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KINEMATIC PATTERNS OF START IN TRACK AND FIELD SPRINTS

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ABSTRACT :

Sprint start and acceleration phase are very essential parts in a complete sprint run. Thus, it is of high importance to know how the elite sprinters conform through these phases. The study was purely kinematic in nature and was aimed to report the kinematic patterns of experienced athletes. Five highly skilled male athletes volunteered for this study. The test was carried out in the outdoor setting on an athletics track and the movement was recorded with a high resolution camera recording at 50fps in the sagittal plane. The joint angles formed, linear velocity and angular velocity of the athletes from the "set" position and until the first stride were registered. The study found moderately strong or strong correlation of the hip joint angle at first contact(r=0.6772) ,ankle joint angle at the first contact(-0.7095), the rear foot flight time after the take-off(r=0.7213), first support phase(r=0.8493), first step length(r=0.6363) with the performance value of the sprinters.

KEYWORDS : *kinematic, ,ankle joint and athletes.*

INTRODUCTION

Sprint is a highly athletic endeavour which requires high and sustained muscle contraction velocity. The goal is to reach the finish line in shortest possible time. So, it appeals to a wide audience around the globe. The 100 m at the 2008 Beijing Olympic Games was broadcast in over 200 countries worldwide, and 95 different nations were represented throughout the heats (IAAF, 2008).

P.T. Usha missed the bronze medal by 0.01s in the 400 m hurdles summer Olympics 1984. This tells us about the propinquity between winning and losing a medal. Therefore small alterations in performance can be the defining factor between gold and silver medal placing (Docherty and Hodgson, 2007; Young, 2006)

An efficient start is crucial in sprint events to deliver a high class performance (e.g. Mero, 1988; Dickinson 1934).To achieve an efficient start, An athlete can optimize the position of their limbs by configuring the starting blocks as they want to get the most ideal "set" position(Mero, Luhtanen, &Komi, 1983;Dickinson,1934).

In starting the emphasis is upon getting away from the mark as quickly as possible, making a smooth transition into the acceleration phase without losing coordination of the body.

The sprint start has been studied on numerous occasions both intensively as well as extensively, with many authors having registered the "set" position body configurations (e.g. Guissard 1992;Atwater, 1980; Mero, 1988; Tellez &Doolittle, 1984),sprint start and the fallowing successive supports (Debaere et al.,2010),kinematics of gender difference (Ciacci et al.,2017),differences between faster and slower athletes (Čoh et al.,2017),kinetics of sprint start(Willwacher et al.,2014;Brazil et al,2107) and kinematics of sprint start (Bezodis, Trewartha and Salo,2008)

An athlete reacts to the gun shot and starts his sprint by first clearing the block and then going into the acceleration phase. Block clearance and the transition into the acceleration phase are complex series of movements, these series of moments require a precise and high-level muscle activation that are well timed and progressive in order. These cyclic and acyclic movements need to be coordinated well to a perfect execution (Coh , 2007).

According to many biomechanical studies reaction time, block velocity and sprint start position are recognized as major contributing factors to a sprint performance (Korchemny,1992; Coppenolle et al.,1989; McClements et al.,1996). It was also pointed out that the bio-mechanists and coaches should not quantify performance on the bases of velocity alone (Bezodis, Trewartha and Salo,2008).

The linear kinematics of the Centre of mass (CM) have typically been reported once the sprint has commenced. Although linear CM data provide important information, such data are largely indicative of performance and reveal little about the specific techniques used to achieve these translations. Furthermore, much of the previously presented technique data have been collected from sub-elite sprinters. A lack of information thus exists regarding the techniques used by sprinters capable of achieving international success (Bezodis, Trewartha,G., and Salo,A 2008).

