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Implication of centrifugal force on curve running

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Abstract
The purpose of the present study was to observe the implication of centrifugal force on eight (8) different curves running performance. Twenty (20) male state level sprinters from different districts of West Bengal were purposively selected for the study. The average age of the subjects was 21 years ranging from 18 to 24 years. A running distance of 100m was marked from the starting line in each of these curves. To find out the significant difference of running time, running velocity and centrifugal force of eight different curves, 'ANOVA' test was employed at the 0.05 level. The present study did not show any significance difference of running time and running velocity among eight different curves but the centrifugal force of running are significantly different. So the researcher concluded that the different centrifugal forces of eight different curves radii track are not effect on running performance of sprinters.

Keywords: Centrifugal Force, Curve Radius, Running Time, Running Velocity, Distance.

1. Introduction

The glamour of track and field surrounds over different events in the broad areas of running, jumping and throwing. The study was concerned with running. Among the running events there are 1) Sprint 2) Middle distance and 3) long distance. The all running events except 100 m sprint are curve running. This study deals specifically with curve sprint, one of the most interesting and exciting events in athletics.

The maximum velocity in running around a bend is less than that obtained while running in a straight line. Greene (1985) described the effects that runners experience around bends. He pointed out that lanes are unequal because of the effect of their radii on the runner's "speed, since in order to balance centrifugal acceleration, a runner must heel over into the turn, with the approximate centerline of his body making an angle with respect to the vertical.

- The objective of the study was to investigate the difference in running performance in different curve radius track.
- The secondary objective of the study was to analyze the changing influence of centrifugal force on different curve running performance.

2. Methods
2.1 Selection of Subject
Twenty (20) state level sprinters were purposively selected from eight (8) different districts of West Bengal (4 subject from Birbhum, 3 from Burdwan, 3 from Nadia, 3 from Murshidabad, 2 from Bankura, 2 From Hooghly, 2 from Howrah, 1 from Koch Bihar).

2.2 Criterion Measure
- The running performance was assessed by the time taken in **second.**
- The running velocity was measured by **distance / using time** i.e. **meter / second**.
- the centrifugal force was measured by Newton i.e. $\dfrac{Mass \times Velocity^2}{Radius}$

2.3 Lay Out of Track and Lanes
Four different ratios of curve and straight were selected from each and every track of 400 m, 500 m, and 600 m.

Four Different Ratios of Curve and Straight of Every Track
(1) 2.59: 2.41 **(2)** 2.89: 2.11 (According to standard track) **(3)** 3.1: 1.81 and **(4)** 3.49: 1.51.

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On the above ratio, the distance of straight is 84.39m for standard track (400 m track). On that basis the ratio of curve and straight distance in standard track is 2.89: 2.11 (36.60 m curve radius track without raised border). Consider this as a standard. 0.30 was deducted from the curve ratio and 0.30 was added to the straight ratio for first one, 0.30 was added to the curve and 0.30 was deducted from the straight for third ratio and 0.60 was added to the curve and 0.60 was deducted from the straight for fourth ratio. This particular deduction and addition of straight and curve ratio was made by consultation with the experts on this field. So according to the four (4) different ratio of curve and straight for every individual track of 400 m, 500 m, and 600 m total twelve (12) different curve distance radii (C.D.R) were discovered, four (4) from 400 m track, four (4) from 500 m track and four (4) from 600 m track. These different curve distance radii are as followed in table-1.

Table 1: Total Twelve (12) Different C.D.R. of 400m, 500m and 600m Tracks

Four Different C.D.R. of 400 m Track	Four Different C.D.R. of 500 m Track	Four Different C.D.R. of 600 m Track
32.76 m	41 m.	49.25 m.
36.60 m (According to Standard Track)	45.78 m.	54.97 m.
40.40 m	50.55 m.	60.70 m.
44.22 m.	55.32 m.	66.43 m.

But in 500 m track, 1st and 2nd C.D.R i.e. 41 m and 45.78 m is too close with the 3rd and 4th C.D.R of 500 m track i.e. 40.40 m

and 44.22 m. On the other hand similarly in 600 m track 1st and 2nd C.D.R i.e. 49.25 m and 54.97 m is something like same as 3rd and 4th C.D.R of 500m track i.e. 50.55 m and 55.32 m. That for reason the researcher had chosen four (4) C.D.R. from the above eight (8) C.D.R. These four C.D.R. are 40.40 m, 44.22 m, 50.55 m and 55.32 m. Finally the researcher was investigating on eight (8) lanes. Four (4) lanes from 400 m track, two (2) lanes from 500 m track and two (2) lanes from 600 m track following the above ratio of curve and straight. These eight (8) C.D.R are presented in table-2.

