for Social Sciences
- TSI – Total Stability Index
- TTSD – Trunk Total Standard Deviation

ABSTRACT

Background and Objective :

This observational study aimed to investigate the relationship between run-up speed, release angle and dynamic balance in elite javelin throwers using video analysis with timing gates and dynamic prokin. The study sought to identify whether there are the components which can alter dynamic balance which will result in decrease in throw capacity and reduce the chance of injury.

Methods :

An observational study was conducted on 11 elite throwers (age 18–25 years) who had participated at national or international levels. Run-up speed was measured using timing gates, release angle was assessed through Kinovea video analysis, and dynamic balance was evaluated with the Dynamic Prokin system. Pearson correlation analysis was performed using SPSS v27, following confirmation of data normality with the Shapiro-Wilk test.

Results :

The analysis demonstrated weak, non-significant negative correlations between momentum and total stability ($r = -0.279$, $p = 0.407$), and between release angle and total stability ($r = -0.288$, $p = 0.391$). No significant association was found between release angle and trunk stability ($r = -0.054$, $p = 0.875$). These findings indicate that neither initial momentum nor release angle substantially influences dynamic balance among elite throwers.

Interpretations & Conclusion :

The absence of significant correlations suggests that elite athletes possess motor control adaptations and technical proficiency that enable them to maintain balance irrespective of approach velocity or release angle variations. These results highlight that speed, angle, and balance may be better addressed as independent components in training and performance optimization. Larger samples and advanced biomechanical tools are recommended for future studies to refine these observations.

Keywords :

Balance; javelin; release angle; run-up speed; throwing performance

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The javelin throw is an international athletic event that combines sprinting, coordination and biomechanical control. This sport is governed by the International Association of Athletics Federation (IAAF) and has been its part since 1908 for men and since 1932 for women [1]. Over the years, javelin performance has improved significantly not only because of advancing in training but also due to more knowledge in biomechanics and movement science [1,3]. The event requires the athletes to generate high linear velocity during the approach phase convert this into angular momentum and release the javelin at an optimal angle, throughout this the athlete has to maintain balance and stability. In various elite competitions where the distances exceed 85 to 90 meters, this has become a benchmark of excellence. [2][4]

If we follow epidemiological perspective this sport is not just about distance but also how frequently injuries occur. There are several recurrent injuries which occur due to overuse of shoulder, elbow and lumbar spine and are frequently reported because there are extreme mechanical stress factors involved. There are studies which show that javelin throwers have reported one of the highest incidences of upper limb injuries which nearly accounts to 20-30% of all throwing related conditions in sports. This type of injuries are linked with poor imbalance in technique, improper coordination between run up momentum and release and also compromises the dynamic stability while delivering the stride. [1]

The biomechanical demand of the javelin throwing puts the athlete at a risk of some specific clinical condition. The common symptom includes shoulder impingement, ulnar collateral ligament strain at the elbow and lumbar spine stress reactions. The loss of dynamic balance during the transition from approach to release often results in asymmetrical loading which can impair performance efficacy while predisposing the athlete to injury. Also, due to an incorrect release angle when coupled with insufficient initial momentum can lead to reduced throwing distance and suboptimal competitive performance. These outcomes show that beyond strength and endurance the three activities i.e. momentum generation, optimal release angle and balance are critical to both health and performance of the throwers. [2]

There are various studies which has examined throwing mechanics. Morris and Bartlett did highlight that approach velocity directly correlates with throwing distance and also confirms regarding the importance of initial momentum. Very similar to the previous study, Viitasalo and colleagues demonstrated that elite throwers typically generate horizontal velocities in excess of 7-8 m/s during the final strides, which is associated with release speed. The research studies regarding release angle demands that while theoretical projectile motion indicates 45 degrees as optimal, during an actual practice elite javelin throws occur between 32-36 degrees due to aerodynamic factor. The dynamic balance has also received attention with Yu and Andrews which noted that trunk stability and control of the plane leg are significant predictors of safe and effective throws.

There are numerous studies across different populations ranging from high school athletes to Olympic level throwers which reveal common themes that are greater approach momentum which enhances release velocity but without sufficient balance athletes are unable to transfer force efficiently. The suboptimal release angles diminish the benefits of high momentum which marks the need to evaluate these variables collectively rather than in isolation. [3]. Though previous studies are valuable still some literature shows up some limitations. Most of the study has talked about one parameter either that is approach velocity, release angle or balance without complementing each other much in the previous researches. Morriss and Bartlett have emphasized approach velocity but gave very limited attention to release angles variations among athletes. Another gap lies in population specificity where in the elite throwers are often studied but there is less data on developmental athletes which makes it difficult to generalize the findings across various levels in performance. The injury epidemiology studies focuses on clinical outcomes rather than correlating these with biomechanical inefficiencies which leaves a gap between sports science and performance analysis.

There is need for such study which evaluates initial momentum, release angle and dynamic balance as interconnected determinants of performance. There is need of a concise approach which can deliver a more realistic picture of the mechanical demands of the javelin throw [2, 7]. By correlating these variables the study aims to fill a critical gap in performance optimization research. It is relevant for elite athletes where the marginal gains of 1-2 % also can create a lot of difference [3, 5]. And also due to presence of such a research study which talks about the interactive elements it might guide preventive strategies against overuse injuries [7].

