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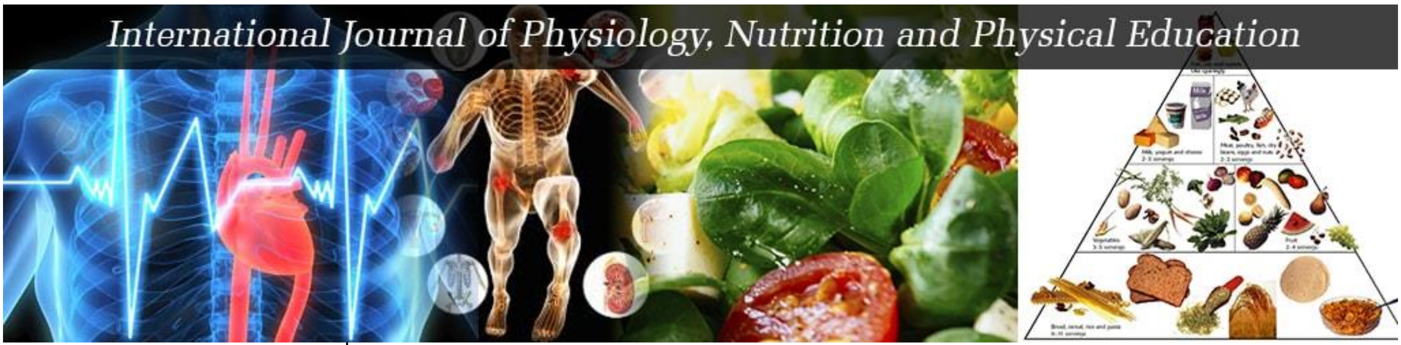

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Relationship of selected linear and angular kinematic parameters with javelin throw performance of junior level (U-18) throwers

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Abstract
Aim: Aim of the present study was to determine relationship between selected linear and angular kinematic parameters with javelin throw performance of junior level (U-18) throwers
Methods: Fifteen Junior (U-18) male Javelin throwers with Height; 172.34±4.48, Weight; 70.06±5.66, and Age; 16.9±0.57 from Navdeep stadium Narwana, Jind, Haryana were chosen for the study.
Results: Relationship between wrist joint angle and javelin throw performance was significant at 0.05 level, whereas knee joint angle had shown significant relationship with javelin throw performance at 0.01 level.
Conclusion: The results of the current study conclude that Wrist joint angle and knee joints angles are significant contributors for optimum conditions of projection for release of javelin and knee joint angle might play a dominant role in transfer of momentum and summation of forces to optimise javelin throw performance.

Keywords: Linear kinematic, angular kinematic, javelin throw performance

Introduction
In the distant past, man had to battle to survive; he had to run, jump, or throw himself into combat or away from dangerous animals. Our DNA is wired for throwing. As with javelin throwing, spear throwing has been transformed into a popular sport, and the struggle for survival has become the strive for perfection. Javelin was a popular sport in Ancient Greece and was introduced to the Olympic Games in 708 BC as a component of the pentathlon. Since 1908 for the men's games and 1932 for the women's games, it has been a part of the modern Olympic Games (Sharma & Mukhopadhyay, 2022) [14].
The men's javelin throw event was added to the Summer Olympic program in 1908 in London, while the women's competition made its debut in the 1932 Games in Los Angeles. After being revived in Germany and Scandinavia in the 1870s, the sport gradually evolved into its present-day shape, with two-handed and freestyle variants of the competition losing favor by the 1920s. Currently, the javelins can only weigh 800 grams and be between 2.6 and 2.7 meters long for men and 600 grams and be between 2.2 and 2.3 meters long for women. Contrary to other throwing competitions, the javelin throw is subject to tight rules since several experimental and freestyle techniques from the 1950s were seen to pose a risk to spectator safety (worldathletics, 2022) [3].
At first, competitors hurled poles with a metal tip that were typically constructed of birch wood. The Held Javelin, created by American brothers Bud and Dick Held in the 1950s, revolutionized the sport. The Held Javelin flew farther than solid wooden javelins because of its hollow wooden shaft (later variations were constructed entirely of metal). These javelins were less likely to land point first, which made estimating distances more challenging. More advancements made it possible for athletes to throw javelins farther than ever before, and by 1984 the male world record had reached 104.8 meters. This distance presented challenges for event organizers because it was getting riskier to hold javelin competitions in stadiums. The Centre of gravity of the javelin was moved in 1986, and specific coatings of holes that would affect aerodynamics were prohibited. These changes increased the possibility that the javelin would land on the ground (Bartlett, 1988) [4].

