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Performance analysis of female sprinters in different curve radius

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Abstract
Running on a curve path is an integral part of track events. In humans, compared with straight running, maximum running speed is slower on unbanked curves and related to curve radius [4, 6]. The curved path of 400 m track is longer than the straight path. According to IAAF (2008) the Straight path length is 84.39 m and the Curved path length is 115.61 m. Therefore the curved running techniques are important for the running performance. The main purpose of the study was to determine the maximal sprinting performance of sprinters on curves of different track radii (18.79 m, 28.34 m and 36.50 m track radius). To conduct the present study a total of ten (10) female sprinters were selected from College and B.P.Ed, M.P.Ed courses and their age ranged between 20-26 years. For collecting data nine separate sprint performance tests were conducted in different curve radius. And these performance score of all the tests was considered as the data for the presented study. After collected the data the Mean, SD and ANOVA were computed for analysis of results. And there was no significant difference found in running performance among all lanes and tracks in different curve radius, except the 1st and 4th lane. On the basis of analysis of the present study results and previous studies it may be concluded that the sprinting performance was vary from lane to lane or track to track. And sprinting performance was improve by increases the curve radius but in a separate limit.

Keywords: Track radii/curve radius, curve path, curve running, maximum running speed, maximal sprinting performance

1. Introduction
Man becoming more and more speedy in movement, in social adjustments, in psychological makeup and almost in every aspect of life. There are so many sports where speed plays an important role for better performance, such as track event sprinters, sprint swimmers, cyclists and speed skaters etc. Maximum speed that can be achieved by a person in a sprint race definitely is an important factor for his performance.

Running on a curve path is an integral part of track events. In humans, compared with straight running, maximum running speed is slower on unbanked curves and related to curve radius [4, 6]. For example, human maximum speed on a 6 m radius unbanked curve is ~26% slower than straight running [1]. In the 200 m outdoor event, Greene (1985) calculated a 0.123 s advantage for an elite-level sprinter running in lane 8 compared with lane 1 [6]. The effects of curve radius are more profound on indoor tracks, where the recommended minimum radius is 17.2 m (IAAF Track and Field Facilities Manual 2008). The IAAF abandoned indoor 200 m races in 2005 because the athletes assigned to outer lanes showed a clear advantage over those assigned to inner lanes [17].

The radius of curvature or 'r' is the radius of a circle. The curved path of 400 m track is longer than the straight path. According to IAAF (2008) the Straight path length is 84.39 m and the Curved path length is 115.61 m. Therefore the curved running techniques are important for the running performance.

In order to be continuously changing direction around the curve, a runner must generate centripetal forces with the ground. This requires athletes to put some of their efforts into generating ground reaction forces that accelerate them towards the axis of rotation of the curve. As the medio-lateral (ML) ground reaction forces increase to generate centripetal forces, the vertical forces are decreased which results in a loss of running speed [1]. Linear sprint speed increases with increased vertical ground reaction forces and decreased ground contact time [18].

The primary purpose of this study was to determine the maximal sprinting performance of female sprinters on curves of different track radii. At maximal running speed of sprinters were expected to be on curves of 18.79 m, 28.34 m and 36.50 m track radius. And to compare the performance levels among 200 m, 300 m & 400 m track in three lanes and to compare the performance levels among 1st, 4th & 8th lane of three tracks.

2. Materials and Methods

Ten (10) female University level sprinters between 20-26 years of age were selected as the subject of the present study.

For the present study age, height and weight of the subjects were taken as personal data and to run in different curve radius were measure as criterion measured.

For collecting data nine separate sprint performance tests were conducted. The subjects were asked to run in different curve radius such as – 18.79 m for 200 m track, 28.34 m for 300 m track and 36.50 m for 400 m track in 1st lane, 4th lane and 8th lane only. At first day the subjects were run on 200 m track in 1st lane, 4th lane and 8th lane separately and the radius of the lanes in crossed accordingly. The running distance in each lane was 90 m among which 30 m was straight and 60 m was curve. All run was started from straight and finished in curve. Each subject was performed in 3 lanes in a day with proper recovery among all the running. Time was recorded in second of each running. Likewise all the subjects were run on 300 m & 400 m track in 1st lane, 4th lane and 8th lane separately. And the running distance was also 90 m of which 30 m straight and 60 m curve.

Table 1: Different Curve Radius (CR) of Three Tracks

Lane No.	CR (m) in 200 m Track	CR (m) in 300 m Track	CR (m) in 400 m Track
1st	18.79	28.34	36.5
4th	22.45	32	40.16
8th	27.33	36.88	45.04

All the tests were taken within three weeks and it was taken only one day in a week for better recovery. The tests were conducted in the morning session only.