The present study carries significant benefits for both the scientific community and athletic practice [5]. The recent evidence culminates that dynamic balance training enhances agility and stability in athletes with measurable improvements occurring within weeks of intervention (Kiyani et al, 2023). For javelin throwers this implies that improved balance could translate into more efficient transfer of momentum during the run up and release phases [6]. There are studies which are readily incoming for throwing kinematics which throws importance on combined role of release angle and velocity which suggests that optimizing both together accounts for a major share of performance variability [9].

By understanding the moderating role of dynamic balance, the training strategies can be modified to safeguard the athlete's health. And there is a research which talks about how individual biomechanics influences the effectiveness of changes in momentum and release mechanics.

The findings from the current study can support the possibility of more individualized coaching approaches which will allow the training programs to be customized to the specific needs of each athlete [10].

And by combining all three aspects i.e. momentum, release angle and balance into a single analysis, the study addresses the research gap by providing evidence that could improve consistency of the performance.

AIMS & OBJECTIVES

Aim:

To find the relationship between initial momentum, optimal release angle and dynamic balance in javelin throwers.

Objective:

To find the correlation between initial momentum, optimal release angle and dynamic balance in javelin throwers using the Timing Gates, Kinovea Doftware and Dynamic Prokin.

HYPOTHESIS

Study Hypothesis:

Null Hypothesis: There is no significant relationship between run-up speed, optimum release angle and dynamic balance.

Alternate Hypothesis: There is significant relationship between run-up speed, optimum release angle and dynamic balance.

REVIEW OF LITERATURE

1. Bhandurge S, et al. **(Aug, 2024)** conducted a study on **“Technique Variables Associated with Fast Bowling Performance: A Systematic-Narrative Review”** The aim of this study was to systematically review biomechanical literature related to cricket fast bowling performance and narratively synthesize findings to provide a comprehensive summary of key performance characteristics.

2. Ghosh P, Mondal P, et al. **(2016)** conducted a study on **“Biomechanical factors contributing to effective bowling in cricket: A review study”** The study aims to assess biomechanics of cricket bowling, with the goal of identifying and analysing the biomechanical factors that enhance bowling performance.

3. Pavlović R, et al. **(2020)** conducted a study on **“Biomechanical analysis in athletics: The influence of kinematic parameters on the results of javelin throw of elite athletes”** The study aimed to examined various biomechanical factors, including release velocity and angle of release to assess their impact on the performance outcomes of elite javelin throwers.

4. Lin WH, Cheng JH et al. **(2016)** conducted a study on **“A Comparison of balance control between javelin throwers and baseball pitchers.”** The purpose of this study was to compare the static and dynamic balance in javelin throwers and baseball pitchers.

5. **Zabaloy S, et al. (2024)** conducted a study on **“Estimation of maximum sprinting speed with timing gates: greater accuracy of 5-m split times compared to 10-m splits”** The aim of the study was

to compare the maximum sprinting speed (MSS) recorded during a 30-meter sprint using two different split times (5 meters and 10 meters) with MSS recorded by a radar gun (RG).

6. **Raharja AT, et al. (2022)** conducted a study on **"Analysis Motion At The Release Stage of The Javelin Using Kinovea Software"** The purpose of this study to analyze the movement in the javelin release stage.

7. **Mauch M, et al. (2011)** conducted a study on **"Reliability of the ProKin Type B line system (Techno Body™) balance system"** The aim of the study was to assess the reliability of a new stabilometry system, the Pro-Kin Type B line system (Techno Body^{TM}) and to quantify intra-day and inter-day variability.

8. **Su, W., et al. (2025)** conducted a study in **"Injury risk reduction programs including balance training: A systematic review"** The study aims to assess how injury prevention programs, especially balance training, affect ACL injury rates in soccer players to enhance athlete health and performance.

9. **Makino, M et al. (2023)** conducted a study on **"Kinematic contribution to javelin velocity at different run-up velocities."** The study aimed to investigate how different run-up velocities affect the contributions of body movements to javelin velocity within individual athletes.

10. **Kohler, H. P., Witt, M., et al. (2023)** conducted a study on

“Energy flow in men’s javelin throw and its relationship to joint mechanics” The study aimed to analyze the joint mechanics of men’s javelin throwing using energy flow analysis to understand how joints transfer, generate, and absorb mechanical energy, and to examine how these processes relate to throwing performance and joint loading

11. **Wang, J., Qin, Z., Zhang, Q. (2025)** conducted a study on **“Lower limb dynamic balance, strength, explosive power, and agility and sports injuries in male volleyball players”** The study aimed to examine how lower limb dynamic balance relates to muscle strength, explosive power, agility, and injury risk in male volleyball players, highlighting the interconnection of these physical attributes and their impact on athletic performance and injury prevention.
12. **Wang, P., et al. (2024)** conducted a study on **“Effects of neuromuscular training on dynamic balance in athletes”** The study aimed to determine whether NMT effectively improves athletes' balance performance, thereby providing evidence to support its application in sports training and injury prevention.

