Modes of Centripetal Ground Reaction Force Application in Curved Sprinting on an Athletic Track

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Summary

We aimed to determine the application mode for the centripetal ground reaction force (GRF) by analyzing the correlation between the maximum GRF and both lower joint torque and posture. The application mode during the left contact phase involved inward inclination of the pelvis and/or torso and inward turning caused by hip and ankle torques. Conversely, the application mode during the right contact phase involved inward inclination of the support leg with hip abduction. The application mode during both the left and right contact phases can be achieved by emphasizing motion and torque production during sprinting on a straight path.

Introduction

Sprinting in curved paths generates a centripetal ground reaction force (GRF) to facilitate directional changes. Although previous studies have examined asymmetry between the left and right legs, as well as differences with respect to straight sprinting [1, 2], there is no knowledge on how to apply a centripetal GRF. Two application modes exist for the centripetal GRF: (1) pushing outward with hip abduction/adduction and ankle inversion/eversion and (2) shifting the action direction of the extension torque with inward inclination and/or inward turning of the support leg. In this study, we aimed to determine the application mode by analyzing the correlation between the maximum centripetal GRF and both the lower joint torque and posture at the moment of maximum centripetal GRF.

Methods

Fourteen male sprinters performed submaximal sprinting on both curved and straight paths. The analyzed region was located approximately 35 m from the standing start. The three-dimensional marker trajectories on their bodies and GRFs were measured using a motion capture system and force platforms. The centripetal GRF direction was defined as the cross product of the vertical and forward directions defined as the direction of the mean velocity of the center of mass. The relationships between the maximum centripetal GRF and lower joint parameters were evaluated using the Pearson product−moment correlation coefficient. The significance level was set at 5%.

Results and Discussion

Although the inward inclination of the support leg is a common mode during both the left and right phases, its biomechanical factors exhibit certain asymmetry, which originates from the pelvic and/or torso tilt during the left contact phase and from hip abduction during the right contact phase. Additionally, the inward turning of the pelvis and shank, occurring alongside the hip internal rotation and ankle adduction torques, is involved during the left contact phase. We also examined the same motion pattern during sprinting on a straight path: the pelvis rotates in the opposite direction to the supporting leg from landing to the middle of the contact phase and then rotates in the same direction as the supporting leg toward takeoff. Hip abduction and internal rotation torques are exerted from landing to the middle of the contact phase, and the hip joint changes from the adducted position to the abducted position during the contact phase. Therefore, the application mode during both the left and right contact phases can be achieved by emphasizing motion and torque production during sprinting on a straight path.

Conclusions

The results suggest that the common application mode of the centripetal GRF is shifting the action direction of the extension torque through inward inclination. However, the biomechanical factors of inward inclination exhibit certain asymmetry, which originates from the pelvic and/or torso tilt during the left contact phase and from hip abduction during the right contact phase. Additionally, the inward turning of the pelvis and shank, which face forward, is also involved during the left contact phase.

References

[1] Churchill et al. (2015). *Sports Biomech.*, **14(1)**: 106-121.
[2] Ishimura and Sakurai (2016). *J. Appl. Biomech.*, **32(4)**: 394-400

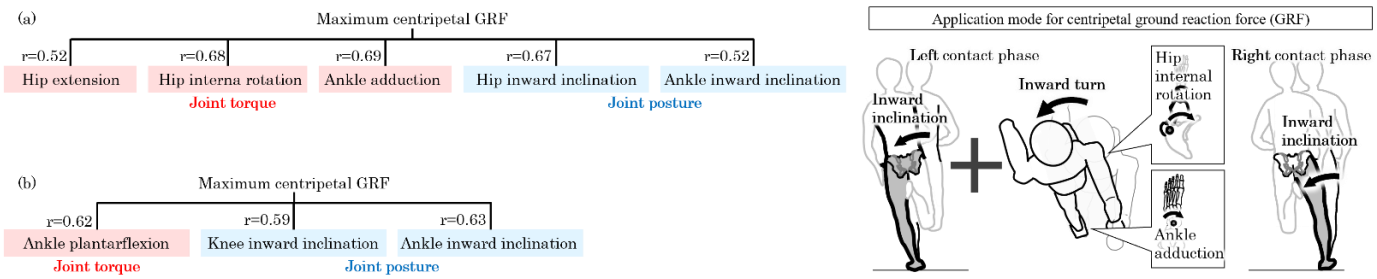

Figure 1: Map of significant Pearson correlations between the maximum centripetal GRF and lower joint torque and posture during (a) the left and (b) right contact phases.