JOINT-SPECIFIC POWER PRODUCTION DURING SUBMAXIMAL AND MAXIMAL CYCLING

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INTRODUCTION: Cycle ergometry is commonly used to quantify muscular work and power, and to elicit perturbations to metabolic homeostasis for a broad range of physiological investigations. Separate authors have reported that knee extension dominates power production during submaximal cycling (SUB_{cyc}; Ericson, 1988) and hip extension is the dominate action during maximal cycling (MAX_{cyc}, Martin & Brown, 2009). Changes in joint-specific powers across broad ranges of net cycling powers within one group of cyclists have not been reported. Our purpose was to determine the extent to which ankle, knee, and hip joint actions produced power across a range of net cycling powers. Based on previous reports we hypothesized that relative contributions of knee extension power would decrease and relative knee flexion and hip extension powers would increase as net cycling power increased.

METHOD: Eleven cyclists performed seated SUB_{cyc} trials (250, 400, 550, 700, and 850W) at 90rpm and MAX_{cyc} trials at 90 and 120rpm. Joint-specific powers were calculated using inverse dynamics and averaged over complete pedal revolutions and over extension and flexion phases. Portions of the cycle spent in extension (duty cycle) were determined for the whole-leg and ankle, knee, and hip actions. Relative differences in joint-specific powers across the different net cycling powers were assessed with linear regression analyses and absolute differences were assessed with paired t-tests.

RESULTS: Mean powers delivered to the right pedal were approximately one half (116±4, 200±4, 271±5, 351±5, 415±5W) of the prescribed net cycling target powers (250, 400, 550, 700, 850W, respectively) for SUB_{cyc} trials; suggesting that total power from both legs was close to the target power. Absolute ankle and hip joint-specific powers and hip-transfer power increased primarily during the extension phase whereas knee joint power increased during both the extension and flexion phases as net cycling power increased (Figure 1). Relative knee extension power decreased (r^2=0.88, p=0.01) and knee flexion power increased (r^2=0.98, p<0.001) as net cycling power increased (Figure 2). Whole-leg, knee, and hip joint duty cycle values during 250W SUB_{cyc} differed from those for MAX_{cyc} (p<0.01). Ankle joint duty cycle values during 250W SUB_{cyc} differed from those during 550, 700, 850W SUB_{cyc} and MAX_{cyc}. Absolute hip extension power increased by 19% between 90 and 120rpm MAX_{cyc} trials (356±21W vs. 423±24; p<0.01) whereas knee extension and knee flexion powers did not differ.

DISCUSSION: Our main finding was that, on average, these cyclists used relatively less knee extension and more knee flexion power as net cycling power increased. Thus, these data partially support our hypothesis and demonstrate that knee and hip joint actions used to produce power during SUB_{cyc} are relatively different than those joint actions used during MAX_{cyc}. An additional finding was that cyclists spent more time in the extension phase (increased duty cycle) during MAX_{cyc} suggesting that increased duty cycle likely serves as means to increase maximum power production. These findings support work by several previous groups that have observed duty cycle values greater than one during isolated muscle actions, animal locomotion, and single-leg cycling. Our results also suggest that hip extension power may be constrained by pedaling rate.

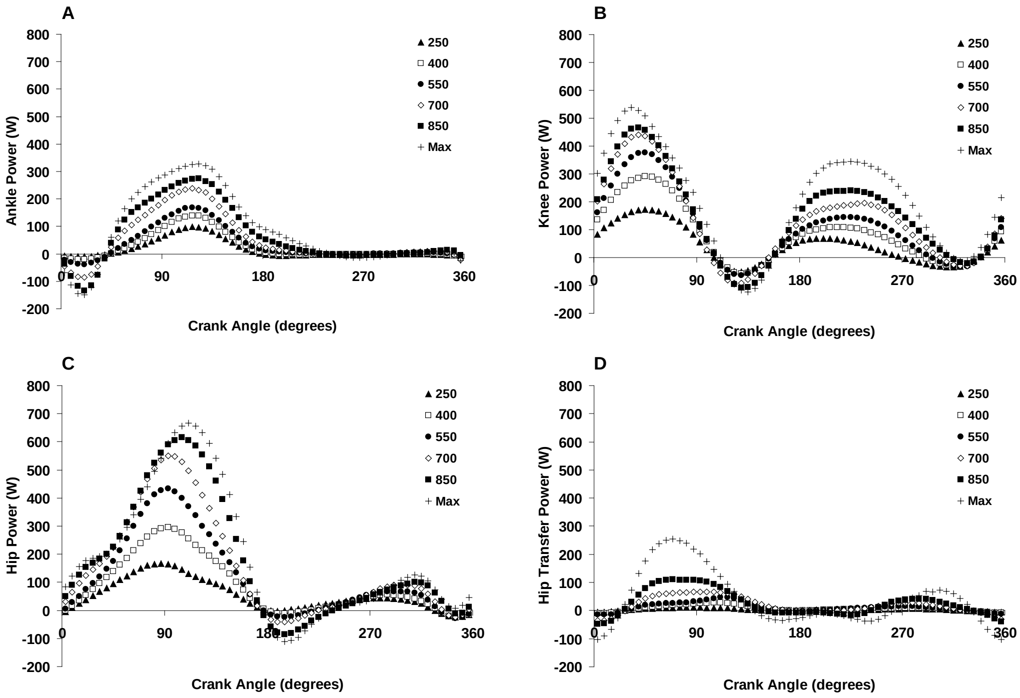

Figure 1. Power produced by ankle (A), knee (B), and hip (C) joint actions and by actions of the upper body (D) that transfer power across the hip with increasing net cycling power.

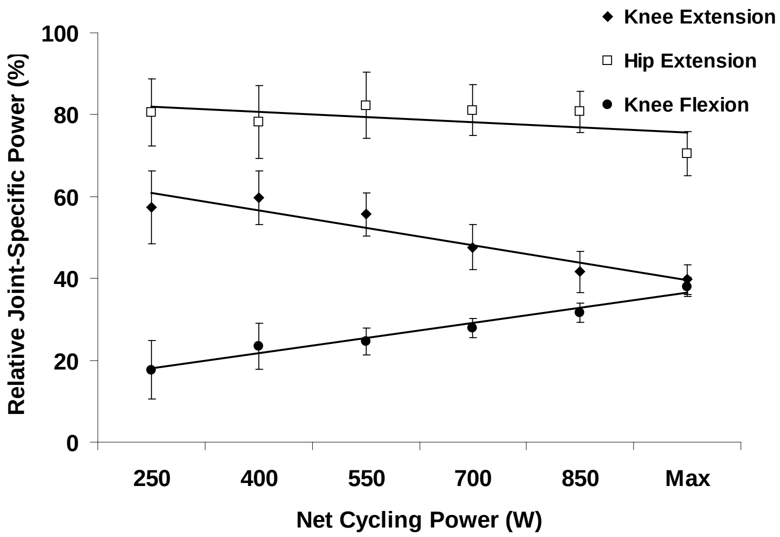

Figure 2. Alterations in relative joint-specific power with increasing net cycling power.

CONCLUSION: These are the first data to document joint-specific power production across such a broad range of net cycling powers and highlight distinct differences between SUB_{cyc} and MAX_{cyc}. These results may allow clinicians, applied sport scientists, and researchers to take even greater advantage of cycling as a laboratory tool and research model. Supported by EPSRC's Doctoral Training Grant scheme.

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