13. **Kumar K, Singh N., et al. (2025)** concludes the study on **“Analyzing the Impact of Release Angle and Speed on Javelin Throw Distances: A Study of Paris Olympics Finalists’ Performance”** The study aims to investigate how release angle and speed influence javelin throw distance among top athletes, with a focus on identifying optimal

release conditions. It emphasizes that increasing release speed has a more significant impact on performance, while maintaining a stable angle within an effective range (around 30–35 degrees) can improve trajectory control.

14. **Anand V., et al. (2025)** concludes the study on **"The Interplay between release angle and release velocity in javelin throw performance: A biomechanical analysis of intercollegiate athletes"** The aim of the study was to analyze the effects of release angle and release velocity on javelin throw performance, quantify their correlation with throw distance, and provide recommendations for optimizing these factors to enhance athletic performance.

15. **Xiao W, Bu T, Zhang J., et al. (2025)** concluded study on **"Effects of functional training on physical and technical performance among the athletic population: a systematic review and narrative synthesis"** The study aimed to assess how functional training affects the physical and technical performance of athletes across different sports, combining existing research to provide a clearer understanding of its benefits and guide future training practices and research development.

METHODOLOGY

Participants:

An observational study was performed on 11 elite javelin throwers selected from Kalinga Stadium in Bhubaneswar. Ethical clearance was taken from the Institutional ethical committee of Abhinav Bindra Sports Medicine and Research Institute (ABSMARI), Pahal, Bhubaneswar prior to the commencement of the study. The protocol ID for approval was (ABS-IEC-2025-PHY-039). The participants were eligible to be included in this study if they had previously competed in national or international competitions. They were within the age group of 18-25 years, with equal consideration given to men and women. The purposive sampling method was used for sampling. Participants who were recreational, experienced discomfort that prevented them from throwing at their best, or had suffered a musculoskeletal injury within the previous three months were excluded.

Sample size calculation:

The sample size was calculated using G-Power software using A prioro power analysis with effect size (0.3), alpha (0.05), power (0.80).

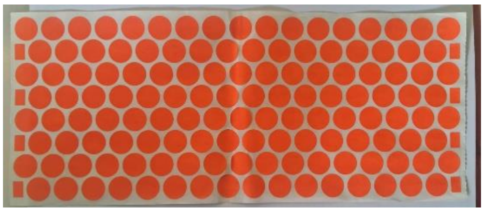
MATERIALS USED

1. Two cameras / phones
2. Two tripod stands
3. Reflective markers
4. Athletic ground
5. 30m run-up space
6. Timing gates
7. Dynamic Prokin

[Fig. 1] on next page

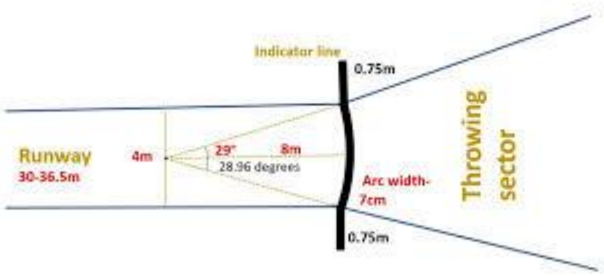
(A) 2 Unit of Mobile Phones

(B) 2 Unit of Tripods



(C) Reflective Markers

(E) 30-m run up space



(F) Timing Gate

(H) Dynamic Prokin

PROCEDURE

This study was permitted by the ethical clearance for the study obtained Institutional Research Ethics Committee (IEC) of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha (ABS-IEC-2025-PHY-039).

The No Objection Certificate has been taken from the college. In the duration between June and July, 2025, the permission was taken from the Head Coach, Athletics Project Odisha, DSYS.

An observational study was undertaken at Kalinga Stadium and ABTP, Bhubaneswar. 11 participants were included for the study and 24 participants were dropped due to the time constraints. A brief demographic data which includes age, gender, height, weight and bmi of all the participants was obtained, written consent was taken from all the participants, and the study was explained with its benefits and harms.

The testing of an individual subject was conducted on 3 separate days. A minimum of 24-72 hours of rest before testing for the complete recovery. To maintain consistency and accuracy in testing, a standardized pre-test checklist was implemented. They were instructed and requested not to conduct maximal resistance exercise for the preceding 24 hours before the test. To prevent gastrointestinal or metabolic disturbation, they were also requested not to have a large pre-test meal two hours before. Pre-workout supplements and caffeine, were not permitted at least 12 hours before. To ensure the results adequately reflected their own natural performance, each participant ultimately confirmed having had ample time to recover and relax before the session.

Before starting of testing, the javelin specific warm-up which includes free exercises, running, stretching, mobility drills. The warm-up will be done for 10-15 mins.

All the participants were screened for inclusion and exclusion criteria by the principal investigator of the study and 11 participants were included for the study and 24 participants were dropped due to the time constraints.

