NOVEL USES OF ELECTROMYOGRAPHY IN EVALUATION OF SKELETAL MUSCLE RECRUITMENT DURING EXERCISE IN ATHLETES WITH DISABILITIES: A KEY TO INJURY PREVENTION AND FUTURE CLASSIFICATION?

PHOEBE RUNCIMAN
DR. YUMNA ALBERTUS-KAJEE
PROF. WAYNE DERMAN
DR. SUZANNE FERREIRA
Electromyography (EMG)

The study of muscle activation by examination of the electrical signals that emanate from skeletal muscle.

Neuromuscular conditions:
- Amyotrophic lateral sclerosis (ALS)
- Cerebral Palsy (CP)

Musculoskeletal injury:
- Chronic gluteal strains
- Chronic hamstring strains
FUNCTIONAL MUSCLE ACTIVITY: ALS vs. CP
# Background: Athletes

## ALS
- Lower motor neuron form of ALS
- Age: 43 yrs
- Time since diagnosis: 4 yrs
- Prognosis: 18 - 24 months
- 2 yrs participation
- Classification- S9
- Side most affected: Left
- Swimming event: freestyle

## CP
- Spastic hemiplegic CP
- Age: 25 yrs
- 8 yrs participation
- Classification- T37
- Side affected: Right
- Track events: 100m, 200m
Testing protocol

Pre fatigue:
- 15 strokes: blue band

Fatigue:
- Swimming strokes using black bands for 30 sec

Post fatigue:
- 15 strokes using blue band

Muscles:

Primary power muscles:
- Anterior deltoid, Posterior deltoid
- Pectoralis major
- Serratus anterior
- Latissimus dorsi

Secondary support muscles:
- Upper trapezius, Lower trapezius
- External oblique

Normalised to 10s max trial

Muscles:
- Erector spinae
- Gluteus medius
- Biceps femoris
- Vastus lateralis
- Gastrocnemius medialis

Normalised to 10s sprint
Results: ALS

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Left</th>
<th>Right</th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis Major</td>
<td></td>
<td></td>
<td>4.5 %</td>
</tr>
<tr>
<td>Posterior Deltoid</td>
<td>16.8 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior Deltoid</td>
<td></td>
<td>20 %</td>
<td></td>
</tr>
<tr>
<td>Serratus Anterior</td>
<td></td>
<td></td>
<td>0 %</td>
</tr>
<tr>
<td>Latissimus Dorsi</td>
<td>21 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Trap</td>
<td></td>
<td></td>
<td>1.2 %</td>
</tr>
<tr>
<td>Lower trap</td>
<td>18.8 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Obliques</td>
<td></td>
<td>11.6 %</td>
<td></td>
</tr>
</tbody>
</table>
Results: ALS fatigue and symmetry

**AFFECTED SIDE**

- **Power muscles**
- **Support muscles**

**NON AFFECTED SIDE**

- **Power muscles**
- **Support muscles**

**Belief of poor affected side**

**Change biomechanics**

**Done to “protect” affected side**

**Over-activation and fatigue**

**With fatigue: natural stroke returned**

**INCORRECT BIOMECHANICS?**

- Supported by Lat Dorsi: starts to activate with fatigue
- Due to loss of “conscious constraint”

**Power: Post delt, Ant delt, Pect major, Serr ant, Lat dorsi**

**Support: Upper traps, Lower traps, External obliques**
## Results: CP: Pre-fatigue symmetry

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Non affected side</th>
<th>Affected side</th>
<th>Similar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erector spinae</td>
<td></td>
<td>23 %</td>
<td></td>
</tr>
<tr>
<td>Gluteus medius</td>
<td></td>
<td>4 %</td>
<td></td>
</tr>
<tr>
<td>Biceps femoris</td>
<td>13 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vastus lateralis</td>
<td></td>
<td>25 %</td>
<td></td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td></td>
<td>1 %</td>
<td></td>
</tr>
</tbody>
</table>
### Results: CP: Post-fatigue symmetry

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Non affected side</th>
<th>Affected side</th>
<th>Similar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erector spinae</td>
<td></td>
<td>27 %</td>
<td></td>
</tr>
<tr>
<td>Gluteus medius</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps femoris</td>
<td></td>
<td>9 %</td>
<td></td>
</tr>
<tr>
<td>Vastus lateralis</td>
<td></td>
<td>25 %</td>
<td></td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td></td>
<td>6 %</td>
<td></td>
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</tbody>
</table>

