Evaluating Muscle Contraction with Tensiomyography
What is Tensiomyography?
Diagnostic method
Contractile properties
Superficial skeletal muscle
Application areas

**Sport** – Performance, Injury prevention

**Medicine** – Rehabilitation monitoring

**Research** – Scientific publications
Tensiomyography
Tensiomyography
TMG Parameters

- **Td** - Delay time
- **Tc** - Contraction time
- **Ts** - Sustain time
- **Tr** - Relaxation time
- **Dm** - Displacement
Muscle Response Scenarios

- High Function
  - Optimal Tc
  - Optimal Dm

- Increased Activation
  - Fast Tc
  - High Dm

- Muscle Weakness
  - Slow Tc
  - High Dm

- Fatigued Muscle
  - Slow Tc
  - Low Dm

- Pain Inhibition
  - Long Tc
  - Low Dm
Sensitivity: raw data signals

- Dm healthy: 4.3 mm
- Dm injured 1: 2.6 mm
- Dm injured 2: 9.0 mm
- Tc healthy: 20.33 ms
- Tc injured 1: 26.85 ms
- Tc injured 2: 31.27 ms
Basic Results
Lateral and Functional Symmetry

- Lateral Symmetry
- Functional Symmetry - Antagonistic Pairs
- Functional Symmetry - Synergistic Pairs
Lateral and Functional Symmetry

**Lateral Symmetry (LS)**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Side</th>
<th>$T_c$ [ms]</th>
<th>$T_s$ [ms]</th>
<th>$T_r$ [ms]</th>
<th>$D_m$ [mm]</th>
<th>$T_d$ [ms]</th>
<th>Sym [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>m.BF</td>
<td>L</td>
<td>35.14</td>
<td>191.05</td>
<td>74.87</td>
<td>14.62</td>
<td>26.46</td>
<td>66</td>
</tr>
<tr>
<td>m.BF</td>
<td>R</td>
<td>24.15</td>
<td>219.19</td>
<td>30.52</td>
<td>5.37</td>
<td>23.23</td>
<td>79</td>
</tr>
<tr>
<td>m.RF</td>
<td>L</td>
<td>23.44</td>
<td>135.17</td>
<td>65.52</td>
<td>11.25</td>
<td>21.62</td>
<td>78</td>
</tr>
<tr>
<td>m.RF</td>
<td>R</td>
<td>20.87</td>
<td>70.67</td>
<td>40.72</td>
<td>6.30</td>
<td>19.97</td>
<td>89</td>
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<tr>
<td>m.ST</td>
<td>L</td>
<td>50.55</td>
<td>102.12</td>
<td>38.40</td>
<td>13.89</td>
<td>31.92</td>
<td>94</td>
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<tr>
<td>m.ST</td>
<td>R</td>
<td>42.47</td>
<td>151.20</td>
<td>44.31</td>
<td>8.92</td>
<td>24.52</td>
<td></td>
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<tr>
<td>m.VL</td>
<td>L</td>
<td>23.72</td>
<td>179.47</td>
<td>152.13</td>
<td>11.00</td>
<td>23.72</td>
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<tr>
<td>m.VL</td>
<td>R</td>
<td>22.84</td>
<td>98.90</td>
<td>71.37</td>
<td>9.27</td>
<td>21.69</td>
<td></td>
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<tr>
<td>m.VM</td>
<td>L</td>
<td>27.09</td>
<td>160.85</td>
<td>54.57</td>
<td>10.65</td>
<td>27.84</td>
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<tr>
<td>m.VM</td>
<td>R</td>
<td>28.41</td>
<td>177.89</td>
<td>84.22</td>
<td>10.28</td>
<td>23.14</td>
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**Functional Symmetry (FS)**

<table>
<thead>
<tr>
<th>Sym</th>
<th>Sym [%]</th>
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<tbody>
<tr>
<td>Elbow: (BB/TB)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Achilles Tendon: (GL/GM)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Lig. Patellae: (VM/VL)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Knee: (VL&amp;VM&amp;RF/BF)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Ankle: (TA/GL&amp;GM)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Leg: (VL&amp;VM/GL&amp;GM)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>
Comments / Recomendations