The participants were instructed to wear tight-fitting clothing such as shorts or track pants along with t-shirts which is suitable for both men and women. Reflective markers were placed as specific body landmarks namely the shoulder, elbow and wrisht joint to facilitate motion analysis. The assessment was conducted on a 30-m running track of an athletic ground which provides proper space for better performance. Two mobile cameras mounted on tripods to capture the movement, cameras were placed at a distance of 5 meters to the sagittal and postero-lateral view respectively. Reflective markers, timing gates and the Dynamic Prokin system is also included. Both the cameras were set at a 5 meters to obtain clear recording of the athletes motion throughtout the test. The athlete was instructed to change into clothing and reflective markers were placed on appropriate locations and athlete was instructed to be in cue of start.

The two pairs of timing gates were placed on the starting and end points of 30-m run up space at the height of 60 cm. A coloured cone was placed at 35 m (5 meters past the last timing gate) as the finish line to minimize the premature deceleration.

The mobile cameras were placed to record cinematic images and videos of all throwers performance. One of the cameras will placed behind and slightly to the left of the javelin runway, and the other camera will placed at the right side of the javelin throwing runway. During the competition, each camera was positioned as far away from the subject's delivery area as possible while yet having the necessary field of view and zoom power.

The **Dynamic Prokin** was used. The player stand in single leg and non-weight bearing leg with 90 degree knee flexed. The position of hand was on waist and sensor placed at center of sternum. For right arm throwers, left leg being assessed and for left arm throwers, right leg being assessed.

The data was recorded using timing gates and videos were analysed using the mobile camera recording in Kinovea Software. Descriptive analysis was done for demographic characteristics of participants. The throw activation was analysed with kinovea for kinematic analysis. The statistical analysis of the data was performed for all 11 participants using SPSS Software version 27.

OUTCOME MEASURES

1. **Timing gates** for **speed**
2. **Kinovea software** for **release angle**
3. **Dynamic prokin** for **balance**

1. Timing Gates :

Timing gates are operated by using laser beams set up between two gates; when an athlete passes through, the beam is broken, and the system records the time taken. This allows for precise measurement of sprint performance and can be used to calculate both average and peak speeds. [21]

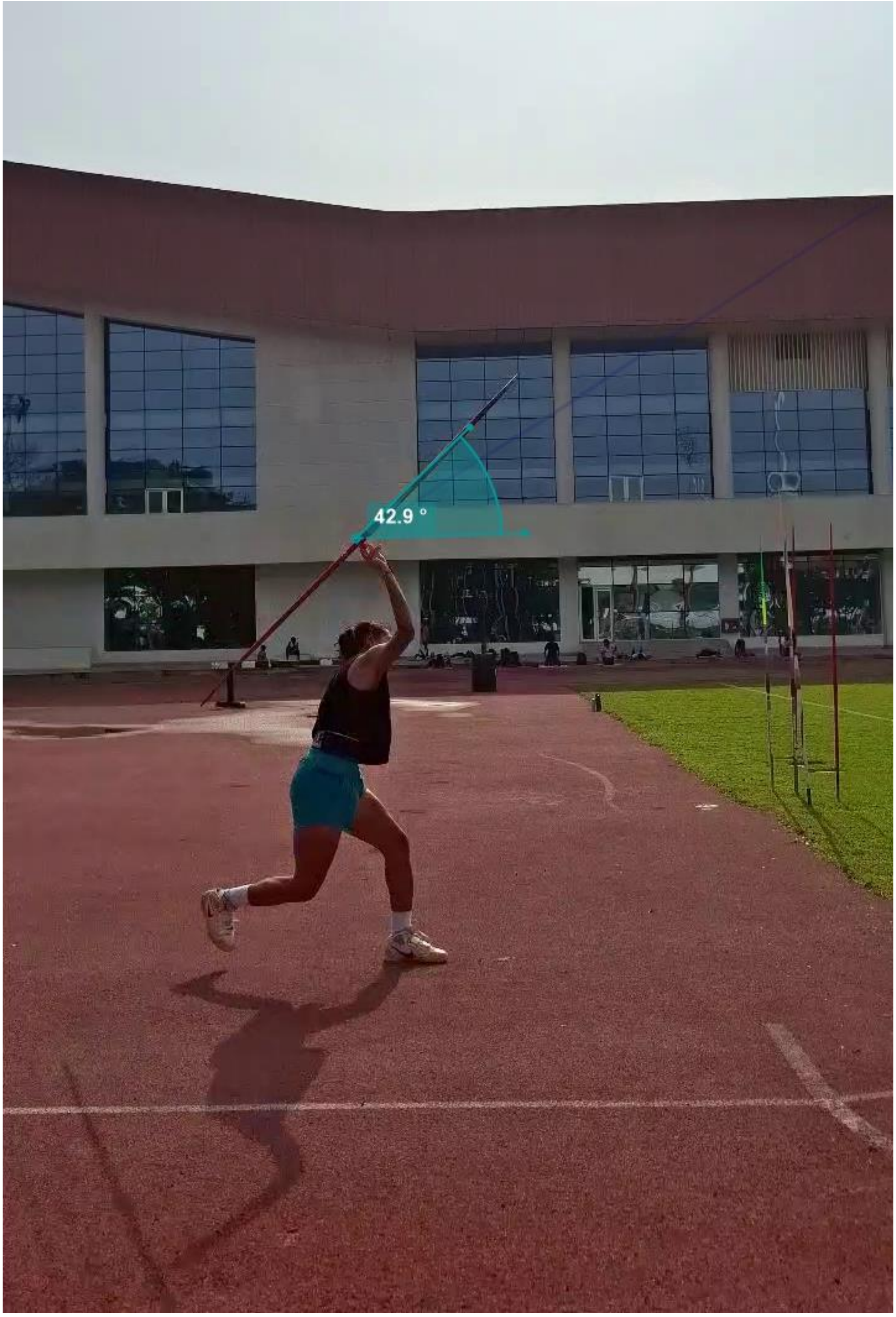
Two timing gates will set at opposing ends of a 30 m line. Both sets of timing gates will set at a height of 60 cm. A coloured cone will placed at 35 m (5 m beyond the final timing gate) which participants will be instructed to consider as the finish point, thus preventing premature deceleration. [22]

