

## MULTILINEAR REGRESSION MODEL OF SPRINT START

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### ABSTRACT

*Aim of the researcher was to investigate the fundamentals of sprint start technique that contribute to higher levels of performance and recognized the major kinematic parameters of the sprint start that impact the result of sprinting. Biomechanical evaluation and kinematics investigation were completed on Indian National Male Sprinter. Ten (10) Indian national male athletes were randomly selected for the study with their mean age  $24.8 \pm 1.31$  yrs. Mean height  $5.1 \pm 0.01$  meter, mean weight  $72 \pm 5.37$  kg. This study based on 2-D kinematic analysis, using high speed camera using two synchronized FDR-AX700 4K HDR Camcorder. The specifications were FDR-AX700 4K HDR Camcorder, a shutter speed set 1/10000, aperture value F2.8-F4.V. The sprinter was performed powerful sprint start up-to 10 m. Each sprinter gives 10 trails, the investigation conducted on 24 kinematics variable BVB AS1, BVP AS1, BVB AS2, BVP AS2, FSL, SSL, FSS, SSS, FT S1, FT S2, SN, TTST. This Study Showed that the selected model is highly significant.*

**Keywords:** Biomechanics, Multilinear regression, Kinematics, Model, Sprinting.

### 1. INTRODUCTION

It is generally accepted that good acceleration performance in sprinting tasks requires highly efficient application of horizontal force (Morin, Edouard, & Samozino, 2011; Morin et al., 2015) in order to increase horizontal impulses generated during ground-contact phases. In addition, good acceleration performance requires high extension moments and positive power output by lower extremity joints in the start and early acceleration phase, particularly at the hip, knee and ankle joint (Mero et al., 2006; Willwacher et al., 2016).

The aforementioned references indicate that acceleration performance can be improved by increasing the capacity of the musculoskeletal system to create power from a resting position. Furthermore, they show that the efficiency of horizontal force application might play an important role in improving acceleration during the start phase (Morin, Edouard, & Samozino, 2011; Morin et al., 2015). The ability to direct a great amount of the total force in the running direction can be considered a key technical skill that determines the quality of a sprinter's starting technique. Currently, it is not clear whether the capacity for high leg power output and that for efficient direction of forces in the running direction are independent abilities that could be worked on separately, or whether both are simultaneously influenced by an underlying "acceleration ability" factor.

A deeper understanding of the mechanism underlying sprint start performance should improve sprint performance diagnostics and aid the design of technical drills and strength and conditioning programs.

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An aim of sport biomechanics factor to exploring a scientific and systematic knowledge of movement techniques throughout the competition or training exercises. The initial phase of a sprint start is a very complex movement sequence in any sprint race (60m to 400m), requisite high muscle stimulation and affective acclimatization of acyclic and cyclic movements.

Crouch start is starting from a position with both feet and both hands on the ground. There are three types of Crouch starts

- Bunch or Bullet start - The toes of the rear foot are approximately level with the heel of the front foot and both feet are placed well back from the starting line.
- Medium start - the knee of the rear leg is placed opposite a point in the front half of the front foot.
- Elongated start - the knee of the rear leg is level with or slightly behind the heel of the front foot.

Research by Henry (1952) and Sigerseth and Grimacer (1963). Reaction from the set position in the sprint start must not only be fast and dynamic but should permit the sprinter to rapidly take up a mechanically efficient running position (Barlow & Cooper, 1972).

A well-known fact that a powerful start plays versatile role for in any competitive sprint race. The aim of sprinter is to generating a top speed as much as possible and smoothly in a very tiny time.

The analysis of biomechanical aspect of the sprinters different segment angle would be of literal understanding how a particular pattern of segment angle influences to take the block start. Biomechanical study provides a logical and fundamental approach will help to understanding the measure impact of a series of sprint performance, bio mechanist and coaches often conation to determine irrefutable aspect of sporting techniques which appear to result on high level of performance. Sports biomechanics provide a versatile method to extensive the individual motion from a performance enhancing and an injury reduction phenomenon.

