THE EFFECT OF SEAT TUBE ANGLE ON SUBMAXIMAL CYCLING: AN ELECTROMYOGRAPHIC INVESTIGATION

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INTRODUCTION

Recent studies (Heil et al., 1995; Price and Donne, 1997) have indicated a significant cardiorespiratory response to seat tube angle (STA) variation. The STA of a bicycle is defined as the position of the seat relative to the crank axis. Biomechanical optimisation studies of cycling (Gonzales and Hull, 1989) have reported that optimal STA varied depending on leg length and cadence. Electromyographic (EMG) techniques have been used to study muscle involvement during the power and recovery phases of pedalling (Faria and Cavanagh, 1978). The aim of the present study was to investigate if the reported cardiorespiratory responses were the result of altered muscle activation.

METHODS

The effect of STA variation (68, 74 and 80°) at a seat height equivalent to 100% trochanteric height was evaluated in 9 competitive male road racing cyclists (age 22.3±0.7 yr, mass 68.4±3.0 kg, height 176.3±1.9 cm, trochanteric height 92.9±1 cm and cycling experience 7.1±0.5 yr, mean±SEM) using a discontinuous submaximal protocol (200 W, load 2.5 kg at a cadence of 80 rpm) on a modified weight loaded ergometer (Monark). Ergometer modifications enabled adjustment to seat tube angle, seat height and handlebar to saddle distance.

A purpose built 2 channel bipolar 8 bit analogue to digital converter under software control recorded EMG activity from high gain differential amplifiers (Johnson et al., 1977). Data was collected using a machine coded subroutine at a rate of 2kHz was displayed and stored to disc using an Amstrad 6128+ computer. Stored EMG traces were later recalled from disc for integration and analysis. EMG activity was recorded over repeated pedal revolutions at each STA from Rectus Femoris (RF), Vastus Medialis (VM), Vastus Lateralis (VL), Biceps Femoris (BF), Semimembranosus (SM), Tibialis Anterior (TA) Gluteus Maximus (GM) and Gastrocnemius (GA).

Subjects cycled for 4 min at each STA (randomised), heart rate (HR) by radio telemetry and EMG activity were recorded in the final 2 min of each exercise period. EMG activity was recorded from a selected pair of muscles at all STA before EMG amplifiers were applied to the alternate muscle pairs, which were then assessed using the same randomised STA order. Integrated EMG activity (IEMG) measured over successive 30° crank rotation from top dead center (TDC = 0°), duration of activity (ms), time to activation (ms) with respect to TDC and HR were recorded. Results are presented as mean ±SEM, comparison of data across STA were carried out 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.

RESULTS

At STA of 74° mean normalised IEMG data (100% represented maximum IEMG activity in each individual) were similar to data previously reported by Jorge and Hull (1986) and with the exception of VM did not differ significantly with STA alteration. The mean duration of activity at a STA of 68° was significantly (P<0.01) longer for VM and VL and significantly shorter for RF and TA, while at a STA of 80° significantly shorter duration of activity were recorded.
for RF (P<0.05) and GA (P<0.01) compared with 74° STA. Mean HR was significantly lower (P<0.05) at STA of 80° compared with 68°, mean±SEM HR were 145.2±1.8 vs. 148.2±2.1 at 80 and 68° respectively.

Mean time to activation and duration of activity data were combined to identify the mean range of arc of crank rotation (zck) over which each muscle was active at each STA studied. Mean zck for STA of 68, 74 and 80° are presented in Table 1.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>STA 68° On</th>
<th>Off</th>
<th>STA 74° On</th>
<th>Off</th>
<th>STA 80° On</th>
<th>Off</th>
</tr>
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<tbody>
<tr>
<td>RF</td>
<td>-74</td>
<td>92</td>
<td>-72</td>
<td>103</td>
<td>-67</td>
<td>102</td>
</tr>
<tr>
<td>VM</td>
<td>-50</td>
<td>105</td>
<td>-39</td>
<td>103</td>
<td>-34</td>
<td>110</td>
</tr>
<tr>
<td>VL</td>
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<td>102</td>
<td>-35</td>
<td>107</td>
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<td>114</td>
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<tr>
<td>BF</td>
<td>18</td>
<td>208</td>
<td>22</td>
<td>217</td>
<td>30</td>
<td>221</td>
</tr>
<tr>
<td>SM</td>
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<td>178</td>
<td>28</td>
<td>182</td>
<td>37</td>
<td>192</td>
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<tr>
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<td>68</td>
<td>-107</td>
<td>78</td>
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</tr>
<tr>
<td>GA</td>
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<td>199</td>
<td>54</td>
<td>207</td>
<td>61</td>
<td>209</td>
</tr>
</tbody>
</table>

Table 1: Mean zck of onset (On) and cessation of activity (Off) for each muscle at STA of 68, 74 and 80°, all angles are relative to TDC (0°), negative zck signify activation before TDC.

Data in table 1 shows that STA alteration resulted in a significant (P<0.05-P<0.01) phase shift in the mean zck range over which activity was recorded in all muscles studied except TA, resulting in an extension of activity into the predominantly power phase (90-110° past TDC) of the pedal stroke for RF, VM and VL at a STA of 80°.

DISCUSSION

We observed a significant phase shift in zck at steeper STA, while in agreement with previous reports (Heil et al. 1995; Price and Donne, 1997) we recorded significantly lower HR. In view of these findings, the reported cardiorespiratory responses to STA alteration during submaximal cycling may in part be explained by an extension of the activation range of the knee extensors into the predominantly power phase of the propulsive stroke.

REFERENCES