3. Results and Discussions

The maximal running speed on 1st, 4th and 8th lane in different curve radius of 200m, 300m and 400m track were measured using standardized test. Numerical score for this parameter was obtained as the measure of performance of the individual. These performance score of all the tests was considered as the data for the present study.

3.1 Performance Analysis of Female Sprinters among 200m, 300m and 400m Track Curve Running in 1st, 4th & 8th Lane

The Mean, SD and F-value of female sprinters in 1st, 4th and 8th lane of 200m, 300m and 400m track curve running were presented in table no-2 and it was also presented graphically in figure no-1.

Table 2: Mean, SD and F-Value of Female Sprinters in 1st, 4th and 8th Lane of 200m, 300m and 400m Track Curve Running

Subjects	Lane No.	Track (m)	Mean (sec)	SD (±)	F-Value	F-crit	Mean Difference			Remarks
							Variables	t- Stat	t- Critical two-tail	
Female Sprinter	1st	200	13.56	0.40	3.85*	3.35	200 m & 300 m	1.44	2.10	Not Sig.
		300	13.31	0.38			200 m & 400 m	2.80*		Sig.
		400	13.10	0.34			300 m & 400 m	1.32		Not Sig.
	4th	200	13.44	0.42	4.29*	3.35	200 m & 300 m	1.41	2.10	Not Sig.
		300	13.20	0.35			200 m & 400 m	2.82*		Sig.
		400	12.95	0.36			300 m & 400 m	1.59		Not Sig.
	8th	200	13.38	0.39	2.45	3.35	-	-	-	Not Sig.
		300	13.03	0.33			-	-		Not Sig.
		400	13.15	0.35			-	-		Not Sig.

$F_{0.05}$ (2, 27) = 3.35, $t_{0.05}$ (2, 27) = 2.10, * Significant at 0.05 level of confidence

It appears from table no-2 that the Mean times of female sprinters in 1st lane of 200m, 300m and 400m track curve running were 13.56 sec, 13.31 sec and 13.10 sec with SD of ±0.40, ±0.38 and ±0.34 respectively. The Mean times of female sprinters in 4th lane of 200m, 300m and 400m track curve running were 13.44 sec, 13.20 sec and 12.95 sec with SD of ±0.42, ±0.35 and ±0.36 respectively. Also the Mean times of female sprinters in 8th lane of 200m, 300m and 400m track curve running were 13.38 sec, 13.03 sec and 13.15 sec with SD of ±0.39, ±0.33 and ±0.35 respectively.

From the above table it was observed that the Mean times of female sprinters in 1st, 4th and 8th lane of 200m, 300m and 400m track curve running were not similar and to observe the differences among three different track curve running in three lanes, the ANOVA was computed and the F-value of female sprinters among 200m, 300m and 400m track curve running in 1st, 4th and 8th lane were 3.85, 4.29 & 2.45 respectively, where the 1st and 4th lane curve running were statistically significant at 0.05 level of confidence. But the 8th lane curve running was statistically not significant at 0.05 level of confidence.

To observe the differences among 200m, 300m and 400m track curve running in 1st and 4th lane, the mean difference ('t'-test) was calculated and the 't'-test value of 1st lane among 200m & 300m, 200m & 400m, 300m & 400m were 1.44, 2.80 & 1.32 respectively and the 't'-test value of 4th lane among 200m & 300m, 200m & 400m, 300m & 400m were 1.41, 2.82 & 1.59 respectively; where only the 1st and 4th lane of 200m & 400m track curve running were statistically significant at 0.05 level of confidence. But others track curve running were statistically not significant at 0.05 level of confidence.

To observe the differences of female sprinters among 200m, 300m and 400m track curve running in 1st, 4th and 8th lane, the Mean and SD value were also represents graphically in figure no-1.