Table 2: Final Eight (8) Different C.D.R of 400 m, 500 m and 600 m Tracks

Four Different C.D.R. of 400 m Track	Two Different C.D.R. of 500 m Track	Two Different C.D.R. of 600 m Track
32.76 m	50.55 m.	60.70 m.
36.60 m (According to standard track)		
40.40 m	55.32 m.	66.43 m.
44.22 m.		

A same process was followed for every running lane. Running distances of 100 m were marked in each of these curves. The width of the lane was 1.22 m. A single midpoint was used for marking every curve lanes. The all eight (8) curves drew in a same direction and a single horizontally straight finishing line used for every running path. The layout of different eight (8) 100 m curve lanes was diagrammatically presented below.
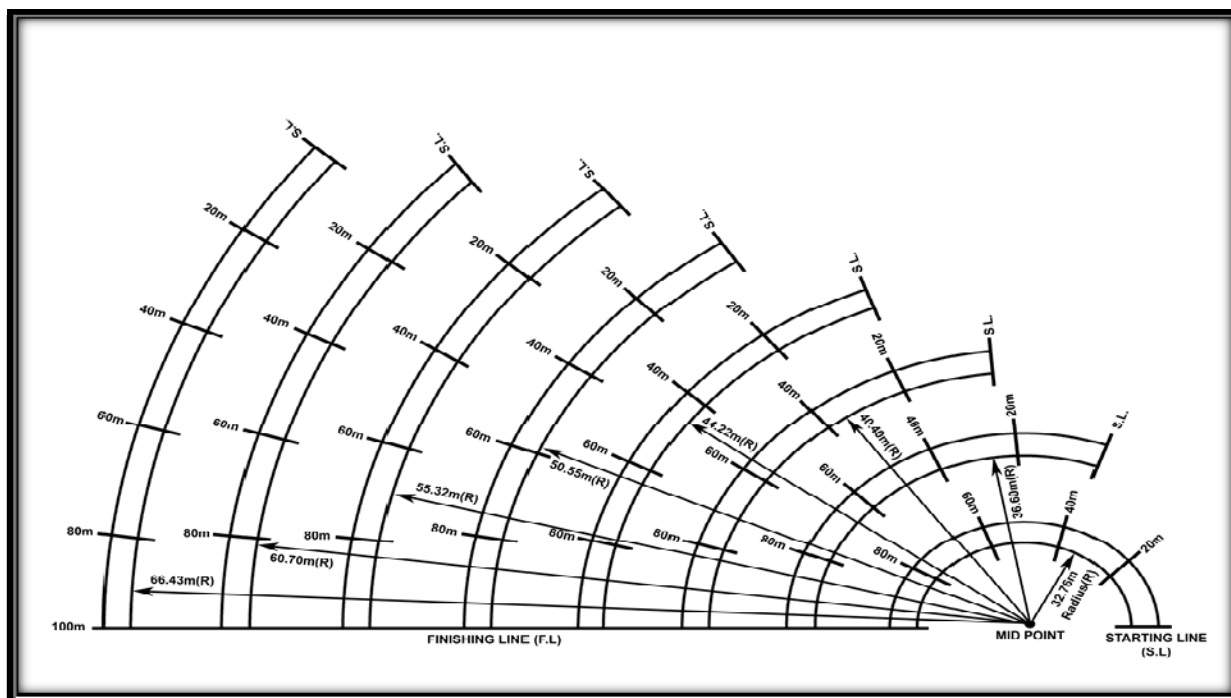

Fig 1: Layout of Different Eight (8) Curve Lanes of 100m Distance

2.4 Detail of Experimentation
The researcher was used total four (4) days (15th to 18th march, 2013) for experimentation or data collection. 15th to 18th March every day morning 6 am to 9 am (1st session) and afternoon 4 pm to 7 pm (2nd session) researcher had collected the data. In a single session all subjects performed one (1) 100 m curve sprint in a particular lane. At a time one (1) subject ran for 100m curve distance.