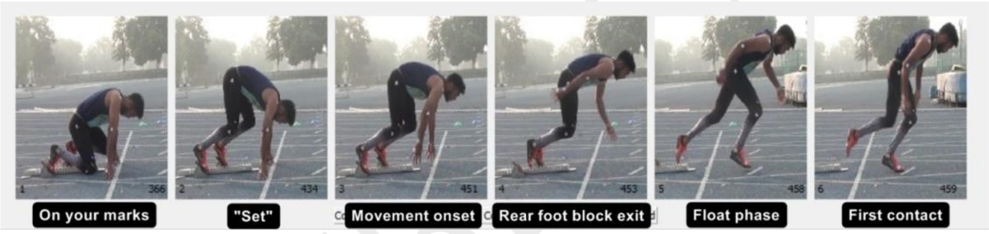

Figure 1: Different phases of the sprint start performance

METHOD

Participants

Five participants (M±SD; Age 26.8±1.92, height (cm) 171.2±5.16, body mass (kg) 65.4±2.73 and training experience (years) 7.6±2.07).who had previous success in the national events in sprint events were chosen for this study as participants.

Table 1: Anthropometric data of sprinters

Name	Age(years)	Height(cm)	Body mass(kg)	Leg length(cm)	Training experience(years)	Medals won at national level in sprint events
Ravi Kumar	26	168	57	38+42=80	6	One gold medal
MukeshPatha k	30	165	67	40+37=77	11	One gold medal & Three silver medals
Arshdeep Singh	25	170	64	41+38=79	6	One gold medal & three silver medals
Hitesh Deshwal	27	176	74	45+42=87	7	One gold medal, two silver medals

						and one bronze medals
YuvrajSingh	26	177	65	45+49=94	8	One gold medal

FILMING PROTOCOL

Motion analysis method was used in this study to record the data on the athletes. A video camera (CASIO EX-FH) that recorded at the speed of 50 frames per second was used. The camera was put perpendicular to the plane (sagittal plane) of motion at a distance of 7 meters so that it could capture the athlete in set position as well as the few successive steps taken by the athlete. The camera was put on a tripod to keep the camera stationary at a height of 0.8 meters.The camera was used with 1.0 zoom to record the data in HD (1080 pixels). The camera was set-up such that the field of view of the camera would record the sprinter in the “set” position and the three successive steps that they would take.

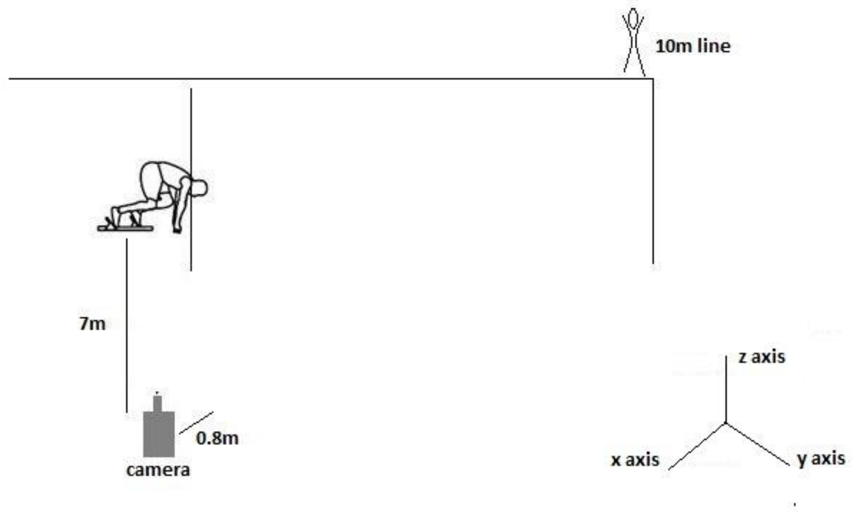

Figure 2 : Plan view of the data collection set-up

TESTING CONDITIONS

Testing took place in the beginning of the summer session on a tartan track in the outdoor setting on the Track A. of National institute of sports, Patiala. After a personalized warming up which consisted of jogging fallowed by stretching exercises the athletes took a test run. After that was done, the athletes ran four to six maximal-effort 20m runs, with complete recovery of the athlete between the sprints. The subjects wore their own spikes and stretchable shorts during the test which they use in competitions. Starting command was identical to that what is used in a competition setting.Apart from the research scholar eight other experienced sprinters who had a diploma in athletics coaching were also employed who worked as officials. Four of them were timekeepers, with two at 10m line and two at 20m line to keep the time independently.

One official was given the task to judge at the starting line while one more official held the clapper and positioned himself behind the start-blocks were the sprinters would place themselves.