[Fig. 2]

2. **Kinovea Software :**

Kinovea is reliable (inter and intra-rater) and valid 2D movement analysis software which is free, used to analyze angles, distance, coordinates and spatiotemporal parameters. [23]

Two high definition digital video camcorders (cameras) will use to record cinematic images of all throwers performances. One of the cameras will placed behind and slightly to the left of the javelin runway, and the other camera will placed at the right side of the javelin throwing runway. Each camera will place as far away as possible from the area in which the subject performed the delivery during the competition within the zoom power of each camera to have a required field of view. [24]



[Fig. 3]

3. **Dynamic Prokin**:

ProKin is the most functional system for proprioceptive-stabilometric assessment for the rehabilitation of the lower limbs. [25]

The player will stand in single leg and non-weight bearing leg with 90 degree knee flexed. The position of hand will be on waist and sensor will placed at center of sternum. For right arm throwers, left leg will assessed and for left arm throwers, right leg will be assessed.

[Fig.4]

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. Normality of the data was found using Shapiro-Wilk test. Descriptive analysis was done using mean and standard deviation while performing interferential statistics.

RESULT

A total of 11 elite javelin throwers participated in the present study, consisting of nine males (81.8%) and two females (18.2%).The mean age of the athlete was 20.73 years with a standard deviation of 2.87 years, the mean height of the group was 171.64 ± 5.68 cm, while the mean body weight was 68.09 ± 5.74 kg. Body mass index (BMI) was calculated to be 23.12 ± 1.74 kg/m², which is within the normal range for this population. These descriptive findings provide a clear overview of the physical profile of the athletes involved in the study.

As the sample size is lesser than 30 the Shapiro-Wilk test was used to examine the normality. The results showed that age ($p = 0.978$), height ($p = 0.463$), weight ($p = 0.206$), and BMI ($p = 0.731$) all had p-values greater than 0.05. This indicates that the data is normally distributed as shown in **(Table 1)**.

Variable	Mean ± SD	Shapiro–Wilk (p-value)	Normality Assumption
Age (years)	20.73 ± 2.87	0.978	Normally Distributed
Height (cm)	171.64 ± 5.68	0.463	Normally Distributed
Weight (kg)	68.09 ± 5.74	0.206	Normally Distributed
BMI (kg/m²)	23.12 ± 1.74	0.731	Normally Distributed
Gender (n, %)	Male: 9 (81.8%) Female: 2 (18.2%)	–	–

Table 1- Descriptive Statistics and Test of Normality

The result of Pearson correlation analysis show how significantly and in which direction of momentum, release angle and markers of dynamic stability in top javelin throwers.

Although the findings are not statistically significant, the relationship between momentum and total stability (r=-0.279 and p=0.407) indicates a weak negative relation **(Table 2).**

Similarly, there is a slightly negative correlation between momentum and trunk total standard deviation (r = -0.272, p = 0.418),indicating minor instability in trunk control as momentum increases. However, this finding cannot be generalised because of the lack of significance.

Although the relationship between release angle and total stability (r = -0.288 and p = 0.391) are not statistically significant, which indicates a weak negative relationship.

Similarly, the release angle and trunk total standard deviation (r = -0.054 and p = 0.875) shows no correlation and also indicating that angle does not affect the trunk stability.

Variables	Pearson Correlation (r) Value	p-value
Momentum and Total Stability	-0.279	0.407
Momentum and Trunk Total SD	-0.272	0.418
Angle and Total Stability	-0.288	0.391
Angle and Trunk Total SD	-0.054	0.875

Table 2- Variables Characteristics Correlation

DISCUSSION

The present study evaluates three critical biomechanical factors i.e., initial momentum, optimum release angle and dynamic balance. There are evidences stating that approach speed, release mechanics or balance independently. This study correlates all three biomechanical factors on performance and injury prevention by correlating them. So an in depth analysis like this closes a significant gap and provide new insights that how javelin athlete can get best training and techniques. [27]

The study aims to correlate run-up speed, optimum release angle and dynamic balance in elite javelin throwers. With the aim, to better understand how these biomechanical factors interact to affect athletic performance as well as training plans to improve efficiency and prevent injuries.