2.5 Collection of Data
The researcher was took help from four (4) Physical Education students they are worked as officials (one starter and three time keepers). Subject ran one at a time using block start. All time keepers were instructed to start their watches on the clap of the starter and they stopped their watches when the torso of the sprinter touched the imaginary line perpendicular to the finished post. The timing elapsed to run was found by subtracting the time clocked up to the end from the starting line. Total one hundred sixty (160) individual times (8 track ×

20 subjects) are collected from this field work as raw data and the researcher was measured subjects weight individually for calculate the Centrifugal force.

2.6 Statistical Procedure
1. Computed mean for calculated the average Running Time, average Running Velocity and average Centrifugal Force.

2. The collected data were put into ANOVA test to find out the significant of mean difference in five different zonal times, five different zonal velocities and different centrifugal force of eight different curve radius lanes.

3. Result and Discussion

Table 3: Mean Running Time of Different Eight Curve Lanes of 100m Distance

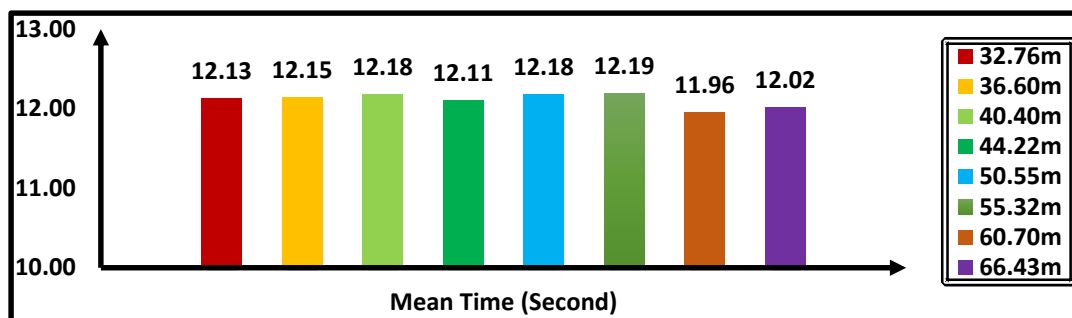| Curve Radius	32.76 m	36.60 m	40.40 m	44.22 m	50.55 m	55.32 m	60.70 m	66.43 m
Mean Time	12.13s	12.15s	12.18s	12.11s	12.18s	12.19s	11.96s	12.02s
S.D	0.44	0.51	0.57	0.51	0.52	0.57	0.49	0.51

Fig 2: Graphical Representation of Mean Running Time of Different Curve Lanes

According to mean running time of different eight curve lanes of 100 m distance the best performance achieved in 60.70 m C.D.R track (11.96s) and maximum running time elapsed in 55.32 m C.D.R track (12.19s), in the curve of standard track 12.15s running time elapsed for 100 m distance. The differences of running time of different curve tracks of 100 m distance are too small.

Table 4: Significance Mean Difference of Running Time of Eight Different Curve Lanes

	SS	df	MS	'F' Value ('p' Value)
Between:	0.972	7	0.139	0.523 (0.816)
Within:	40.335	152	0.265	
Total:	41.307	159		

Table value = 2.07 (at 0.05 level)

There are no significant differences among running time of eight different curve lanes

Table 5: Mean Running Velocity of Different Eight Curve Lanes of 100m Distance

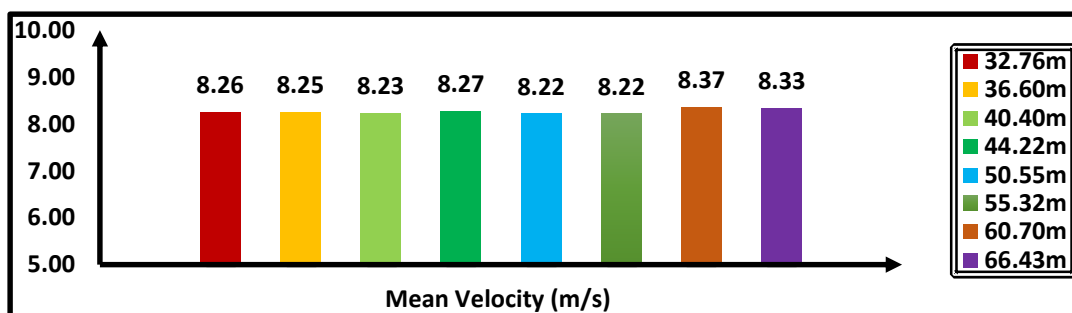| Curve Radius	32.76 m	36.60 m	40.40 m	44.22 m	50.55 m	55.32 m	60.70 m	66.43 m
Mean Velocity	8.26 m/s	8.25 m/s	8.23 m/s	8.27 m/s	8.22 m/s	8.22 m/s	8.37 m/s	8.33 m/s
S.D	0.30	0.35	0.38	0.35	0.35	0.38	0.34	0.35

