Gear Ratios in the Ankle-Foot System

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Gear ratios in locomotion can be defined as the ratio of lever arms between the ground reaction force (GRF) and the calf muscle to the ankle joint. A resultant change in torque can be developed by either lengthening the distance of the GRF arm, or by altering the direction of the GRF. Studies on sports equipment such as speed skating and bicycling have shown that altering the gear ratios can affect performance. The purpose of this study was to investigate the effects of gear ratios on ankle joint moment and power generation.

Seven male subjects participated in the study (US size 9). Each subject performed sprints out of blocks in three conditions: a control, and two modified shoe conditions with carbon plate insoles inserted, one size 9 and one of size 11 adjusted to fit a size 9 runner**.** Kinematic and kinetic data were collected from the first stride out of the blocks and used to calculate ankle angle, torque, velocity and power. In a separate session, isometric and isokinetic measurements of the ankle plantarflexor strength were made in order to establish the torque-angle and torque-velocity relationships for each individual.

Results showed that stiffening the sprint spike increased the gear ratio about the ankle. A larger torque was generated, mainly due to the shift in ankle range of motion toward a more dorsiflexed position. This can be supported by the torque-angle relationship determined from isometric strength measurements. Angular velocity decreased, offsetting the torque increase. As the result, no significant changes in power and energy produced were observed. Looking at individual results, two subjects showed a large increase in torque generation without decreasing angular velocity resulting in increased power, which is valued as increased sprinting performance, with a larger gearing ratio.

References

1. Sabrina S. M. Lee1 and Stephen J. Piazza, “Built for speed: musculoskeletal structure and sprinting ability”