# FOOT PLANTING TECHNIQUES WHEN SPRINTING AT CURVES

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The paper presents the research on foot and shin positioning at the moment of contacting the ground when sprinting at a curve. The results attained allow for expanding the knowledge of foot performance when running. The study revealed that experienced sprinters, when sprinting at curves at maximum speed, have their right and left foot toes turned outwards, the right foot being turned more due to the need to resist centrifugal force.

**KEYWORDS:** sprint, sprinting at curves, foot.

**INTRODUCTION:** The technique of curve sprinting has repeatedly appeared in the focus of scientific research due to its exceptional importance for achieving outstanding performance (e.g. Greene, 1985; Jindrich, Besier & Lloyd, 2006). Yet, the peculiarities of foot plant and its further kinematics have not received the researchers' attention very often; in most cases, this technical element was studied from the lateral position (Umarov, Primakov & Tyupa, 1992; Umarov, 2000). Meanwhile, the characteristics of post-impact body motion is determined not only by the impulses they had before contact, but also by where the forces are applied. The human foot has a complex structure and possesses a number of physical characteristics not taken into consideration in most studies. A widespread assumption when analyzing curve sprinting is the uniaxiality of ankle-joint. This considerably simplifies the analysis of athlete's movements and the results achieved, as any change in foot plant is likely to cause considerable changes in the kinematics of foot during the support phase (and not only in sagittal plane), thus determining the preferred technique and sprinting efficiency on the whole.

It is impossible to evaluate the efficiency foot positioning in straight and curve sprinting while relying only on the results of the experiment in which the subject(s) would plant their feet on the race track in a various manner. In this case, not only would the mechanical characteristics of the athlete's locomotor system come into play, but also the neuropsychic characteristics. Foot plant is, by all means, a skill, and ruining the skill with the aim of forming a new one in the shortest possible time can certainly affect the efficiency of movement.

The aim of this research was to identify the peculiarities of experienced athletes' foot plant when running turns at maximum speed.

**METHOD:** We used 2-D video analysis of sprinters' foot and shin positions in frontal plane at the moment of their touching the track. The video was taken from the front by JVC GR-D379E camcorder with 50 Hz frame rate. The camcorder was positioned at a tangent to the curve at a predicted point of foot plant.

The following foot and shin characteristics at plant instant were determined: foot angle ($\alpha$); sole angle ($\beta$); shin angle ($\gamma$) (Figure 1). Point 1 marks the middle of the horizontal line segment between the intersection of vertical tangent and the inside of the shin and the outermost point of the shin. Point 2 marks the middle of the horizontal line going from malleolus medialis into the outermost points of the shin. Point 3 is the distal point of the spike shoe toe. Point 4 and Point 5 mark the middles of holes for the rear spikes of the shoe. Segments 6-2, 2-7, and 4-8 are vertical; Segment 5-8 is a horizontal one.

The population of the study was comprised of six male sprinters (age: 19.3±1.51 years; height: 1.83±0.05 m; body mass: 76.2±5.2 kg; 100-m race performance: 11.1±0.3 s; 200-m race performance: 22.9±0.4 s).

Videotaping was done on the fourth lane, at the following points of the curve: 1) 30 meters from the beginning of the curve with starting line at the beginning of the curve ("entry point"); 2) 66 meters from the beginning of the curve with starting line marked 25 meters ahead of 200-m race starting line ("middle point"); 3) 96 meters from the beginning of the curve with starting line marked 55 meters from of 200-m race starting line ("exit point"); and also at the 30-th meter of a 40-meter straight path.

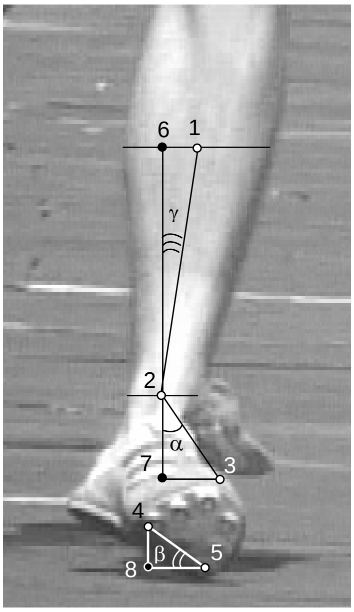


**Figure 1. Calculation of foot angle (α), sole angle (β), and shin angle (γ)**

Data collection lasted for two days. Three out of six subjects had to run 40-meter distance twice (for videotape of the right and left foot), following the procedure outlined above: at the entry and middle points on the first day, and at the exit point and on straight path on the second day. The other three subjects performed the order in reverse: on straight path and at the exit point on the first day, and at the middle and entry points on the second day). All began running at high start.
The statistical significance of sample data variation was estimated with single-factor analysis of variance (ANOVA).