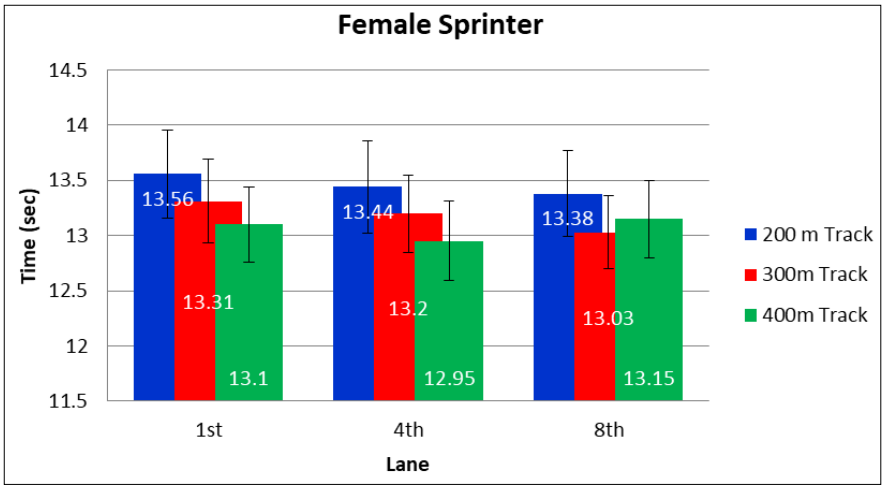

Fig 1: Graphical Representation of Mean and SD Value of Female Sprinters in 1st, 4th and 8th Lane of 200m, 300m and 400m Track Curve Running (Data are in Mean ±SD bars)

To analysis the above performances of female sprinters, it was observed that there were a significant differences found among 200m, 300m and 400m track curve running in 1st and 4th lane of female sprinters. But no significant difference was found among 200m, 300m and 400m track curve running in 8th lane of female sprinters.

From the previous study of Mike D. Quinn [12] it was observed that the time difference (in the outside and inside lane) between the fastest and slowest tracks is about 0.1 sec in the 200m race and 0.2 sec in the 400m race. The time differential between the outside and inside lanes for a double-curve track can be up to 0.08 sec greater than for a standard track with semi-circular bends. Young-Hui Chang and Rodger Kram [1] were founded in their study that sprinters generated significantly smaller peak resultant ground reaction forces during normal curve sprinting compared to straight sprinting. During curve sprinting, the inside leg consistently generated smaller peak forces compared to the outside leg that decreases the running speed.

On the basis of the above analysis of results it was observed that there were significant differences found in running performance among all tracks in different curve radius in two (1st & 4th) lanes, except only one (8th) lane. So the present and previous study results revealed that the sprinting performance of sprinters was improved with increases the track curve radius.

3.2 Performance Analysis of Female Sprinters among 1st, 4th and 8th Lane of 200m, 300m & 400m Track Curve Running

The Mean, SD and F-value of female sprinters of 200m, 300m & 400m track curve running in 1st, 4th and 8th lane were presented in table no-3 and it was also presented graphically in figure no-2.

Table 3: Mean, SD and F-Value of Female Sprinters of 200m, 300m & 400m Track Curve Running in 1st, 4th and 8th Lane

Subjects	Track (m)	Lane No.	Mean (sec)	SD (±)	F-Value	F- crit	Remarks
Female Sprinter	200	1st	13.56	0.40	0.50	3.35	Not Sig.
		4th	13.44	0.42			Not Sig.
		8th	13.38	0.39			Not Sig.
	300	1st	13.31	0.38	1.56	3.35	Not Sig.
		4th	13.20	0.35			Not Sig.
		8th	13.03	0.33			Not Sig.
	400	1st	13.10	0.34	0.91	3.35	Not Sig.
		4th	12.95	0.36			Not Sig.
		8th	13.15	0.35			Not Sig.

$F_{0.05}$ (2, 27) = 3.35

It appears from table no-3 the Mean times of female sprinters of 200m track curve running in 1st, 4th and 8th lane were 13.56 sec, 13.44 sec and 13.38 sec with SD of ±0.40, ±0.42 and ±0.39 respectively. The Mean times of female sprinters of 300m track curve running in 1st, 4th and 8th lane were 13.31 sec, 13.20 sec and 13.03 sec with SD of ±0.38, ±0.35 and ±0.33 respectively. Also the Mean times of female sprinters of 400m track curve running in 1st, 4th and 8th lane were 13.10 sec, 12.95 sec and 13.15 sec with SD of ±0.34, ±0.36 and ±0.35 respectively.

From the above table it was observed that the Mean times of female sprinters of 200m, 300m & 400m track curve running in 1st, 4th and 8th lane were not similar. To observe the differences among three lanes of three different track curve running, the ANOVA was computed and the F-value of female sprinters among 1st, 4th and 8th lane of 200m, 300m and 400m track curve running were 0.50, 1.56 & 0.91 respectively, where all track curve running among three lanes were statistically not significant at 0.05 level of confidence.

To observe the differences of female sprinters among 1st, 4th and 8th lane of 200m, 300m and 400m track curve running, the Mean and SD value were also represents graphically in figure no-2.