The current investigation provides important biomechanical insights into the relationships between initial momentum, release angle, and postural stability during the javelin throw. However, the results indicate that these correlations are weak and statistically non-significant. As there is one dependent variable and two independent variables, a Pearson correlation analysis was conducted.

The demographic characteristics of participants showed that they were very similar young professional athletes with BMI in normal range and average of 20 years. These findings are consistent with anthropometric profiles of throwers documented for past researches where the optimum body composition and muscle mass plays an important role that how effectively force is transferred during the throw.

The Pearson correlation analysis found the non-significant correlation between momentum with total stability ($r = -0.279$, $p = 0.407$) and trunk total standard deviation ($r = -0.272$, $p = 0.418$) which shows that there is no correlation between speed parameters and dynamic balance.

Similarly, the Pearson analysis observed a weak and negative correlation between optimum release angle with total stability ($r = -0.288$, $p = 0.391$) and a minimal relation with trunk total standard deviation ($r = -0.054$, $p = 0.875$) which suggest that release angle does not have an impact on balance parameters during performance. However, release angle is biomechanically important to maximise distance.

The lack of significant correlation between initial momentum with dynamic balance parameters and release angle with dynamic balance parameters suggests that the elite throwers mostly depend more on the motor control adaptations instead of biomechanical variations. The small variations in release angle won't impact dynamic balance after a certain level of skill ability is achieved.

The present analysis examined at Pearson correlation among 11 top javelin throwers approach run-up speed, release angle and dynamic balance parameters. All of the variables are passed the normality tests i.e., Shapiro-Wilk test. We are unable to reject the null hypothesis because in each test the p-value was more than 0.05.

The present study hypothesized that run-up speed and release angle are significantly correlated with balance in elite javelin throwers. So, the Pearson correlation analysis shows the weak and negative non-significant correlations between run-up speed, release angle and dynamic balance parameters (TSI and TTSD). Specifically, the momentum with TSI ($r = -0.279$, $p = 0.407$); momentum with TTSD ($r = -0.272$, $p = 0.418$); angle with TSI ($r = -0.288$, $p = 0.391$) and angle with TTSD ($r = -0.054$, $p = 0.875$) shows small effect sizes and p-values, that's why we fail to reject the null hypothesis.

A recent study by Makino et al. (2024) examined how changes in run-up speed influence the kinematics of javelin throwing in collegiate athletes**.** It showed that changes in run-up speed alter trunk and joint kinematics in javelin throwers, indicating athletes adapt their technique to control higher momentum. This technical compensation helps maintain stability, which may explain why correlations between momentum, release angle, and balance measures often appear weak or non-significant in elite populations. [28]

A recent study by Kumar and Singh (2025) et. al, conducted a study on **"**Analyzing the Impact of Release Angle and Speed on Javelin Throw Distances: Paris Olympics Finalists Performance"**,** analyzed the performance of Paris 2024 Olympic javelin finalists and found a very strong correlation between release speed and throw distance, while the correlation with release angle was much weaker. But dynamic balance was not measured. The study highlights that release speed is closely linked to momentum and is also a dominant factor in performance. This imbalance suggests that if balance were assessed, its correlation with momentum or angle might be weak or over shadow by some factors like strength and technique, which supports the non-significant correlations observed in this study. [9]

A study by V Krishna, T Noronha, AA Pathak et. al, (2024) Association between Core Strength and Dynamic Balance of Throwing Hand in Professional Healthy Cricket Fast Bowlers: A Cross-Sectional Study on professional cricket fast bowlers examine the link between core strength and dynamic balance using Upper Quarter Y-Balance Test. It is found from mild to moderate positive correlations between side plank endurance and certain balance reach directions.

But this confirms that stronger core stability can increase balance, such as elite throwers with already well-developed stability these relationships may be weaker or even non-significant. [29]

This study focus on three important aspects of javelin throw i.e., the run-up speed before throw is known as momentum; the angle of release and ability to maintain balance during throw. The aim was to find that by running faster or changing of angle will affect the athlete balance. The study was done on 11 elite javelin throwers whose age are between 18 to 25 years old and all of them have competed at national or international levels. Their run-up speed was measured by timing gates, their release angle was measured by video analysis and balance was measured using Prokin. Prokin is a measuring device used to measure balance. So the result shows that balance is not connected with both run-up speed and release angle. If the athlete will run faster will not cause to loose stability and any mild change in release angle also had no effect on balance.

The study found that elite throwers can stay balanced no matter how fast they run or what angle they use to release the javelin. Their advanced training and skill allow them to stay steady, means that coaches should train balance, speed, and release mechanics separately to maximize performance and protect athletes from injury.

CONCLUSION

The goal of this study was to examine how best the javelin thrower start momentum, best release angle and dynamic balance correlate to each other or not. This study analysed the biomechanical factors in order to provide a broader overview of performance optimisation and injury prevention. The findings showed that there was no significant correlation between dynamic balance and momentum or release angle too. Statistically non-significant correlation values indicates that elite athletes might be able to maintain balance and stability in different approaches towards speed or throwing angle. This result emphasises an adaptability of highly skilled throwers, whose long-term practice, technical expertise, and motor control enable them to maintain stability.

