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Kinematic Analysis Of Elite Indian National-Level Sprinters: A Comprehensive Analysis

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Abstract

A comprehensive research study was undertaken involving ten national-level sprinters selected purposively from the athletics ground of Jawaharlal Nehru Stadium in New Delhi. The primary objective was to identify the key angles influencing movement during predefined steps in sprinting. The age range of the participants was 19 to 27 years, and the selection process followed purposive sampling. Descriptive statistics were employed to interpret the collected data, providing a summary of the sprinters' performances.

The study considered various biomechanical aspects, including angles related to knee movement, hip articulation, and other relevant variables. The correlation between angular and linear variables was explored, and KINOVEA software was utilized for precise angle measurements, ensuring high accuracy in recording sprinters' movements. This technological approach facilitated a thorough examination of the kinematic aspects of their performance.

Data collection employed a judgmental sampling method, and the results revealed significant relationships. Notably, there was a significant correlation between the angle at the right ankle joint and the angle at the right wrist joint at the 1st step. Additionally, a significant correlation was observed at the right knee joint at the 3rd step, indicating its contribution to the athletes' overall performance.

Keywords: Sprinters, Biomechanical analysis, Kinematic aspects, Angular variables.

INTRODUCTION

Biomechanics provide a varied range of possibilities of for the movement analysis of athletes looking upon their posture and style of movement execution. Even the performance enhancement is seen when the concept of biomechanics is taken into consideration, it works as valuable tool for athletes, coaches and supporting staff who work behind an athlete.

High speed camera is very useful while keeping precise records of athlete’s performance and motion capture camera even help to rectify mistake and help improving athlete for good performance.

“Movements are analyzed biomechanically which can be different from person to person as which technique suits best for a particular athlete although a blueprint of most of the movement patterns has been analyzed in most of the researches involving sports biomechanics". (Mann & Hermann, 1984).

For analysis of human running movement biomechanically one should understand how the running gait cycle works, there are various parameter which are taken into consideration i.e., linear parameters and kinematic parameters.

These are as follows: -

Linear parameters

1. Displacement
2. Speed
3. Acceleration

Kinematic parameters

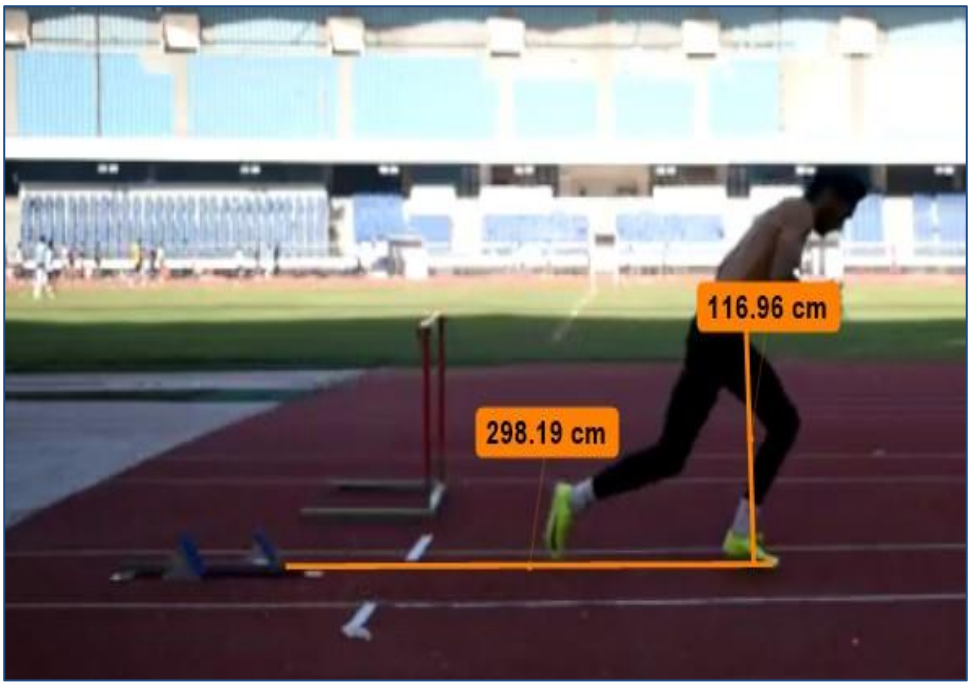
1. Stride length
2. Step length
3. Stride frequency
4. Joint angles
5. Center of mass

Considering both parameters, a relationship was identified in this study. The author hypothesized that there would be a significant difference in the relationship between these two parameters.

MATERIALS AND METHODS

Sample Size For this study Purposive sampling method was implied the study included a total of 10 male athletes who were specialized in the field events of the athlete where their discipline of sprinters was 100m 200 m and 400m. The selection of the athletes was specifically from the ground of Jawahar Nehru Stadium of New Delhi.

Procedure: - The biomechanical analysis of the block start, videography was utilized as the primary method. A Nikon D5600 camera, operating at a frame rate of 120 frames per second, was strategically positioned along the sagittal plane to capture the athlete's movements. The analysis focused on the initial four steps of the start. Kinovea software played a pivotal role in extracting and analyzing various kinematic variables associated with the block start. Specifically, key kinematic variables, including angles at the right ankle joint, right knee joint, right hip joint, right elbow joint, and right wrist joint, were measured and recorded using the KINOVEA program.



KINOVEA which comprises the detailed analysis of movements on a video frame by frame in slow-motion performance helped in finding the relationship.