So respectively, the objective of sports scientists is to endorsement coaches and athlete with authentic and useful acquaintance related to the athletes that technique is decentish or not which movement from crouch position in the sprint start must not only be fast and force full but should permit the sprinter to rapidly catch up a mechanically accomplished running position.

To investigate influences of the leg length and spatiotemporalvariables, in addition to running speed, on leg kinematicvariables, multiple regression analyses would be useful and allowus to evaluate magnitudes of changes in kinematic variableswith manipulating running speed, leg length, and spatiotemporalvariables. Knowledge of difference in magnitudes of changesin kinematic variables associated with changes in runningspeed, leg length, and spatiotemporal variables would be ofgreat value to coaches when training a sprinter to improvemaximal speed sprinting performance. Moreover, because eachof previous studies investigated relationships between maximalspeed sprinting performance and kinematic variables for smallnumber of variables (Kunz & Kaufmann, 1981; Alexander,1989; Ae et al., 1992; Bushnell & Hunter, 2007; Ito et al.,2008; Yada et al., 2011; Toyoshima & Sakurai, 2016; Haugenet al., 2018), the data as normative information which canbe used by coaches and sprinters are limited. Adopting alarge number of kinematic variables therefore would providenormative information for considering faster maximal sprintingperformance based on individual-specific factors.

The aim of this study was consequently to develop a model of a sprinter and find out the angle of different joint segment. Study also presented the biomechanical modelling for human sprint movement analysis. The purposes of the sprint start can be seen below.

1. To found a balanced position in the blocks.
2. To get a body position where the center of gravity is as high as is practical and slightly forward of the base of support.
3. To apply force against the blocks in a line through the ankle, knee and hip joints, the center of the trunk and head.
5. To found the optimum knee joint angles in both the front and rear leg.
6. To clear the blocks on balance and with the minimum possible velocity.

## **2. METHODS AND MATERIALS**

### **2.1 Participants**

Ten (10) Indian national male athletes were randomly selected for the study. The mean and standard deviation of the anthropometric variables of these are - mean age  $24.8 \pm 1.31$  yrs. Mean height  $5.1 \pm 0.01$  meter, mean weight  $72 \pm 5.37$  kg. It was assured that all selected subjects should be free from any type of illness, injuries and researcher also maintain the decorum of data process and focus on ethical issues of selected subjects. Further researchers provided necessity information to the subjects in terms of successful participating during data collection.

### **2.2 Data Collection**

Filming procedure and video acquisition was done during normal practice session and practice session camping on a sunny and clear weather in natural environment at 400 m standard athletic track. The experimental set-up was constructed to obtain the required video data in which portable pre-design block sprint start and target area were established at six number of tracks. The first camera positioned perpendiculars to the starting block, and second camera positioned 600 from the starting block to cover upto 10 m sprinter with obtain high resolution image from the starting block to 10m sprint start. Which is efficient to capture and the frame rate and camera were set as 50hz at a speed 1/10000. The area was calibrating by 1.05 meters calibration stick with two referential point with both end of stick and for the view of camera 1<sup>st</sup> and camera 2<sup>nd</sup> respectively. The field of view was captured only from reaction to first contact of track at 2 meters for the first camera to capture plane of the execution and up to 10 meters field of view for second camera to captured first to forth contact of foot to the track.

### **2.3 Statistical Analysis**

For statistical analysis of the study, statistical package of social sciences (SPSS, version 21.0 for Windows 10) software was used. The Shapiro-Wilk test was applied to the examination the homogeneity of the variance. After appalling this test, if the value of  $p$  resulted in greater than 0.05 ( $p > 0.05$ ), parametric tests were carried out to compare the groups; however, if the value of  $p$  resulted in less than 0.05, for any of the above two mentioned tests, non-parametric tests were carried out for the comparison.

To delineate the sample selection of sample for the study, descriptive statistics was followed (mean  $\pm$  standard deviation) and after due inferences were made. To compare the measurements of the intra group kinematic variables in all the serve skill, one-way ANOVA was applied to determine differences. The level of significance was adopted at  $p < 0.05$ . If a

significant difference was noted, then finally, Multilinear regression method were to developed Regression Equation.