LIMITATIONS & FUTURE RECOMMENDATIONS

The study has a number of limitations even if it offers insightful information. The Eleven athletes made size very less which lowers the statistical power and may hide the minor relationships between the variables. Because of unequal gender distribution, more men and less women, the finding were less applicable to both. Furthermore, the Dynamic Prokin System and 2-D video recording were used for motion analysis. Also, variations in the results may have seen because of weather and ground surface was not appropriate.

To increase predictability the future studies should be include larger in number so that there should be broader samples of male and female athletes from a national or international compete levels. The advanced tools such as 3-D motion capture, force plates and high speed cameras which can provide better results for the same parameters i.e., run-up speed, release angles and balance. Interventional studies might be able to clarify the effects of training on performance and injury risk. EMG can reveal the neuromuscular strategies that support stability under high momentum. So, these approaches would enhance research accuracy and also helps to design the individual training and injury prevention program for elite athletes.

SUMMARY

This study evaluated the correlation between initial momentum and optimum release angle with dynamic balance in elite javelin throwers. The Dynamic Prokin system, video-based movement analysis and timing gates were used to assess the performances of eleven athletes who had previously competed at the national or international level. The aim was to determine the variations in speed and release angle had a significant effects on stability and balance during the throwing movement.

This study found the weak and non-significant correlation between two independent variable and one dependent variables in elite javelin throwers. The result suggest that athletes on this level of game can maintain the stability and reflect the advanced techniques and neuromuscular control. Balance do not directly influence the throw distance, it remains crucial to prevent injuries by reducing uneven loads on shoulder, elbow and spine. To increase the throw velocity and trajectory, the run-up speed and release angle should need to be remain crucial.

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

ABSMARI

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

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/134

Date: 02/05/2025

APPROVAL LETTER
APPENDIX- VIII

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

To,

ANSHUMAN MISHRA
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Correlation Between Initial Momentum and Optimum Release Angle with Dynamic Balance in Elite Javelin Throwers : An Observational Study

Protocol ID.: ABS-IEC-2025-PHY-039

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr Anshuman Mishra

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

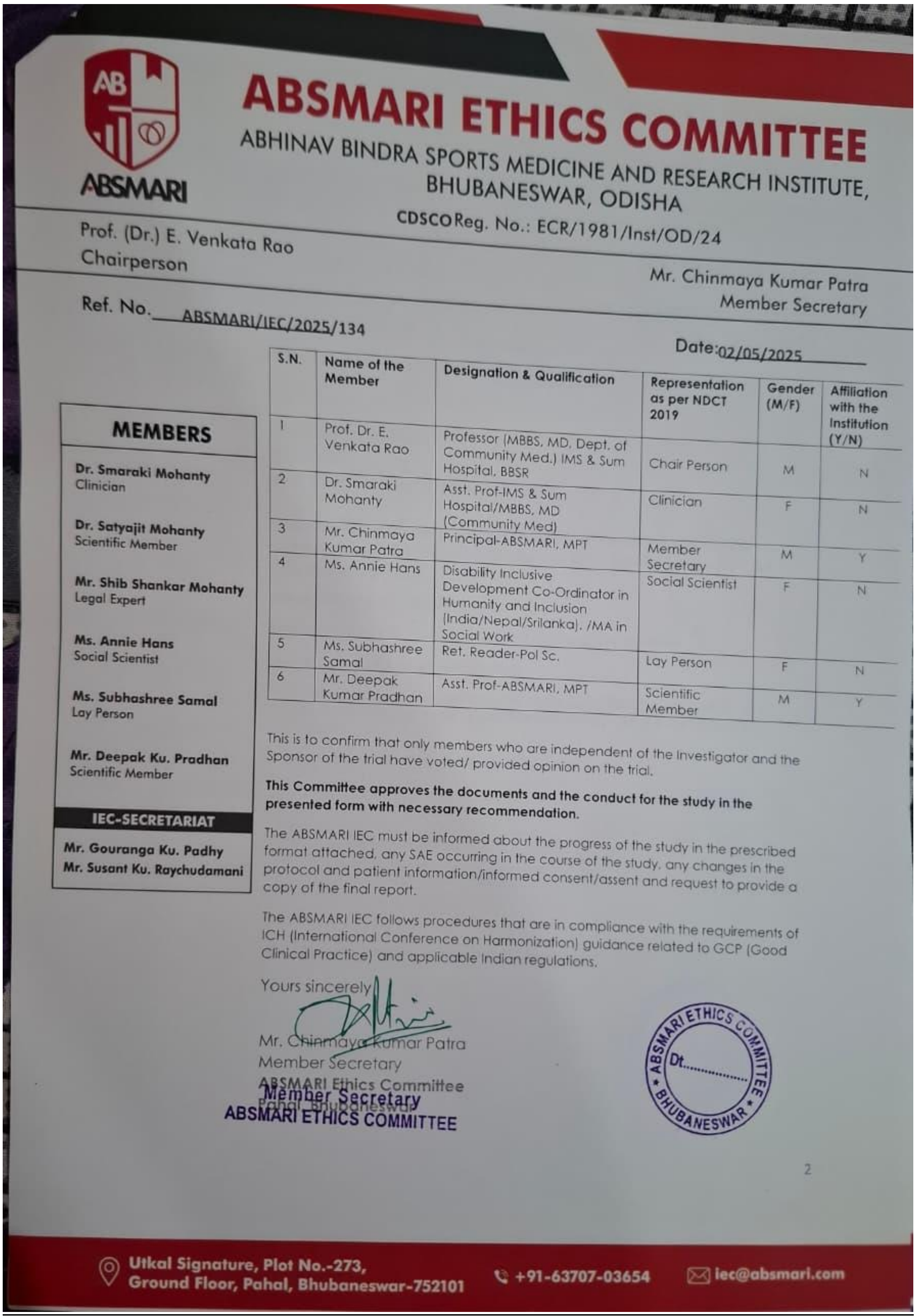
The following members were present at meeting held on 24-04-2025