The sport-motor goal of javelin throwing is to achieve the longest feasible throwing distance. The throwing elements of approach run, release, braking (final phase), and javelin flight are all used by the athlete in an effort to maximize throwing distance. A highly technical workout, javelin throwing requires flawless joint coordination across numerous planes of motion. The distance a javelin is thrown depends on the wind's strength and direction, as well as the javelin's aerodynamics. However, the two most crucial and controllable characteristics are the javelin release speed and angle (Barbar, 2014) [5].

In 1986, a tweak to the javelin used in Olympic competitions forced throwers to modify the angle at which they released. The centre of pressure is the combined aerodynamic drag and lift force. Height at release, release angle, and velocity of release are all important factors in a successful throw. the release velocity increasing by 1 meter/second (Brooker, 2018) [6]. To the best of author's knowledge (Sharma & Mukhopadhyay, 2022) [14] and (Gregor, n.d.) studied about "kinematic analysis of performance of world class Javelin Throwers", (Chow, 2003) [7] had studied about "Kinematic Analysis of Javelin Throw Performed by Wheelchair Athletes of Different functional classes", but the availability of literature regarding kinematic analysis of junior level javelin throwers is scarce and this has motivated the researcher to investigate relationship between selected linear and angular kinematic parameters with javelin throw performance of junior level (U-18) throwers, which is an objective of present study.

The author hypothesised that there will be a significant relationship among javelin throw performance and selected kinematic parameters during release of javelin.

Methods

Participants

Fifteen Junior (U-18) male Javelin throwers with Height; 172.34±4.48, Weight; 70.06±5.66, and Age; 16.9±0.57 from Navdeep stadium Narwana, Jind, Haryana were chosen for the study.

Kinematic Parameters assessment

Selected kinematic parameters (Centre of gravity during release, Wrist joint angle, Elbow joint angle, Shoulder joint angle, Hip joint angle, Knee joint angle & Ankle joint angle) were assessed. All the measurements were taken from dominant side of the body. All study subjects participated in a familiarization session that was held a day before the test. Each individual was instructed to warm-up by stretching all significant muscles involved in the javelin throw movement pattern for at least 15 minutes before assessment. After the warm-up, subjects were instructed to throw. Each subject was given three attempts, and the throw was executed under the guidance of a certified coach or javelin throw expert. For kinematic analysis, the best technical execution and its corresponding performance in which the javelin landed inside the landing sector was taken into account. There was a 90-second recuperation period between each attempt.

Filming protocol

For the kinematical data a high speed GoPro Hero10 black was mounted using a tripod on a height of 1.20 meters to record selected kinematic parameters during release of javelin. Camera was placed in sagittal plane to the movement and it was at a distance of 10 meters from the white square. Reflective markers were also placed on the joints and vertical as well as horizontal references were inducted to minimise cinematic errors. The captured video footages were downloaded, slashed, and edited using the kinovea programme. The same analysis programme was also used for digitization, smoothing, and analysis.

Ethics and consent of data collection

All data gathering processes were carried out in accordance with the review board of the javelin academy's rulings and directives. Before any data were collected, the subjects gave their prior agreement to take part in the study. Before the data collection process began, the subjects were given a permission form that included details about the study and their rights. Additionally, the subjects had the option to withdraw from study at any point of time. The subjects' risk of harm during data collection was kept to a minimum.