Two more official remained seated on the side-lines and registered the information convayed to them.

CRITERION MEASURE

To measure the performance of the athlete for the sprint start, a stopwatch was used to record the timing of the athletes at 10 m distance. Two testers independently recorded the timing at 10 m distance, this was done to increase the reliability of the data recorded.

Statistical analysis

The conventional statistical methods were used to calculate the value of means, standard deviation and Pearson's correlation coefficient.

Kinematic Variables

After many weeks of literature review, correspondence with the experts of the area and scholars own understanding of the research problem the fallowing kinematic variables were selected for this study.

Linear kinematic variables

i. Height of the centre of mass (COM) in the "set" position.
ii. Projection angle of the athlete after the block exit.
iii. First step length after the block clearance (BC).
iv. Rear foot time of flight after the block clearance (BC).
v. Rear foot support phase duration after the first contact.
vi. V_{x_clear}: Horizontal velocity of CM at block clearance.
vii. V_{x_HJ}: Horizontal linear velocity of hip joint at block clearance.
viii. V_{x_KJ}: Horizontal linear velocity of the knee joint at block clearance.
ix. V_{x_AJ}: Horizontal linear velocity of the ankle joint at block clearance.

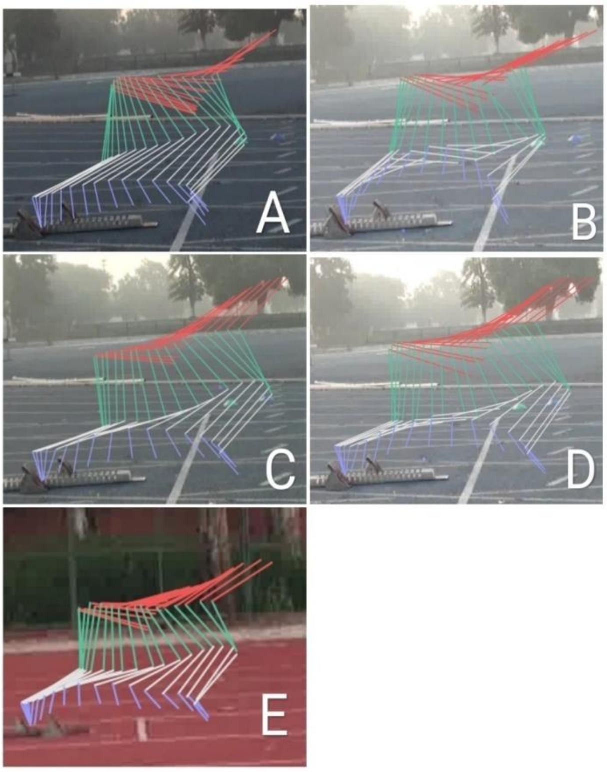

Figure 3: The disparities in the sprint-start technique from block phase to first touchdown of five elite sprinters

Table 2. Relationship between hip joint values in sprinters with their performance value

Variable	Mean	Standard deviation	Correlation(r) value
Hip joint angle (FC)	105.2	13.97	**0.6772**
Performance value	1.89	0.06	

Table 2 displays the relationship between the hip joint value in sprinters with their performance value. The mean of hip joint angles of the sprinters at first contact (FC) was 105.2(deg.) with standard deviation of 13.97. The value of correlation was found to be 0.6772.

This implies that for a high value of performance value there is a high value of hip joint angle at first contact(FC).

