EFFECT OF SEAT TUBE ANGLE ON ANKLING PATTERN AND CARDIORESPIRATORY RESPONSE TO SUBMAXIMAL CYCLING

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INTRODUCTION

The seat tube angle (STA) of a bicycle is defined as the position of the seat relative to the crank axis. Road racing bicycles have a STA of 72-74°; in contrast, triathletes bicycles have steeper STA of 78-82°. Biomechanical optimisation studies of cycling (Gonzales and Hull, 1989) have reported that optimal STA varied depending on leg length and cadence. The effect of positional changes from shallow (<74°) to steeper (>74°) STA on cycling performance have rarely been addressed in the literature. Heil et al. (1995) investigated the effect of STA change on kinematic and cardiorespiratory variables in cyclists and triathletes and concluded that only the 69° STA appeared to be a detriment to steady state cardiorespiratory responses during submaximal cycling. More recently Price and Donne (1997) have reported that at a STA of 80°, significant physiological and biomechanical advantages were observed in comparison with 74 and 68° STA during submaximal cycling. The present study was designed to investigate the effect of STA variation on selected cardiorespiratory variables and ankling patterns during the propulsive phase of the pedal stroke during submaximal cycling in trained cyclists.

METHODS

The effect of STA variation (68, 74 and 80°) at a seat height equivalent to 100% trochanteric height was evaluated in 16 competitive road racing cyclists (age 22.6±1 yr, mass 72.8±1.8 kg, height 176.8±1 cm, trochanteric height 89.6±1 cm and cycling experience 3.9±0.7 yr, mean±SEM) using a discontinuous submaximal protocol (200 W at 85 rpm) on an air resistance ergometer (Kingcycle Ltd). Subjects cycled on a standard road racing bicycle fitted with a lockable seat shifter to allow the effective STA to be increased or decreased. Heart rate (HR) was recorded by radio telemetry, metabolic data VO2 (ml/kg.min), VE (L/min) and RR (breath/min) were recorded by open circuit spirometry during the final 2 min of each 5 min exercise element. Exercise elements were interspersed by 3 min rest period during which STA was adjusted. A microprocessor controlled 2-dimensional Mac Reflex infrared gait analysis system was used to record lower limb kinematic data and ankling angle (ZAnk, angle between plane of the pedal and crank arm). Reflective markers were attached to a) greater trochanter, b) lateral femoral condyle, c) lateral malleolus, d) fifth metatarsal-phalangeal joint, e) pair of markers on a 30 cm bar fixed parallel to the pedal and f) pair of markers fixed on the horizontal frame of the Kingcycle. Kinematic data was recorded for 15 s in the final minute of each exercise element.

Subjects were randomised to complete STA's in opposite directions from a starting position of 74° to eliminate any time or sequence bias, this resulted in STA of 74° being repeated on 3 occasions for repeatability analysis. To ensure submaximal effort, capillary blood lactate samples (BLa) were collected and analysed at the end of each exercise element (YSI Lactate Analyser). Results were analysed using ANOVA for repeated measures, P<0.05 was accepted for establishing statistical significance and post hoc analysis of detected differences were examined using Scheffe F test.

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RESULTS

No significant differences were observed in cardiorespiratory or kinematic data on repeat testing at STA of 74° and no significant differences were recorded for BLa during the entire test protocol. HR, VOa and VE were significantly lower (P< 0.01) at STA of 80° compared to 74 and 68°, for STA change of 68-80° mean AHR ±SEM was 5.3±0.7, mean AVO₂ ±SEM was 4.3+0.6 and mean AVE±SEM was 6.8±0.9. For ankle and knee angles, no significant differences were observed with STA in minimum or maximum angle or total range of movement during a pedal revolution.

Mean ZAnk at fixed crank angles of 60, 90 and 120° past top dead centre (TDC) are presented in Table 1.

<table>
<thead>
<tr>
<th>Crank angle °</th>
<th>STA (°)</th>
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<tbody>
<tr>
<td>60</td>
<td>68</td>
</tr>
<tr>
<td>60</td>
<td>21.0±0.9</td>
</tr>
<tr>
<td>90</td>
<td>-14.6+0.9</td>
</tr>
<tr>
<td>120</td>
<td>-44.1±0.9</td>
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Table 1: Mean ± SEM ZAnk°

The optimal ZAnk for maximum efficiency in force transmission during the propulsive phase would ideally be 0°. In this study mean ZAnk were significantly higher at 60° and significantly lower at 90 and 120° ( P<0.001) at a STA of 80° compared with 74 and 68°.

DISCUSSION

The results of the present study indicate that during submaximal cycling STA has a marked effect on cardiorespiratory parameters, mean HR, VOa and VE decreased significantly at steeper STA confirming the reported findings of Price and Donne (1997). In the present study, while each cyclist had his own particular ankle pattern, all exhibited similar trends in ZAnk with increasing STA, during the propulsive phase of the pedal stroke. Lafortune et al. (1983) concluded that most of the power was generated during the mid section (60-120° past TDC) of the pedal stroke. In the present study the mean ZAnk produced by altering STA would result in a decrease in the effective force transmitted during the early phase of the pedal stroke but in an increased effective force transmission over the arc from 90 -120° past TDC which may in part account for the reduced cardiorespiratory costs observed during submaximal cycling.

REFERENCES


