Preseason Neuromuscular Profile of Knee Extensor and Flexor Muscles in Elite Amateur Road Cyclist’s Assessment through Tensiomyography

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Abstract

The aim of this study was to determine the baseline neuromuscular tensiomyography (TMG) parameters of knee extensor and flexor muscles in amateur road cyclists and then calculated percentages for the lateral symmetry and the functional symmetry. Twelve Spanish amateur road cyclists, category Elite, were considered (age 18.7 ± 0.7 years, body mass 68.0±8.2 kg, height 180.1±5.4 cm; fat 8.8±2.3% maximal power output5.6±0.3 w/kg). The cyclists were assessed, through TMG, on the first days of the pre-season, after a rest period of 3 weeks, at least 48 hours after performing any physical activity. A paired-samples t test (p<.05) was used to compare sides (dominant vs. non-dominant lower limb) and one-way ANOVA with the Bonferroni test (p < .01) was applied, with muscle being taken as an independent factor. No significant differences were observed between the dominant and non-dominant leg except in maximum radial displacement and contraction velocity of rectus femoris. Lateral symmetry percentages obtained were of about 82% in all muscles and functional symmetry percentages obtained were above 73%. This is due to higher contraction time (between 11.8 and 16.9 ms, p < .01) and lower contraction velocity (between 65.5 y 123.9 mm·s−1p < .01) of cyclist’s biceps femoris about knee extensor muscles. The neuromuscular evaluation of the principal muscles of pedalling at the beginning of the training season may set initial values of reference in theoretical absence of fatigue. So that it becomes a tool that helps the coach to control and study subsequently the changes that occur due to the training loads and competition that receives the cyclist during the different training cycle of the season. Moreover, in case of muscle tendon injury would help to identify the anomalous values product of the injury and carry out the monitoring of the recovery.

ABBREVIATIONS

TMG: Tensiomyography; Ms: Milliseconds; Mm: Millimeters; W: Watios; Ma: Milliamperes; Cm: Centimeters; LS: Lateral Symmetry; FS: Functional Symmetry

INTRODUCTION

To evaluate the relation or balance between different muscles acting on a given joint or on different side of the body, it may be used different techniques and tools. Some such as carrying out a comparative test of maximum strength, or the comparison of the muscular symmetry percentages obtained were above 73%. This is due to higher contraction time (between 11.8 and 16.9 ms, p < .01) and lower contraction velocity (between 65.5 y 123.9 mm·s−1p < .01) of cyclist’s biceps femoris about knee extensor muscles.

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muscles in amateur road cyclists and then calculated percentages for the lateral symmetry and the functional symmetry.

**MATERIALS AND METHODS**

**Participants**

Twelve Spanish amateur road cyclists, category Elite, were considered (age 18.7 ± 0.7 years, body mass 68.0 ± 8.2 kg, height 180 ± 5.4 cm; fat 8.8 ± 2.3%; maximal power output obtained in a progressive maximal test in a laboratory 5.6 ± 0.3 W/kg). They were in good health and injury-free and they had passed the medical examination. All participants provided written consent subsequent to being informed about the research process and the possible risks of TMG assessment. The coaching staff and management board were also informed about the nature of the study. The research protocol followed the principles of the Declaration of Helsinki regarding biomedical research involving human subjects. The local ethics committee approved the study.

**Procedure**

The cyclists were assessed on the first days of the pre-season, after a rest period of 3 weeks, at least 48 hours after performing any physical activity. TMG was used to measure the radial muscle belly displacement of the vastus medialis (VM), vastus lateralis (VL) and rectus femoris (RF) knee extensor muscles, and of the long head of the biceps femoris (BF) flexor muscle. Knee extensors were measured with the knee joint fixed at an angle of 120° and the knee flexor muscle was measured with the knee joint fixed at an angle of 150°.

The TMG assessments were performed once the subject had been in a relaxed supine position for 10-15 minutes following the protocol described by García-García et al. [8] with professional cyclists. Electrical stimulation was applied with pulse duration of 1 ms and initial current amplitude of 30 mA, which was progressively increased in 5 mA steps until reaching 110 mA (maximal stimulator output). Only the curve with the highest maximum radial displacement was included in the analysis for each muscle assessed. In order to obtain repeatability coefficients for the TMG parameters, two measurements were taken at random from one of the cyclist’s muscles; the sensor and electrode position used for the first measurement was marked so that they could be placed in the same location when taking the second measurement 20-30 minutes later.