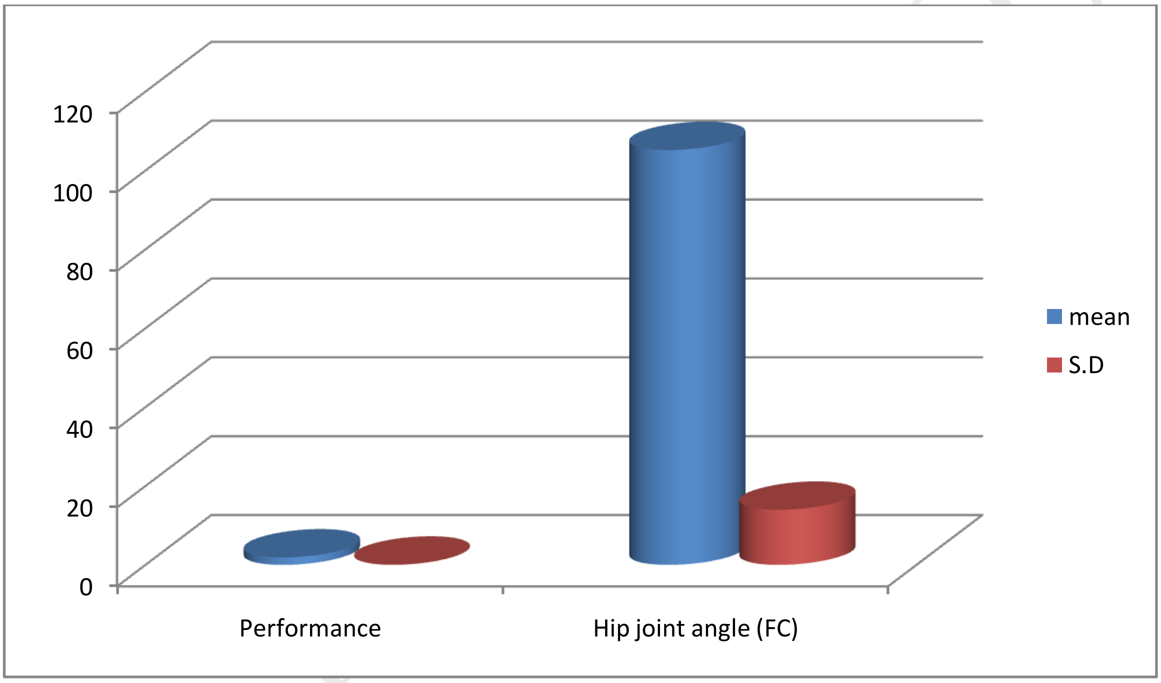

Figure 4: The mean and standard deviation values performance and the hip joint angle at the first contact

Table 3. Relationship between the ankle joint angle at first contact (FC) in sprinters with their performance value

Variable	Mean	Standard deviation	Correlation(r) value
Ankle joint angle (FC)	108.4	7.3	**-0.7095**
Performance value	1.89	0.06	

Table 3 displays the relationship between the ankle joint angle at first contact with the performance value of the sprinters. The mean of ankle joint angle was 108.4 (deg.) with standard deviation of 7.3. The performance values had a mean of 1.89(s) and standard deviation of 0.06.

The correlation value was -0.7095 suggesting that for high values of performance value there were low values of ankle joint angle at first contact.