### 3. RESULTS

The purpose of the research study was to analyse the variable of the selected biomechanical parameter of sprint start into short distance track events and the results of the statistical analysis is presented below.

**Table 1: Results of Descriptive Statistics**

|   | Mean     | Std. Deviation | N  |
|---|----------|----------------|----|
| Total ten meter step time                           | 2.5494   | 0.1039         | 10 |
| Block velocity breaking phase acceleration step 1   | 1.4312   | 0.1607         | 10 |
| Block velocity propulsive phase acceleration step 1 | 3.1818   | 0.4423         | 10 |
| Block velocity breaking phase acceleration step 2   | 3.6036   | 0.2593         | 10 |
| Block velocity propulsive phase acceleration step 2 | 3.7036   | 0.1886         | 10 |
| First step length                                   | 192.1470 | 29.7293        | 10 |
| Second step length                                  | 265.9030 | 26.4915        | 10 |
| First stride step                                   | 112.6186 | 13.2066        | 10 |
| Second stride step                                  | 81.9324  | 14.0678        | 10 |
| Flight step 1                                       | 0.3368   | 0.0248         | 10 |
| Flight step 2                                       | 0.3187   | 0.1039         | 10 |
| Step number   | 4.0000   | 0.0000         | 10 |

The Table 1 represents the descriptive statistics of the selected parameters of the study. Whereas the mean value of block velocity breaking phase acceleration step 1 is 1.4312 m/s and standard deviation was found as  $\pm 0.1607$  for ten numbers of Athlete. The mean value of block velocity propulsion phase acceleration step 1 is 3.1818 m/s, and standard deviation similar was found  $\pm 0.4423$  for ten numerals of athlete. The mean value of block velocity breaking phase acceleration step 2 is 3.6036 m/s and the standard deviation initiated as  $\pm 0.2593$  for ten number of athletes into these sequences the mean of block velocity propulsion phase acceleration step-2 is 3.7036 m/s, hence standard deviation was founded as  $\pm 0.1886$  for ten number of athletes. The mean value of first step length is 192.1470 cm and standard deviation was founded as  $\pm 29.7293$ , for ten number of athletes. The mean value of second step length is 269.13900cm, and standard deviation was founded as  $\pm 14.067891$ , for ten number of athletes. The mean value of third step length is 328.26800 cm, and standard deviation was founded as  $\pm 60.861823$ , for ten number of athletes. The mean value of fourth step length is 389.79600 cm, and standard deviation was founded as  $\pm 103.414206$ , for ten number of athletes. The mean value of First stride step is 112.61860 cm and standard deviation was founded as  $\pm 13.206662$ , for ten number of athletes. The mean value of Second stride step is 81.93240 cm, and standard deviation was founded as  $\pm 14.067891$ , for ten number of athletes. Whereas, the mean value of flight step 1 is 0.3368 sec and the standard deviation noted at  $\pm 0.0248$ , for ten number of athletes. The mean value of flight step 2 is 0.3187 sec and the standard deviation noted at  $\pm 0.1039$ , for ten number of athletes.

**Table 2: Regression coefficients**

| Coefficients <sup>a</sup>                        |                    | Unstandardized Coefficients |            | Standardized Coefficients |        | 95.0% Confidence Interval for B |             | Correlations |            |         |       |
|--|--------------------|-----------------------------|------------|---------------------------|--------|---------------------------------|-------------|--------------|------------|---------|-------|
|  |                    | B                           | Std. Error | Beta                      | t      | Sig.                            | Lower Bound | Upper Bound  | Zero-order | Partial | Part  |
| 1  | (Constant)         | 1.223                       | .223       |                           | 5.495  | .001                            | .710        | 1.736        |            |         |       |
|  | Flight step 3      | 3.458                       | .579       | .904                      | 5.975  | .000                            | 2.124       | 4.793        | .904       | .904    | .904  |
| 2  | (Constant)         | 1.326                       | .129       |                           | 10.249 | .000                            | 1.020       | 1.632        |            |         |       |
|  | Flight step 3      | 4.365                       | .395       | 1.141                     | 11.052 | .000                            | 3.431       | 5.299        | .904       | .973    | .954  |
|  | Second step length | -.002                       | .000       | -.432                     | -4.190 | .004                            | -.003       | -.001        | .193       | -.846   | -.362 |
| a. Dependent Variable: Total ten-meter step time |                    |                             |            |                           |        |                                 |             |              |            |         |       |

