COMPARISON OF INSIDE CONTACT PHASE AND OUTSIDE CONTACT PHASE IN CURVED SPRINTING.

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INTRODUCTION: One of differences of running between in straight path and in bent path is the body lean inward. When athletes run in the bent path, athletes are influenced by centrifugal force. Athletes produce the medio-lateral component of ground reaction force (GRF) with inclining the body inward, to balance the centrifugal force. The centripetal force can be estimated by

$$F=mv^2/r \qquad (1)$$

where F is the centripetal force, m is the mass of the body, v is the running velocity, and r is the radius of track. We can see from this equation, the influence of the running velocity on centripetal force is strong. So we can't ignore the centripetal force in sprint race (i.e. 200m dash). The body lean angle increase, as the running velocity increase. Athletes must change the running direction along the bent path. One step of running consist of the flight phase and the contact phase. It is impossible to change running direction during the flight phase. Therefore it is expected to change running direction during the contact phase. It was said the functions of inside and outside legs were asymmetrical (Stoner and Ben-Sira, 1979, Hamill et al, 1987). But there are no study to compare the inside foot contact phase with the outside foot contact phase with in relation to the centripetal force and the body lean angle. The purpose of this study is to compare the inside (left) foot contact phase with the outside (right) foot contact phase with in relation to the centripetal force and the body lean angle. Then we would obtain new knowlege about curved sprinting.

METHOD: Six male sprinters (age: 20.7±1.5years, height: 171.9±5.3cm, body mass: 63.7±4.3kg) participated in this study. Each subject ran about 60m with maximal effort on the bent path 3 times (4th lane, radius: 41.85m) of an official outdoor track with his own spike shoes and with 41 reflective makers. The running motion was recorded using 3D motion capture system (Vicon) with 10 infrared cameras (125Hz). The experiment was conducted after dark because of the data collection with the infrared motion capture system. The obtained 3D coordinate data were smoothed using butterworth type digital filter, with the optimal cutoff frequencies (Winter, 1990). The variables, 1) average horizontal velocity of center of mass runner's body, 2) contact time, 3) average centripetal force, 4) body lean angle at foot contact and toe off, were compared between two contact phases of inside and outside using a paired t-test. The centripetal force was calculated using formula (1). The body lean angle was defined as the angle between the vertical line and the line from the center of mass of foot to that of body in frontal plane. Hip adduction-abduction angles were also obtained and compared between two phases.

RESULTS: There were no significant differences in the average horizontal velocity, and the average centripetal force between two contact phases of inside and outside feet. The outside foot contact time was shorter than the inside one (right: 0.112s, left: 0.125s, $p<.01$). The body lean angles had significantly different at toe off (right: 13.6deg, left: 2.05deg, $p<.01$). During inside foot contact phase, the body lean angle was decreasing, while during outside, the angle was increasing (Figure 1).

DISCUSSION: The previous study (Stoner and Ben-Sira, 1979) showed the average velocity of inside foot contact phase was slower than the outside. But our results didn't show the difference between two phases. It because there was no remarkable difference in the velocity, the centripetal force had no difference. The inside foot contact time was longer than the outside foot contact time, and it agree with result of previous study (Stoner and Ben-Sira, 1979). It had been predicted that to accomplish curved running, athletes may run along bent path for adjusting running direction by adducting inside leg and abducting outside leg. But the inside hip abducted (Figure 1). Our study's radius was 41.85m, it was sufficient radius not to adjust running direction by adduction. As expected, the body lean angle was increasing with hip abduction during outside foot contact phase (Figure 1). It may be accomplished curved running by outside leg abduction. Hamill, et al (1987) described "modifications in body position, and thus the lower extremity, are, strictly speaking, a function of the runner's velocity." We think the centripetal force is also functions of the runner's velocity. But in this study, there were no difference in the centripetal force. It is required more advanced research including measurement of GRF to explain the curved running mechanism.

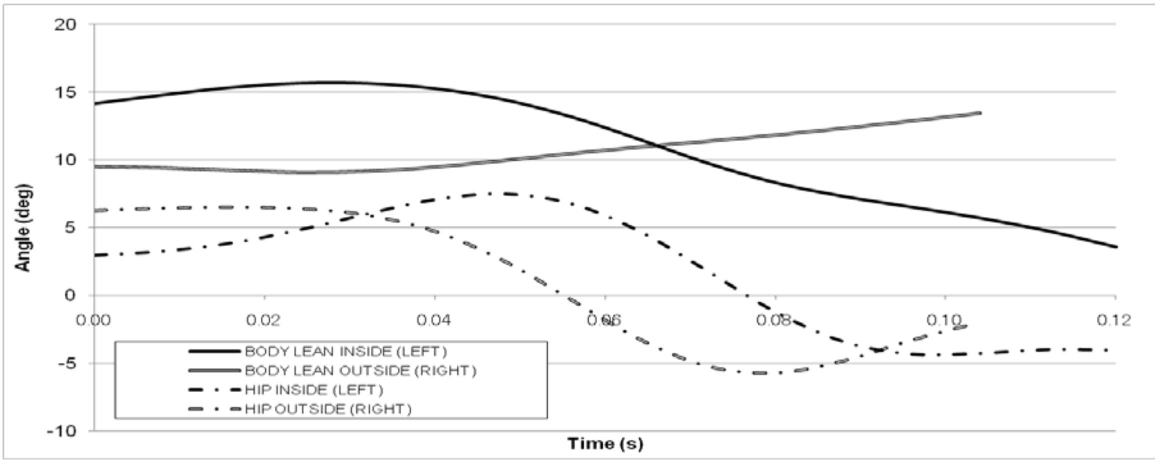

Figure 1. The typical example of the change of the body leaning angle and hip adduction-abduction angle during foot contact phases. In the body leaning angle a positive value indicates the body incline inward, and a negative value indicates the body incline outward. In the hip add-abd angle, a positive value shows adduction, a negative value shows abduction.

CONCLUSION: This study indicated the differences between the inside foot contact phase and the outside in curved sprinting. The body lean angle was decreasing during inside foot contact phase and increasing during outside foot contact phase. It seems that more advanced study is needed to explain the curved running.

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