- Activiation exercises
- Strength exercises
- Stretch / Relax
- Tc too slow
- Dm too high
- Dm too low

Muscles:
- Vastus Lateralis
- Vastus Medialis
- Rectus Femoris
- Biceps Femoris
- Semitendinosus
Rehabilitation Process Monitoring

<table>
<thead>
<tr>
<th>Date</th>
<th>Left</th>
<th>%</th>
<th>Right</th>
<th>%</th>
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<td>16.11.2010</td>
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<td>0</td>
<td>25.27</td>
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<td>18.03.2011</td>
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Sym I%I
80
99
99
About 2000 professional soccer players from 10 countries were followed between 2001 and 2010. Muscle injuries were registered prospectively by the club medical staffs. A muscle injury was defined as “a traumatic distraction or overuse injury to the muscle leading to a player being unable to fully participate in training or match play.”

- 31% of injuries in soccer are related to muscle injuries.
- 92% of all muscle injuries affected the 4 major muscle groups of the lower limbs: hamstrings (37%), adductors (23%), quadriceps (19%), and calf muscles (13%).
- 16% of the muscle injuries were reinjuries.
X2
increased rate of calf injury in older players, but no association was found in other muscle groups

0.6
on average, the number of muscle injuries sustained per player per season

15
muscles injuries expected per year for a squad of 25 players

References
“Tensiomyography is used for follow-up the functional recovery of muscle and to help decide return to play”
FC Barcelona & ASPETAR Example:
“Management of a muscle injury”

<table>
<thead>
<tr>
<th>Initial acute phase</th>
<th>Clinical history</th>
<th>Physical exam</th>
<th>US</th>
<th>MRI</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>Immediate</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>Could be made anytime</td>
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<tr>
<td>12 hours</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>Rest Ice Compression Elevation Analgesia</td>
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<tr>
<td>24 hours</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48 hours</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Subacute and functional phase</th>
<th>1st week</th>
<th>Monitorize players feelings</th>
<th>Weekly</th>
<th>Return to play</th>
<th>Functional tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>To evaluate how the progression of loads are assumed</td>
</tr>
</tbody>
</table>

For follow-up the functional recovery and sometimes to help to decide return to play:
- **Muscle**: Tensiomyography, electromyography and strength tests.
- **Player**: GPS, HR and self administered scales during and after the rehabilitation sessions on field.
Rehabilitation Monitoring

Hamstring (Biceps Femoris) injury

1<sup>st</sup> measurement: 4 days after the injury
2<sup>nd</sup> measurement: 10 days after the injury
3<sup>rd</sup> measurement: 16 days after the injury
Knee Surgery - ACL

**VM = 53 %**

**RF = 59 %**

**VL = 79 %**

4 days after the surgery
Patellar tendon graft

--- Healthy leg

--- Injured leg
Recovery Monitoring – before/after ACL surgery

Adaptation pattern to rehabilitation
Is different for each muscle
Other Diagnostic Methods

Hamstring (Biceps Femoris) injury

43% difference in Tc

Healthy leg

Injured leg
Muscle Fatigue Monitoring

TMG response (Biceps Femoris - BF) after 60m sprint

- before
- 1 - 60m
- 2 - 60m
- 3 - 60m
- 4 - 60m
- 5 - 60m
- 6 - 60m

mm vs. ms
Muscle Fatigue Monitoring

BF response after 60m sprint

- Tc (ms)
- Td (ms)

Sets

- before
- 1 - 60m
- 2 - 60m
- 3 - 60m
- 4 - 60m
- 5 - 60m
- 6 - 60m

ms

17 18 19 20 21 22 23 24 25
Muscle Recovery Monitoring

Acute local muscle fatigue test (Biceps Brachii) Displacement - Dm

Muscle fatigue protocol

Acute local muscle fatigue test (Biceps Brachii) Contraction Time - Tc

Muscle fatigue protocol
Tensiomyography

Non-invasiveness  (No conflict with rehabilitation process)

Selectiveness

Simplicity

High objectivity (no influence of motivation)

Immediate interpretation of results
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