In the above table the unstandardized and standardized regression coefficient in all two models. Unstandardized coefficients are known as “ $\beta$ ” coefficients and are used to developed regression equation whereas standardized coefficients are used to denoted by beta “ $\beta$ ” and are used to explain the relative importance of independence variables in terms of their contribution towards dependent variables in the model. In second model t- value for all the regression coefficients are significance as their value (p value) are 0.05 thus it may be concluded that the variables Flight step 3 and second step length significantly explain the variations in the sprint start.

#### Regression Equation:

Using understandardized regression coefficients (B) of the second model shown in above table, the regression equation can be developed which is as follows

Sprint start = 1.326 + 4.365 (flight step 3) – 0.002 (second step length)

**Table 3: Estimation of standard deviation – model summary**

| Model Summary <sup>c</sup> |                   |          |                   |                            | Change Statistics |          |     |     |               |
|----------------------------|-------------------|----------|-------------------|----------------------------|-------------------|----------|-----|-----|---------------|
| Model                      | R                 | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change   | F Change | df1 | df2 | Sig. F Change |
| 1                          | .904 <sup>a</sup> | .817     | .794              | .047157                    | .817              | 35.703   | 1   | 8   | .000          |
| 2                          | .974 <sup>b</sup> | .948     | .933              | .026917                    | .131              | 17.554   | 1   | 7   | .004          |

a. Predictors: (Constant), Flight step 3

b. Predictors: (Constant), Flight step 3, Second step length

c. Dependent Variable: Total ten-meter step time

The two regression models generated by the SPSS have been presented in table. In second model the value of  $R^2$  is 0.948 which is maximum and therefore second model used to develop regression equation. It can be seen from the above table two independent variables namely flight step 3, second step length and dependent variable which is total ten-meter step time have been identified therefore regression equation will be developed using these three variables only. The  $R^2$  of this model is 0.948. These three variables explain 94.8 % variations in sprint start thus the model is considered appropriate to develop the regression equation.

## 4. DISCUSSION

The aim of the study was to examine the selected kinematics variables in sprint start and developed the model enlightened of multiple regression. The generic objective of the investigation was to developed the model and identify starting mechanics due to the



methodical difference in start technique, similarly, Hunter, Marshall, and McNair (2004), developed a deterministic model to explore the understanding. Precisely, study was to recognize and explore the most appropriate kinematic parameter that significantly contribute to the proficiency of the sprint start. Coh et al. (2001) found that step length (SL) was not significantly different between two groups of elite athletes.

## 5. CONCLUSION

Aim of the researcher was to realize the characteristics of sprint start technique that contribute to higher levels of performance. This study analyzed Total ten-meter step time. Block velocity breaking phase acceleration step 1(BVB AS1), Block velocity propulsive phase acceleration step 1(BVP AS1), Block velocity breaking phase acceleration step 2 (BVB AS2), Block velocity propulsive phase acceleration step 2 (BVP AS2), First step length (FSL), Second step length (SSL), First stride step(FSS), Second stride step (SSS), Flight step 1(FT S1), Flight step 2(FT S2), Step number (SN).

Researcher pointed out to the undeniable correlation of the sprint start. The source is an optimally set position ensuring the maximal block velocity of the sprinter. The change from block velocity to block acceleration depends on the execution of the first step, particularly the length of the step and positioning of the foot in the braking phase. Step length and frequency have to be coordinated to such an extent as to enable ground contact times to equal those of the flight phases within the shortest time possible.

Finally, in this investigation researcher founded that t- value for all the regression coefficients are significance as their significance value (p value) are 0.05 thus it may be concluded that second model with the variables of Flight step and second step length highly significantly explain the variations in the sprint start. So, it is proposed that to athletes, coaches, physical educator and sport scientist should take this phenomenon into their training.

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