**RESULTS:** The main results are presented in Table 1.

**Table 1. Mean±S.D. angles of foot, shin, and sole at the plant moment when running various parts of the curve and during straight path running**

| Angle | Right | Left | p value |
|---|---|---|---|
| | | Entry | |
| Foot | 33.7 ± 2.8 | 20.1 ± 3.6 | <0.001 |
| Shin | 3.3 ± 1.4 | 20.9 ± 2.8 | <0.001 |
| Sole | 8.6 ± 5.4 | 28.0 ± 5.8 | <0.001 |
| | | Middle | |
| Foot | 29.3 ± 3.7 | 19.6 ± 5.0 | <0.001 |
| Shin | 2.0 ± 1.4 | 22.6 ± 2.0 | <0.001 |
| Sole | 17.3 ± 3.9 | 24.1 ± 5.6 | <0.001 |
| | | Exit | |
| Foot | 31.6 ± 4.2 | 17.5 ± 4.2 | <0.001 |
| Shin | 1.4 ± 0.8 | 24.1 ± 2.0 | <0.001 |
| Sole | 18.4 ± 2.8 | 30.4 ± 5.2 | <0.001 |
| | | Straight path | |
| Foot | 29.5 ± 4.2 | 28.8 ± 1.9 | >0.05 |
| Shin | 8.7 ± 2.3 | 8.5 ± 1.9 | >0.05 |
| Sole | 35.7 ±10.3 | 31.4 ± 7.1 | >0.05 |

Angular values for right and left foot on all segments of the curve differed considerably, while remained similar for straight sprinting. It was found out that left (inside) foot in all three videotaping points was planted with the toe turned towards the inside of the lane, although the foot angle at the moment of plant when running on the curve was smaller than during straight sprinting ($p<0.001$). Note that beginning from sprinter's entering the curve, the foot angle gradually diminished (the significant difference between entry and exit point values was $p<0.001$).
The right (outside) foot was turned to the right. The angle of the right foot exceeded that of the left; in the middle of the curve, this value was practically the same as for straight sprinting ($p>0.05$). At the entry and exit points the right foot angles were slightly bigger than those observed during straight path sprinting ($p<0.01$).
Most of the subjects demonstrated that at the moment of touchdown, especially at the entry and middle points of the curve, their right (outside) shin was positioned almost vertically; at the same time, the left shin was visibly tilted with its proximal end aimed towards the center of the curve. When running on the straight, the angle of the tilt was the same for both right and left shins.
The table shows that the angle of the right foot sole is clearly smaller than that of the left one on every segment of the curve. It also proves to be clearly smaller on every segment of the curve compared to straight running. The right foot plant is the flattest when entering the curve (the difference between the sole angles at entry and exit points is statistically significant); yet, in the middle and at the curve exit point these angles are practically the same ($p>0.05$). The differences between the angles of the left sole when running on the curve and straight running reached statistically significant values once only, i.e. in the middle of the curve.

**DISCUSSION**: Biomechanical evaluation of curve sprinting determined clear differences in foot and shin positions at the moment of contacting the ground. When doing the curve, the left foot is planted with the toe pointed inside the curve at a sole angle slightly smaller than when running on the straight path; the toe of the right foot is more turned outwards, and the foot plant is flatter. It is speculated that such foot positioning allows for more efficient resistance to centrifugal force due to the work of shin muscles.
At the moment of foot plant, the angles of the left and right shins at any point of the curve are considerably different: the left shin's proximal end is much tilted inwards the curve; the right shin is only slightly tilted inwards, and in some cases retains its vertical position. Thus, it is wrong to think that during sprinting on the curve "the whole body" tilts towards its center (Umarov, Primakov & Tiupa, 1992; Umarov, 2000); at least, the tilt angles of different body parts might be very different. No doubt, these different positions of left and right shins result from the resistance to centrifugal force, though the mechanism of this counteraction is not that obvious compared to when the right (outside) foot is planted outwards.

**CONCLUSION**: The results of the study reveal that the need to counteract the centrifugal force results in sprinter's planting his/her right foot outwards more than the left one, and in a much flatter manner. This helps the athlete to keep balance more effectively.
The further developments in the study of curve sprinting techniques might require the following: 1) 3-D video analysis of movements produced by foot, shin and the whole locomotor system of sprinters when running both on the curve and on a straight path; 2) study of elite sprinters' foot and shin kinematics in support phase; 3) biomechanical modeling of curve sprinting technique employing various foot planting techniques.

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