Fig 3: Graphical Representation of Mean Running Velocity of Different Curve Lanes

Table-5 shows the maximum running velocity achieved by the sprinters in 60.70 m C.D.R track and minimum velocity achieved in 50.55 m and 55.32 m C.D.R tracks, in standard track the velocity was 8.25 m/s

Table 6: Significance of Mean Difference of Running Velocity of Eight Different Curve Lanes

	SS	df	MS	'F' Value ('p' Value)
Between:	0.428	7	0.061	0.503 (0.831)
Within:	18.472	152	0.122	
Total:	18.9	159		

Table value = 2.07 (at 0.05 level)

There are no significant differences among running velocity of eight different curve lanes.

Table 7: Mean Running Centrifugal Force of Different Eight Curve Lanes of 100 m Distance

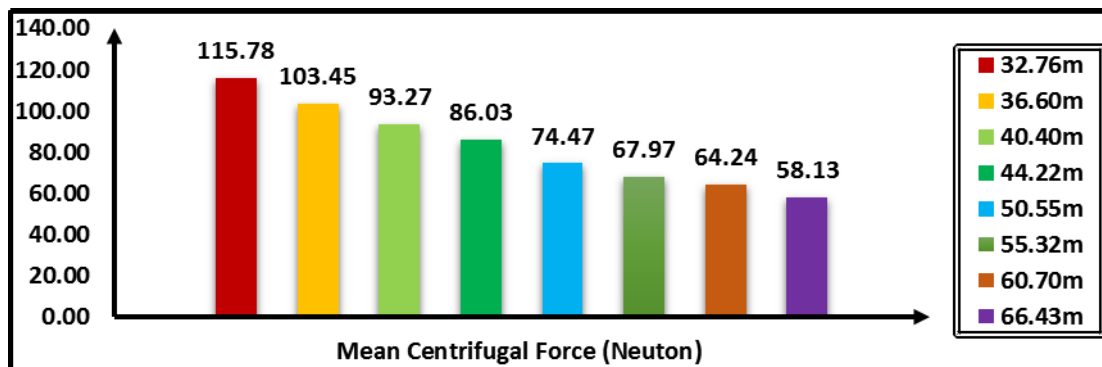| Curve Radius	32.76 m	36.60 m	40.40 m	44.22 m	50.55 m	55.32 m	60.70 m	66.43 m
Mean C.F	115.78N	103.45N	93.27N	86.03N	74.47N	67.97N	64.24N	58.13N
S.D	11.63	11.21	10.41	9.20	8.40	7.81	6.41	6.16

Fig 4: Graphical Representation of Mean Running C.F. of Different Curve Lanes

According to mean running centrifugal force of eight different curve tracks the centrifugal force gradually decreased with the increase of curve distance radius.

Table 8: Significance of Mean Difference of Running Centrifugal Force of Eight Different Curve Lanes

	SS	df	MS	'F' Value ('p' Value)
Between:	52550.93	7	7507.28	90.38 (0)*
Within:	12625.86	152	83.07	
Total:	65176.79	159		

Table value = 2.07 (at 0.05 level)

There are highly significant differences among running centrifugal force of eight different curve lanes.

4. Conclusion
I. A sprinter can achieve highest performance in 100 m curve running when radius of the curve is 60.70 m and lowest performance in 55.32 m curve radius.
II. In respect of all eight curve tracks the running times and running velocities are very close but these small differences are very crucial for sprint event.
III. Running time and running velocities do not significantly differ in different curve radii tracks of 400 m, 500 m and 600 m length.
IV. Centrifugal force encountered by the athletes while running in the curve progressively increases with decrease in the length of the radius.
V. Change in the magnitude of centrifugal force encountered by the athletes while running in different curves do not change the running performance significantly.

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