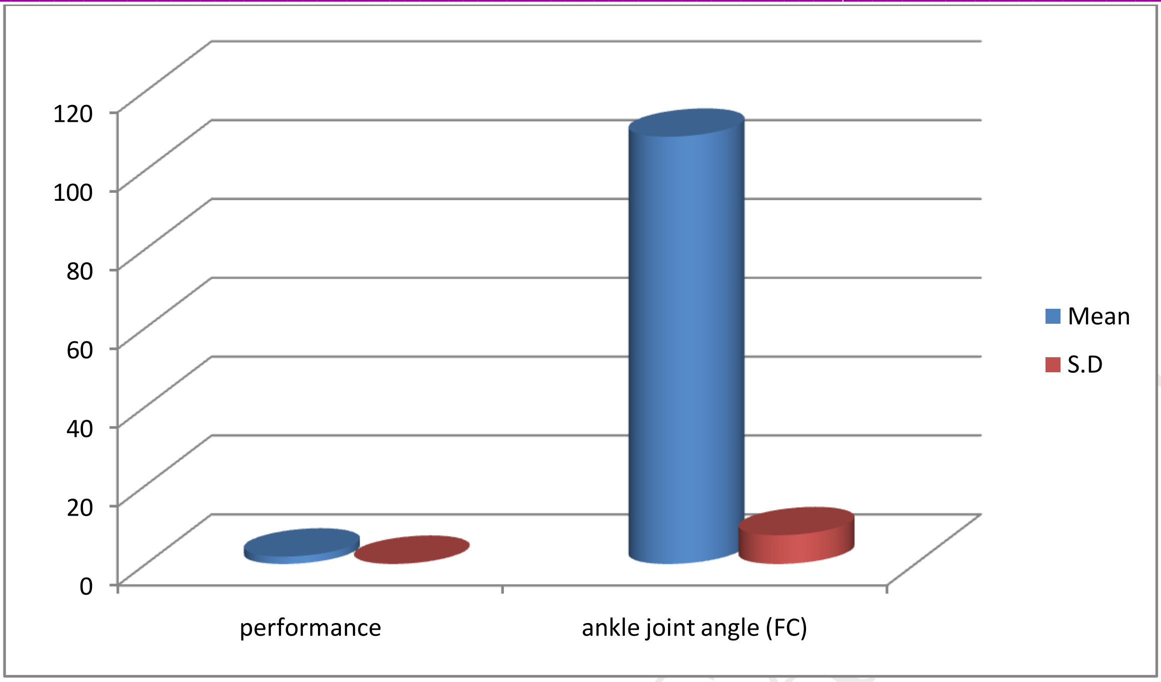

Figure 5: The mean and standard deviation values of performance and the ankle joint angle at first contact (FC)

Table 4. Relationship between rear foot flight time(s) in sprinters with their performance value

Variable	Mean	Standard deviation	Correlation(r) value
Rear foot flight time	0.236	0.032	**0.7213**
Performance value	1.89	0.06	

Table 4 shows the relationship between rear foot flight time and the performance value. The mean of the rear foot flight time of the sprinters was 0.236(s) with standard deviation of 0.032. The correlation value of 0.7213 was calculated between the rear foot flight times with the performance value suggesting a moderately strong association between the two variables. The performance values had a mean of 1.89(s) and standard deviation of 0.06.

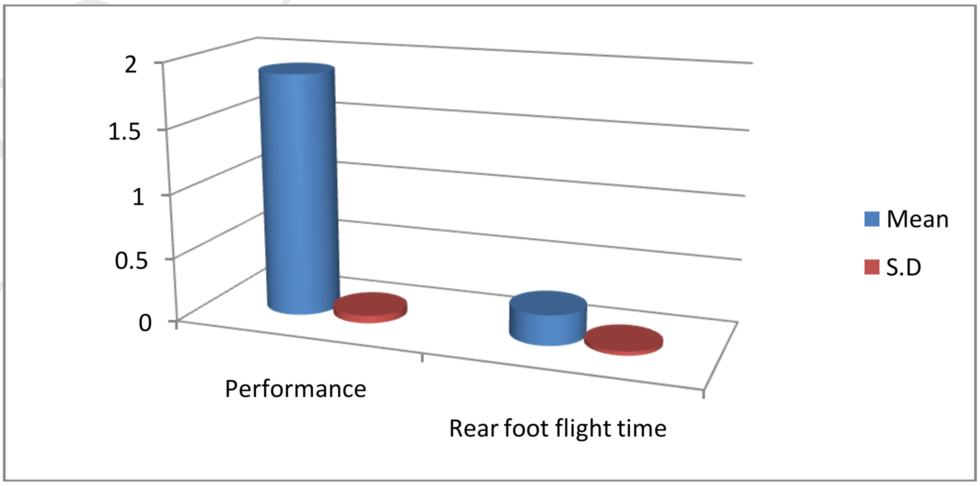

Figure 6: Themean and standard deviation values of performance and the rear foot flight time

Table5. Relationship between first support phase(s) in sprinters with their performance value

Variable	Mean	Standard deviation	Correlation(r) value
First support phase	0.174	0.023	**0.8493**
Performance value	1.89	0.06	

The table 5 shows the relationship between the first support phases in sprinters with their performance values. The mean value of first support phases of sprinters was 0.174(s) with a standard deviation of 0.023. The value of correlation of 0.8493 was found between the sprint start performance value and first support phase of the sprinters.