Statistical Procedure: Pearson correlation method was implied to find if there was any significant difference among the two variables. It help in measuring the strength of the linear relationship between two variable.

RESULTS

The data collected by adopting the above procedure were statistically analyzed and the results are presented in the tables below.

TABLE 1 Correlation between Selected Linear Kinematic and Angular Kinematic Variables at the First Step with 10m Sprint Time Performance

S. No.	Variables	Pearson correlation	p-value (sig.)
1	Centre of Gravity	0.466	0.087
2	Angle at right ankle joint	0.585*	0.038
3	Ankle at right knee Joint	-0.347	0.163
4	Angle at Right hip joint	-0.235	0.257
5	Angle at right elbow joint	0.257	0.190
6	Angle at right wrist joint	0.561*	0.046

Table 1 shows correlations between kinematic variables and 10m sprint time at the first step. Significant positive associations were found for the "Angle at Right Ankle Joint" (0.585, p = 0.038) and "Angle at Right Wrist Joint" (0.561, p = 0.046). While the "Angle at Right Knee Joint" showed a negative correlation (-0.347), it did not reach statistical significance (p = 0.163). The angles at the right hip and elbow joints did not exhibit significant correlations. These results highlight the potential importance of the right ankle and wrist joint angles in influencing 10m sprint performance during the first step.

TABLE 2 Correlation between Selected Linear Kinematic and Angular Kinematic Variables at the Third Step and 10m Sprint Time Performance

S. No.	Variables	Pearson correlation	p-value (sig.)
1	Centre of Gravity	0.139	0.702
2	Angle at right ankle joint	-0.174	0.630
3	Ankle at right knee Joint	0.712*	0.021
4	Angle at Right hip joint	0.397	0.255
5	Angle at right elbow joint	-0.320	0.368
6	Angle at right wrist joint	-0.075	0.836

Table 2 shows the correlation analysis revealed the relationship between selected linear kinematic and angular kinematic variables at the third step and 10m sprint time performance. Notably, the angle at the right knee joint exhibited a statistically significant and strong positive correlation ($r = 0.712$, $p = 0.021$) with 10m sprint time performance. Conversely, the centre of gravity, angle at the right ankle joint, angle at right hip joint, angle at right elbow joint, and angle at right wrist joint did not show statistically significant correlations with sprint performance. These findings suggest that, among the variables examined, the angle at the right knee joint at the third step may play a crucial role in influencing 10m sprint time performance.

TABLE 3 Correlation of Selected Linear Kinematic and Angular Kinematic variables at First step with Horizontal Distance

S. No.	Variables	Pearson correlation	p-value (sig.)
1	Centre of Gravity	0.780**	0.008
2	Angle at right ankle joint	0.257	0.474
3	Ankle at right knee Joint	0.310	0.383
4	Angle at Right hip joint	0.007	0.984
5	Angle at right elbow joint	-0.419	-0.262
6	Angle at right wrist joint	0.002	0.995

Table 3 displays the correlation coefficients between selected linear kinematic and angular kinematic variables at the first step and horizontal distance. Notably, the center of gravity at the first step exhibits a strong positive correlation with horizontal distance ($r = 0.780$, $p = 0.008$), indicating a significant influence. Conversely, the angle at the right ankle joint, ankle at the right knee joint, angle at the right hip joint, angle at the right elbow joint, and angle at the right wrist joint do not show statistically significant correlations with horizontal distance. These findings suggest that, among the variables considered, the center of gravity at the first step plays a crucial role in influencing horizontal distance during the performance.

DISCUSSION

Table 1 presents the correlation between Linear Kinematic and Angular Kinematic variables and the performance of the 10m time with the First Step, including their corresponding significance values (p-values). The results indicate a significant correlation between the performance of the 10m time and the angles at the right ankle joint and right wrist joint during the first step of the sprint start, with a significance level of 0.05.

Table 2 displays the correlation between Linear Kinematic and Angular Kinematic variables and the

performance of the 10m time with the Third Step, including their respective significance values (p-values). The findings indicate a significant correlation between the performance of the 10m time and the angle at the right knee joint during the third step of the sprint start, with a significance level of 0.05.
Table 3 illustrates the correlation between Linear Kinematic and Angular Kinematic variables and the Horizontal Distance with the First Step, along with their corresponding significance values (p-values). The results indicate a significant correlation between the performance of the 10m time and the center of gravity during the first step of the sprint start, with a significance level of 0.01.

CONCLUSION

Various research studies have been conducted to analyze the kinematics of sprint starts. In this study, we selected 10 male athletes competing at the National level, all of whom trained at Jawaharlal Nehru Stadium (JNU) in New Delhi. To ensure accuracy and reliability in our measurements, we employed standard and calibrated equipment such as cameras, measuring tapes, Casio stopwatches, and an international-level standard running track. The study was conducted under controlled conditions. The athletes' movements were recorded in the sagittal plane using a Nikon D5600 camera operating at a frame rate of 120 frames per second. Following video capture, specific moments of interest were extracted by pausing or stopping the video, aided by the Kinovea Software Version-0.9.5, which is distributed under the GNU GENERAL PUBLIC LICENSE Version 2, dated June 1991.With the above study it can be concluded that the kinematic variables play a very important role in the performance of athletes. Both the parameters the linear as well as the kinematic variable plays a crucial role in performance enhancement from the study, we found out that when an athlete leaves the block at the starting phase in a sprint the center of gravity, he acquires plays an important role in increasing the length of horizontal distance, furtherstudy reveals that the right ankle angle plays a crucial role in performance of the first 10m in the sprint athletes.

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