Measures of radial muscle belly displacement were acquired by means of a digital displacement transducer (GK 30, Panoptikd.o.o., Ljubljana, Slovenia) set perpendicular to the thickest part of the muscle belly. The thickest part of the muscle belly was determined visually and through palpation during a voluntary contraction. The self-adhesive electrodes (5x5 cm, Cefar-Comex Medical AB Co., Ltd, Malmö, Sweden) were placed symmetrically at a distance of 5 cm from the sensor. A TMG-S2 stimulator (EMF-FURLAN & Co. d.o.o., Ljubljana, Slovenia) produced the electrical stimulus.

Each measurement involved recording the following parameters of involuntary isometric contraction produced by the electrical stimulus. Maximum radial muscle belly displacement (D_m) in mm. Contraction time (T_c) as the time in ms from 10% to 90% of Dm. Delay time (T_d) as the time in ms from onset to 10% of Dm. Sustain time (T_s) as the time in ms between 50% of Dm on both the ascending and descending sides of the curve. Half-relaxation time (T_r) as the time in ms between 90% and 50% of Dm on the descending curve. Contraction velocity (V_c) as the rate (mm·s⁻¹) between the radial displacement occurring during the time period of T_c (Dm80) and T_c [Dm80/T_c].

**Statistical analysis**

Application of the Kolmogorov-Smirnov test, in conjunction with the Lilliefors test (p < .05), showed that the sample distribution was normal, linear and homoscedastic. Intraclass correlation coefficients (ICCs) with a 95% confidence interval (CI) were used to assess the reliability of TMG measurements. A paired-samples t test (p<.05) was used to compare sides (dominant vs. non-dominant lower limb). One-way ANOVA with the Bonferroni test (p < .01) was applied, with muscle being taken as an independent factor. All data were analysed using SPSS v19.0 for Windows (SPSS Inc., Chicago, IL, USA). The lateral symmetry (LS) and functional symmetry (FS) percentages were calculated using the algorithm implemented by the TMG-BMC tensiomyography® software (Figures 1,2).

**RESULTS AND DISCUSSION**

The ICC values (95% CI) obtained ranged between 0.79 and 0.98: D_m 0.98; T_c 0.98; T_d 0.90; T_r 0.89; and T_s 0.79. If one considers a value below 0.8 as the cut-off for insufficient reliability [9], then the ICCs for these pre-season data indicate good reliability for all the TMG parameters except Tr parameter. TMG measurements of these muscles have previously been reported to show good same-day reliability [10-12], except T parameter [11] coinciding with our findings. In addition, research has suggested that TMG measurements are also reliable when tests are performed on amputees [13].

![Figure 1](image1.png)

**Figure 1** LS= lateral symmetry, where “r” is the right side and “l” is the left side in all parameters. Min= minimum; Max=maximum.

![Figure 2](image2.png)

**Figure 2** FS= Functional symmetry, where “r” is the right side and “l” is the left side in all parameters. Min= minimum; Max=maximum.
Table 1: Differences between dominant vs. non-dominant lower limb in TMG assessments of cyclists. Tc, Td, Ts and Tr are in ms, while Dm is in mm, and Vc is in mm·s⁻¹. Difference between lower limbs is significant at p < .05*. Values are mean and standard deviation.

<table>
<thead>
<tr>
<th>TMG Parameter</th>
<th>Biceps femoris</th>
<th>Rectus femoris</th>
<th>Vastus Lateralis</th>
<th>Vastus medialis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc dominant</td>
<td>42.1±14.5</td>
<td>31.8±6.6</td>
<td>26.5±5.2</td>
<td>25.2±3.6</td>
</tr>
<tr>
<td>Tc non-dominant</td>
<td>43.0±16.6</td>
<td>30.6±7.1</td>
<td>25.7±4.2</td>
<td>27.0±4.6</td>
</tr>
<tr>
<td>Td dominant</td>
<td>24.2±2.1</td>
<td>25.2±3.3</td>
<td>23.9±2.1</td>
<td>21.8±1.6</td>
</tr>
<tr>
<td>Td non-dominant</td>
<td>24.4±2.5</td>
<td>24.8±3.8</td>
<td>23.7±2.4</td>
<td>22.8±1.7</td>
</tr>
<tr>
<td>Tr dominant</td>
<td>57.8±19.2</td>
<td>98.1±79.6</td>
<td>90.4±77.6</td>
<td>73.9±64.4</td>
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<tr>
<td>Tr non-dominant</td>
<td>60.3±11.3</td>
<td>57.6±55.4</td>
<td>102.8±50.6</td>
<td>73.5±33.5</td>
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<tr>
<td>Dm dominant</td>
<td>8.2±2.7</td>
<td>10.0±1.6*</td>
<td>6.5±1.6</td>
<td>8.9±1.7</td>
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<tr>
<td>Dm non-dominant</td>
<td>6.8±1.8</td>
<td>7.5±1.2*</td>
<td>7.1±1.3</td>
<td>8.5±1.8</td>
</tr>
<tr>
<td>Tsd dominant</td>
<td>210.3±22.2</td>
<td>140.5±88.5</td>
<td>125.5±82.1</td>
<td>225.9±41.0</td>
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<tr>
<td>Tsd non-dominant</td>
<td>208.1±22.0</td>
<td>96.3±66.2</td>
<td>146.0±66.6</td>
<td>229.1±43.1</td>
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<tr>
<td>Vc dominant</td>
<td>161.1±51.5</td>
<td>256.1±36.6*</td>
<td>210.7±86.6</td>
<td>290.6±81.3</td>
</tr>
<tr>
<td>Vc non-dominant</td>
<td>143.7±51.6</td>
<td>203.9±53.7*</td>
<td>225.2±53.7</td>
<td>262.1±81.8</td>
</tr>
</tbody>
</table>