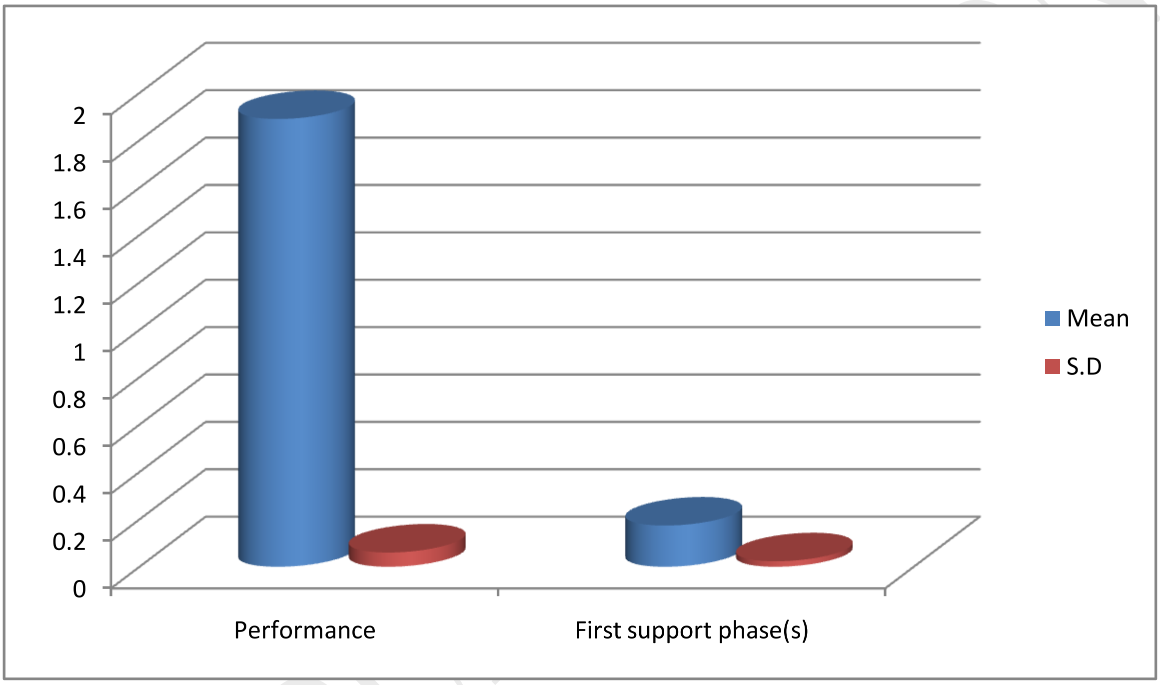

Figure 7. The mean and standard deviation values of performance and the first support phase duration (seconds)

Table 6:Relationship between first step length(m) of sprinters with their performance value

Variable	Mean	Standard deviation	Correlation(r) value
First step length	0.982	0.133	**0.6363**
Performance value	1.89	0.06	

The table 6 shows the relationship between the first step length with their performance value.

The mean value of the first step lengths was 0.982 with a standard deviation of 0.133. The value of correlation was 0.6363.

