INTRODUCTION

Cycling represents an integration of man and machine. Optimizing this integration through changes in rider position may enhance performance of the total human/machine system.

One variable that may be optimized is the position of the foot relative to the pedal spindle. Altering the anterior-posterior position of the foot does not change overall metabolic efficiency (van Sickle & Hull 2007, Murray & Kram 2003). However, changes in this relationship do change muscle activation patterns in the ankle plantarflexor muscles (van Sickle & Hull 2007). Van Sickle and Hull suggested that changes in one muscle group may elicit compensatory changes in another muscle group thereby keeping the metabolic efficiency the same.

The purpose of this pilot study was to investigate the anterior-posterior foot position in more detail to help determine where these compromises in muscle activation occur and if an optimal position may exist. This will be done by measuring activation of eight major muscles of the lower limb and over a wider range of foot positions.

METHODS

Subject and Protocol
Two male experienced cyclists volunteered for this pilot study. The subjects rode a stationary bicycle with adjustable frame geometry. The subject pedaled using a look brand pedal/rider interface adapted to dual piezoelectric element force pedals (Broker & Gregor, 1990). Saddle location and handle bar position relative to the crank spindle were set according to subject’s personal bicycle.

Each subject pedaled at a constant resistance of 200 watts at a constant cadence of 90 rev/min. Each maintained this resistance and cadence via feedback from a cyclecomputer mounted within his field of view. Each subject was allowed a 5 minute warm up period at a self selected wattage/cadence and then pedaled for 3 1/2 minutes at 200 watts and 90 rev/min before data collection commenced. Data collection lasted 30 seconds for each cleat position.

Cleat position
For the cleat position trails the subject wore a modified pair of cycling shoes. These shoes had 6mm aluminum plate attached to the sole of the shoe with a cleat bolt pattern drilled in the four positions tested. The subject pedaled at four different randomly selected cleat positions that included directly underneath the subject’s calcaneous, the medial longitudinal arch of the foot, the first metatarsal head, and underneath the proximal joint of the 2nd metatarsal.

EMG recording and analysis
Surface EMG recordings were taken on the right leg over eight muscles using bipolar surface electrodes (2 cm apart). These muscles included the tibialis anterior, soleus, gastrocnemius, semimembranosus, biceps
femoris, vastus medialis, vastus lateralis, rectus femoris, and gluteus maximus. EMG was recorded at 1 kHz.

The signal was bandpass filtered from 30 – 450 Hz, rectified, condensed to 100 data points and averaged across five continuous cycles. EMG was normalized to the maximum amplitude recorded during the experiment and expressed as a percent. Average of normalized EMG for each muscle was taken. Percent differences from the minimum averaged normalized EMG was used for comparison between conditions.

**Kinetic Analysis**
Normal and tangential components of the pedal reaction force were measured using dual piezoelectric instrumented force pedals (Broker & Gregor, 1990). Average wattage across five pedal strokes was calculated and compared across each condition. Power output varied slightly between trails and EMG data were corrected using linear interpolation based on power output.

**RESULTS AND DISCUSSION**
Total average muscle activation showed a trend to minimize between the arch and standard cleat positions (Fig. 1). Trends were the same in both subjects. However, differences between positions are not great and within the variability of the measurement. As the cleat position moved toward the toe, ankle plantarflexor activity increased while ankle dorsiflexor decreased. Knee extensor activity was minimized at the toe in one subject with no change in the second subject. Knee flexor activity was minimized at the arch position. No changes were noted in the gluteus maximus.

**SUMMARY/CONCLUSIONS**
These data support the findings of van Sickle and Hull (2007) but extend their work over a larger range of foot positions and EMG recoding from more muscles. These data do show compensatory changes within muscle groups but are limited due to the number of subjects. Trends are very interesting, however, and may lead to stronger conclusions if a larger study was undertaken.

**REFERENCES**

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