Abbreviations: Dm: Maximum Radial Muscle Belly Displacement; Tc: Contraction Time; Td: Delay Time; Ts: Sustain Time; Tr: Half-Relaxation Time; Vc: Contraction Velocity.
Table 2: Differences between cyclists’ muscles assessments. Mean difference and standard deviation. Tc, Td, Ts, and Tr are in ms, while Dm is in mm, and Vc is in mm·s⁻¹. One-way ANOVA with the Bonferroni test (p<0.01) muscle as an independent factor.

<table>
<thead>
<tr>
<th></th>
<th>BF-RF</th>
<th>BF-VL</th>
<th>BF-VM</th>
<th>RF-VL</th>
<th>RF-VM</th>
<th>VL-VM</th>
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<tbody>
<tr>
<td>Tc</td>
<td>11.8±3.4</td>
<td>16.9±3.4</td>
<td>16.9±3.4</td>
<td>5.0±3.4</td>
<td>5.0±3.4</td>
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<tr>
<td></td>
<td>P=0.008</td>
<td>P=0.001</td>
<td>P=0.001</td>
<td>P=0.893</td>
<td>P=0.893</td>
<td>P=1.000</td>
</tr>
<tr>
<td>Td</td>
<td>0.7±0.9</td>
<td>0.5±0.9</td>
<td>1.9±0.9</td>
<td>1.2±0.9</td>
<td>2.7±0.9</td>
<td>1.4±0.9</td>
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<tr>
<td></td>
<td>P=1.000</td>
<td>P=1.000</td>
<td>P=0.230</td>
<td>P=1.000</td>
<td>P=0.035</td>
<td>P=0.724</td>
</tr>
<tr>
<td>Tr</td>
<td>18.8±20.2</td>
<td>37.5±20.2</td>
<td>14.6±20.2</td>
<td>18.7±20.2</td>
<td>4.1±20.2</td>
<td>22.9±20.2</td>
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<tr>
<td></td>
<td>P=1.000</td>
<td>P=0.415</td>
<td>P=1.000</td>
<td>P=1.000</td>
<td>P=1.000</td>
<td>P=1.000</td>
</tr>
<tr>
<td>Dm</td>
<td>1.2±0.7</td>
<td>0.7±0.7</td>
<td>1.1±0.7</td>
<td>1.9±0.7</td>
<td>0.0±0.7</td>
<td>1.9±0.7</td>
</tr>
<tr>
<td></td>
<td>P=0.522</td>
<td>P=1.000</td>
<td>P=0.601</td>
<td>P=0.046</td>
<td>P=1.000</td>
<td>P=0.055</td>
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<tr>
<td>Ts</td>
<td>90.7±21.7</td>
<td>73.4±21.7</td>
<td>18.2±21.7</td>
<td>17.3±21.7</td>
<td>109.0±21.7</td>
<td>91.7±21.7</td>
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<tr>
<td></td>
<td>P=0.001</td>
<td>P=0.009</td>
<td>P=1.000</td>
<td>P=1.000</td>
<td>P=0.001</td>
<td>P=0.001</td>
</tr>
<tr>
<td>Vc</td>
<td>77.6±24.5</td>
<td>65.3±24.5</td>
<td>123.9±24.5</td>
<td>12.2±24.5</td>
<td>46.3±24.5</td>
<td>58.4±24.5</td>
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<tr>
<td></td>
<td>P=0.01</td>
<td>P=0.06</td>
<td>P=0.001</td>
<td>P=1.000</td>
<td>P=0.386</td>
<td>P=0.126</td>
</tr>
</tbody>
</table>

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Table 3: Differences between muscles indominant and non-dominant lower limbs. Tc are in ms. Difference between Tc is significant at p < .01.*
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REFERENCES