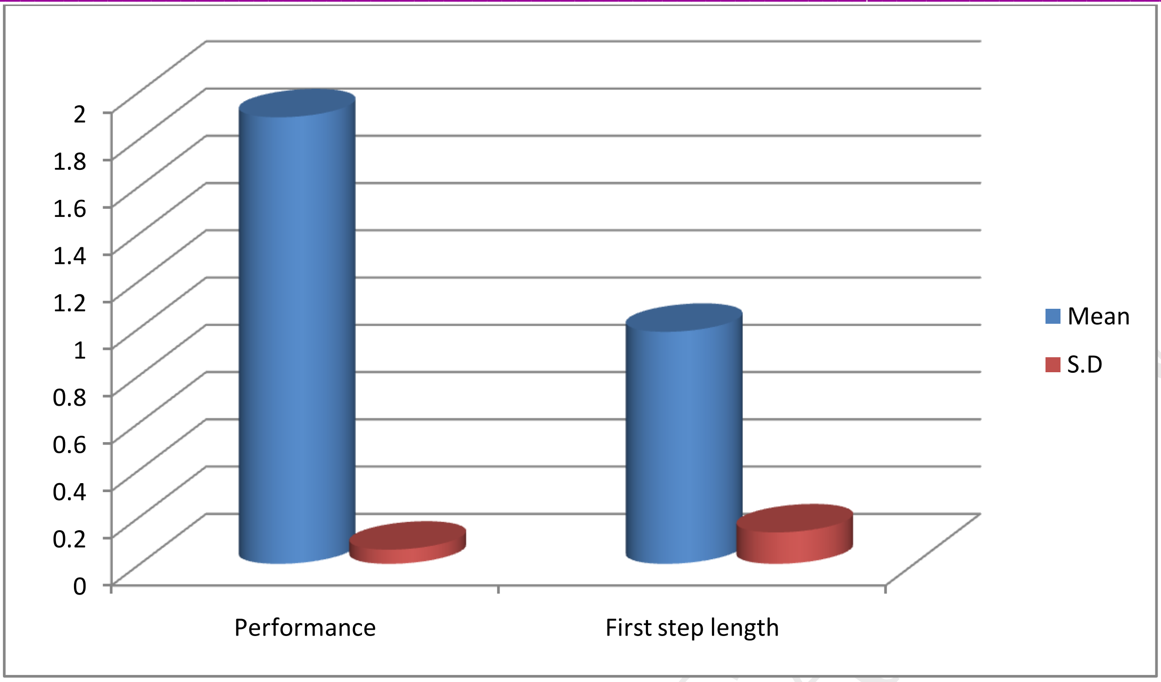

Figure 8. The mean and standard deviation values of the performance and first step length

DISCUSSION OF FINDINGS

1. A positive correlation(r=0.6772) was found between the 10m timing(s) and the hip joint angle at First contact (FC). This finding dictates that lesser the hip joint angle at the time of first contact (FC) the better were the results of the sprint start performance. This comes to terms with Harland and Steele (1997) who suggested that the centre of gravity of the athlete should be ahead of the contacting foot in the initial two steps after block clearance to minimize the potential braking force in the horizontal direction.
2. A negative correlation value (r= -0.7095) between the performance criterion value and ankle joint angle at first contact was found, this implies that the sprint start performance got better when the sprinters landed with greater amount of ankle joint extension.
3. The better sprint start performances (r=0.7213) had their rear foot in flight for a shorter duration, which means that the better sprint starts don't lift their foot too high and generally take a shorter first step.
4. The better sprint start performances elapsed less time in the first support phase; this is also otherwise true when the sprinter races through the track. The best athletes elapse less time on the ground (Mann, R., 1986; Mann, R. and Herman, J., 1985).
5. A moderately strong correlation (r=0.6363) was found between the performance value and the first stride length. This implies that shorter first step gives better sprint-start performance. A first step of greater length will put the athlete centre of mass ahead of his contacting foot resulting in greater breaking force in the horizontal direction (Harland and Steele, 1997).
6. Atwater (1982) analysed various disparities in the "set" position at various level of performances and couldn't fixate on one position that would be suitable for all sprinters however the most ideal position seems to be the one were the athlete raises his/her hips higher than the shoulders, shoulders directly above the start line and body weight balanced on the foot that is upfront (Hay, 1993).

Study	Front knee angle(^{0})	Rear knee angle(^{0})	Trunk lean(^{0})
Borzov	100	129	-14
Atwater(1982)	89	118	-23
Mero et al.	111	134	-29
Tellez &Doolittle	90	135	Not reported
Mero&komi	99	136	-21
Hussain (2019)	111	120	-20

Partly adapted from Harland and Steele(1997)

CONCLUSION

The sprinter should adjust himself in the blocks such that the center of mass of the sprinter is as close as possible to the starting line and as close to the ground as possible. However, chasing both the mentioned things at once may not be practical as getting oneself closer to the starting line will automatically raise the center of mass above the ground and in getting the center of mass closer to the ground the athlete's center of mass will move away from the starting line. So a sprinter must strike a balance between the two variable, this could be done by trial and error method while the performance at 10m is recorded for each sprint-start performance. In case the stakes are too high, expert's advice must be sought in setting up the start-block especially in the international events.It is also suggested that the first step that the sprinter takes should be short and that the sprinter should not exaggerate or try to over reach with the first step as doing so will increase the breaking force in the horizontal direction affect the sprint-start performance of the sprinter.

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