Possible compensation for lack of BF over-activation on affected side.
CP: A closer look shows a muscle irregularity

Able bodied

Cerebral palsy

Amplitude (mV)

BF

VLO

AFFECTED

AFFECTED

AFFECTED

12 ms

13 ms

14 ms
Summary: ALS & CP

ALS:
- The results suggest that by protecting the side that he believed to be “severely affected”, he was compromising his whole stroke
- This is supported by the correction of his stroke post-fatigue
- With knowledge of muscle activation:
  - Know that the rehabilitation is working (keep doing what he is doing)
  - Correct stroke (and performance) by changing flawed ideas

CP:
- Compensation for the BF may indicate reliance on the non-affected side for power output in this cycling task
- May also be a result of co-activation of the affected BF
- The identification of this co-activation is of clinical significance
MUSCLE INJURIES IN TWO VISUALLY IMPAIRED ATHLETES
Athletes: Injury history

Case 1:
- T/F 13
- 100m, 200m, LJ
- No precipitating trauma
- Prior right foot strain
- Prior achilles injury
- Chronic gluteus medius pain/strains (bilateral)

Case 2:
- T 12
- 200m, 400m
- No precipitating trauma
- Prior right foot fracture
- Right proximal hamstring strain at 2011 IPC WC
- Chronic left hamstrings strains

Previous literature in athletes with visual impairment?
Methodology: Testing protocol

**Case 1:**
- 3 starts
- 2 max sprints
- Fatigue (1km at 400m pace)
- 1 max sprint

**Muscles:**
- Erector spinae
- Gluteus medius
- Gluteus maximus
- Biceps femoris
- Gastrocnemius lateralis

Normalised to 20m max sprint

**Case 2:**
- 3 block starts
- 5 40m @ 400m pace
- 1 block start

**Muscles:**
- Tibialis anterior
- Gluteus maximus
- Vastus lateralis
- Biceps femoris
- Gastrocnemius lateralis

Normalised to 20m max sprint
### Results: Case 1

- **2\textsuperscript{nd} max sprint**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Left</th>
<th>Right</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erector spinae</td>
<td>33.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteus medius</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteus maximus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps femoris</td>
<td>71%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral gastrocnemius</td>
<td>24.3%</td>
<td></td>
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**Left leg muscles compensating for low Glut Max activation**
Results: Case 1

- Bilateral gluteus medius pain

Glut Med – Only one peak on right

Combination of these can contribute to recurrent strains

Max – Left not firing!

Gazendam et al, 2007
Results: Case 2

400m pace run

Low stability on left stride: overloading on other muscles (hamstring strains)

Glut Max: co-activation on Right stride

Left hamstring strains
Case 2: Rehabilitation

- Glut max rehabilitation
  - As opposed to glut med rehabilitation

- Biofeedback
  - EMG

- Shockwave therapy
  - Sports Medicine Clinic
Summary: EMG for injury

- **Case 1:**
  - We identified a possibly large compensation for extremely high gluteus maximus activation during maximal sprinting.
  - Identification of reciprocal EMG irregularities in the gluteus muscles exposed possible contributing factors for chronic gluteal strains and pain.

- **Case 2:**
  - It is possible that co-activation of gluteus maximus on right stride may lead to low stability on the left stride.
  - This may lead to overloading on surrounding muscles on the left side, thus leading to injury.
  - EMG allowed us to pursue correct rehabilitation of the injury.
Clinical application of EMG

- EMG is recommended as a tool in clinical management of all athletes **WITH** and **WITHOUT** disabilities

- EMG allows for identification of **neuromuscular asymmetry**, which is becoming a vital addition to overall clinical assessment

- In depth investigation into muscle pathology
  - **GOES BEYOND** functional testing
Clinical application of EMG cont.

- Abnormal recruitment patterns can persist for *months* or *years* after original injury.
- Use information to *inform clinicians* on correct rehabilitation.
- Easy to administer / User friendly.
Possible implications for classification?

- EMG can be used to assess functional muscle activity in athletes with NM conditions:
  - Different activation levels in classes
Thank you!

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Contact

Boundary Road, Newlands
Cape Town, South Africa
7700

+2779 074 0097
+4979 3522 450

phoebe.runciman@gmail.com
phoebe.runciman@paralympic.org