ABSMARI ETHICS COMMITTEE Dt.............. BHUBANESWAR

1

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ANNEXURE A (2): IEC COMMITEE 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/2025/134

Date: 02/05/2025

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Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

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

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

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

Member Secretary
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE BHUBANESWAR Dt............

2

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ANNEXURE B: INFORMED CONSENT

Study Title: Correlation between initial momentum and optimal release angle with dynamic balance in elite javelin throwers : An Observational Study

Study Number: ABS-IEC-2025-PHY-039

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 concent 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

Age	Gender	Height (cm)	Weight (kg)	BMI (kg/m2)	Momentum (sec)	Release Angle	Total Stability Index [°]	Trunk Total Standard Deviation[°]
25	Male	170	72	24.9	3.99	38.3	0.6	1.24
16	Male	176	70	22.6	3.7	44.7	1.13	1.1
18	Male	180	77	23.8	4.34	44.8	1.95	2.08
20	Male	175	63	20.6	3.37	36.4	1.76	2.17
21	Male	167	71	25.5	3.14	37.3	1.1	1.44
25	Female	168	62	22	4.17	42.9	0.96	1.16
20	Female	165	58	21.3	3.19	30.6	1.05	1.22
20	Male	168	63	22.3	4.25	41.5	0.66	0.87
22	Male	177	70	22.3	3.19	31.8	2.55	2.26
18	Male	164	70	26	3.26	41.2	2.3	6.34
23	Male	178	73	23	3.11	49.1	0.77	0.99

ANNEXURE D (1) : PROKIN 252 – Brouchure

TecnoBody

THE POSTURAL LINE

The ProKin 252 is both a static and dynamic balance system designed for the assessment and training from a single or double leg stance. Paired with the intuitive TecnoBody software, it is easy for fitness or rehabilitation professionals to assess and evaluate each client with precise and detailed data to use to measure progress and create powerful and specific training plans and programs.

<u>ANNEXURE D (2) : PROKIN 252 – Brouchure</u>

PROKIN 252

● Standard Feature

○ Optional Feature

		PROKIN 252
USER INTERFACE	20" Touchscreen Display	●
	Adjustable Display Height	●
	Processor Frequency	2.3 GHz
	RAM Memory	4GB
	Wireless Keyboard & Mouse	●
	Wireless Printer	○
	TecnoBody Management System	●
SPECIFICATIONS	User Weight Capacity	330 lb.
	Dynamic Platform	22" Diameter (55 cm)
	Support Platform	43" x 43" (110 x 110 cm)
	Ground Elevation	8.27" (21 cm)
	Unit Weight	297 lb. (shipping weight 340 lb.)
	Width	47.2" (120 cm)
	Length	67" (170 cm)
	Height	71"-79" (180-200 cm)
	Trunk Sensor	●
	Wrapping Upper Supports	●
	Safety Step	●
	Trunk Balance Seat	●
	110 Vac 20 Amp	●
	Warranty	1 Year All Components 1 Year Labor Lifetime Software

SOFTWARE

- Assessment modules including the Romberg & equilibrium
- Training modules including rehab tracings & load training
- Protocols & analysis including patient files & comparison tests
- Games including equilibrium and flight simulator
- Integration with TecnoBody Management System

FUNCTIONALITY

- Dynamic and static balance board
- Single and double leg stance
- 50 different selectable levels of instability
- Balance tilt measurement: +/- 15° (maximum resolution of 0.2° and 0.5° precision)
- Trunk Sensor with detection angles of +/- 30° AP - ML with 0.1° resolution
- Seat tilt measurement: +/- 15° (maximum resolution of 0.2° and 0.5° precision)

ANNEXURE E: TURNITIN PLAGARISM REPORT

Anshuman Mishra

CORRELATION BETWEEN INITIAL MOMENTUM AND OPTIMUM RELEASE ANGLE WITH DYNAMIC BALANCE IN ELI...

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ANNEXURE F: TURNITIN AI REPORT

Anshuman Mishra

CORRELATION BETWEEN INITIAL MOMENTUM AND OPTIMUM RELEASE ANGLE WITH DYNAMIC BALANCE IN ELI...

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