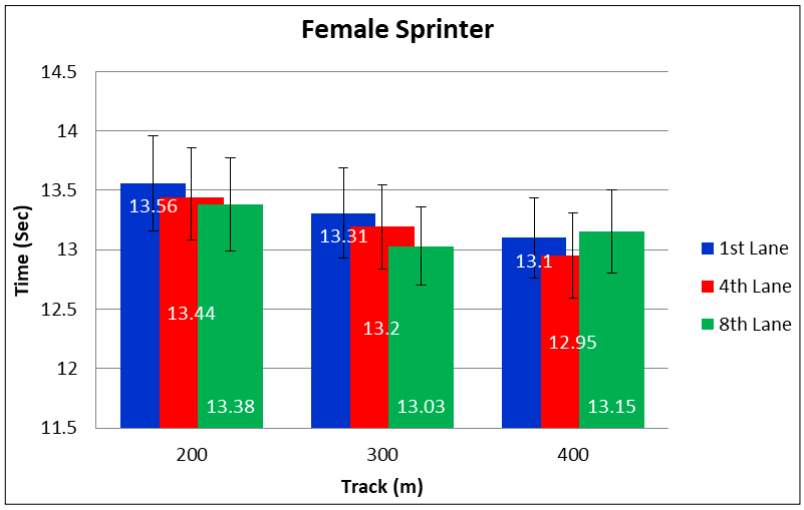

Fig 2: Graphical Representation of Mean and SD Value of Female Sprinters of 200m, 300m and 400m Track Curve Running in 1st, 4th and 8th Lane (Data are in Mean ±SD bars)

To analysis the above performances of female sprinters, the investigator had seen that there were no significant differences found among 1st, 4th and 8th lane of 200m, 300m and 400m track curve running.

From the previous study of Jesse Tipasa Tukuafu [10] it was found that sprinting speed was significantly slower when running on a curve. From his discussions it was observed that if a 200m race were performed on both track curves, the track with 21m curve would be 0.12s faster than the track with the 15m curve. Sarah M. Churchill1 and others [4] was investigated in his study that more inward impulse during left (39.9 ± 6.5 Ns) than right foot contact (24.7 ± 5.8 Ns) resulted in 1.6° more turning during the left step on the bend. There was a 2.3% decrease in velocity from straight to bend for both steps. Overall force production reduced on the left step on the bend resulting in lower velocity, contrary to the assumptions of Usherwood and Wilson's [17] mathematical model. The decrease in velocity was due to decreased step length and frequency similar to Churchill *et al*. [4]. However, the contradicting studies of small radii of Chang & Kram [1] and Smith *et al*. [14] explained that the left step contributed more than the right step to the generation of inward impulses and turning.

On the basis of analysis of the above results it was observed that there were no significant differences found in running performance among all lanes in different track curve radius. But all the previous theories showed that the sprinting speed was significantly slower at smaller curve than the larger curve. Like wise the present study mean times of the female sprinters were also showed that the sprinting speed was improve with increases the track curve radius; but this is not statistically significant. The performance of the sprinters depends on time which was recorded in micro second. For this limiting factor of the present study the results might not be statistically significant. But on the basis of the present study results and the previous theories revealed that the sprinting performance of sprinters improves with increases the track curve radius.

4. Conclusion

On the basis of analysis of result and limitation of the study the following conclusions were drawn.

4.1 Conclusion Lane wise

(i) It was observed that a significant difference found in sprinting performance of female sprinters among 200m, 300m and 400m track curve running of 1st & 4th lane. But there was no significant difference observed among three tracks curve running of 8th lane.

(ii) In 1st and 4th lane of 400m track was better than 1st and 4th lane of 200m and 300m track.

(iii) And the 1st and 4th lane of 300m track was also better than 1st and 4th lane of 200m track.

(iv) In 8th lane of 400m track was better than 8th lane of 200m but not better than 300m track.

(v) In case of 8th lane of 300m track was better than 8th lane of 200m and 400m track.

4.2 Conclusion Track wise

(i) It was clear that no significant difference found in sprinting performance among 1st, 4th and 8th lane of 200m, 300m & 400m track curve running of female sprinters.

(ii) In 200m and 300m track 8th lane was better than 1st and 4th lane.

(iii) And the 4th lane of 200m and 300m track was also better than 1st lane.

(iv) In 400m track 4th lane was better than 1st and 8th lane.

(v) In case of 1st lane of 400m track was better than 8th lane but not better than 4th lane.

So, all the above conclusions it was cleared that the sprinting performance was better at 400m track and 4th lane of 400m track than other two tracks and lanes. The sprinting performance in 8th lane of 300m track was found nearly to the 4th lane of 400m track. So the present study reveals that the sprinting performance was spread from 4th lane of 400m track accordingly. So the present study concluded that the sprinting performance was vary from lane to lane or track to track. And the performance was improve by increases the curve radius but in a separate limit. This has also been supported by the scientific studies and researches.

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