Statistical analysis

IBM SPSS version 22 was used for all statistical analyses (IBM, New York, USA). The mean, standard deviations and correlation of the data are presented. The Shapiro-Wilk test was used to determine normality. Relationship of selected kinematic parameters and javelin throw performance was determined using Pearson's product moment correlation. The level of statistical significance was set at $p \leq 0.05$.

Results

In order to analyze the relationship of selected linear and angular kinematic variables on javelin throw performance during release, Product moment correlation was employed and description of Mean, SD for selected variables in presented in table1.

Table 1: Mean and Standard Deviation of Linear and Angular Kinematic Variables of Javelin Throw Performance at the Time of Release

Variables	Mean	SD	N
Javelin throw performance	51.10	2.86	15
Center of Gravity	0.87	0.05	
Wrist Joint Angle	217.40	9.59	
Elbow Joint Angle	154.80	39.62	
Shoulder Joint Angle	225.47	15.35	
Hip Joint Angle	148.13	13.15	
Knee Joint Angle	110.73	17.16	
Ankle Joint Angle	134.4	11.28	

From table 1, In case of selected angular kinematic variables, It is evident that Mean was maximum for Shoulder Joint angle (225.47) and minimum for Knee Joint angle (110.73). SD was maximum and minimum for Elbow Joint angle (39.62) and Wrist Joint angle (9.59) respectively. Mean and SD for javelin throw performance was 51.10±2.86 for junior level (U-18) throwers.

Table 2: Relationship between selected Kinematic Parameters and Javelin throw performance during release

	Center of Gravity	Wrist Joint Angle	Elbow Joint Angle	Shoulder Joint Angle	Hip Joint Angle	Knee Joint Angle	Ankle Joint Angle
Javelin throw performance	.155	.542*	-.392	.181	.387	.656**	.155
N	15	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**.Correlation is significant at the 0.01 level (2-tailed).

From table 2, It is evident that correlation between wrist joint angle and javelin throw performance was significant at 0.05 level, whereas knee joint angle had shown significant relationship with javelin throw performance at 0.01 level. Remaining linear and angular kinematic variables had not shown significant relationship with javelin throw performance at the time of release.

Discussion

Aim of the study was to determine relationship between selected linear and angular kinematic parameters with javelin throw performance of junior level (U-18) throwers. It was hypothesized that there will be a significant relationship between selected linear and angular kinematic parameters with javelin throw performance and null hypothesis was rejected in case of wrist joint angle as well as knee joint angle of dominant sides of the thrower, whereas for other selected variables, researcher failed to reject null hypothesis as no significant relationship was obtained between javelin throw performance and center of gravity, elbow joint angle, shoulder joint angle, hip joint angle, ankle joint angle at 0.05 level of significance.

In the current study, a positive correlation was obtained between javelin throw performance and knee angle (.656) at 0.01 level of significance. (Biomechanics of a javelin throw, 2022) has reported that thrower's Centre of mass is shifted over the back of the leg during the single-legged support phase and knee joint of throwing side plays a vital role in this phase which further contributes in optimization of release angle and transfer of momentum by driving hips to the front and transferring the weight from rear to front leg. So, this might be the reason for significant relationship between javelin throw performance and knee joint angle reported in the study.

A positive correlation was also reported between javelin throw performance and wrist joint angle (.542) at 0.05 level of significance. Wrist angle contributes in transfer of sum of forces to the javelin and it also brings stability to the javelin by assisting in the spin imparted by palm and the movement of fingers. Position of wrist angle helps in attainment of optimum angle of release, which is a primary concern for a thrower (Mackenzie, 2022) [9] (Barbar, 2014) [5].

Findings of the current study are in line with a previous study conducted by (Basumatary Maidangshri, 2019) [10] about “Two-dimensional analysis of javelin throw with their performance”.

Conclusion

On the basis of outcomes of present empirical investigation, it can be concluded that Wrist joint angle and knee joints angles are significant contributors for optimum conditions of projection for release of javelin and knee joint angle might play a dominant role in transfer of momentum and summation of forces to optimise javelin throw performance.

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