Effect of Muscle Fatigue on Wrist Proprioception

Proprioception Decline from Muscle Fatigue

- Declined JPS post exercise (Conc & Ecc)
- Not a new concept!
  - Skinner et al., 1995 - Knee
  - Sexton et al., 1995 - Elbow
  - Vogrin et al., 1996 - Shoulder
  - Lattanizzi et al., 1997 - Knee
  - Bredt et al., 1997 - Elbow
- No clear effect on kinesthesia

Normal Wrist JPS Error

1. Passive positioning Ext 20°
   - MS input against (stretcher)
2. Active memorization reference angle
   - MS input against (extensors)
3. Active motion away
   - Against MS stationary input
   - Muscle feels longer or shorter
4. Active reposition
   - Over or Under
   - Normal Wrist: ± 15°

What do we know?

- 20-50% Muscle fatigue leads to JPS deficit
  - Various joints (i.e. shoulder, elbow, knee, ankle)
  - Immediately following exercises
  - Causing functional deficits
- Elbow JPS error: 25% → 6.5 - 11.5°

Pathophysiology

- Muscle fatigue produces neuromuscular deficiency
  - Distortion of MS sensitivity
  - Altered sensory input on JPS
  - Altered cortical feedforward motor commands
  - Muscle effort required to maintain joint position
  - Local metabolites (e.g., LA) alter MS firing
  - JPS errors

2/18/2018
What are we missing?

- No available research to date:
  - Muscle fatigue effect on wrist JPS (healthy or injured)
  - Association between muscle fatigue and wrist JPS deficit
  - Muscle fatigue effect difference on young or older adults
  - Recovery time for JPS deficit post exercise

Clinical Significance

Determining these relationships:
- Wrist rehabilitation paradigms within safe levels of muscle fatigue
- Preventing JPS impairment prior to functional testing or demanding activity
- Promoting injury prevention

Most Recent Evidence

- DeSales DPT Program

Primary Aim

- Determine whether exercise-induced muscle fatigue affects wrist JPS among healthy adults

  **Hypothesis:**
  - Exercise-induced muscle fatigue will sig increase post-exercise wrist JPS deficit

Secondary Aims

1. Comparison between young & old healthy adults
   - **Hypothesis:** No age-group differences on wrist JPS change due to muscle fatigue

2. Association between JPS change and total fatigue rates post-exercise
   - **Hypothesis:** Sig association between post-exercise wrist JPS change and TFM rates

Research Design & Participants

- Pre & Post-test
- Experimental study
- Sample of convenience 40 healthy individuals (18-45 yrs)
- Specific inclusion and exclusion criteria
- Stratified in young (18-40 yrs) and old (40-65 yrs) groups

<table>
<thead>
<tr>
<th>Inclusions</th>
<th>Exclusions</th>
</tr>
</thead>
</table>
| Adults 18-45 yrs | Inability to speak/understand English
| Parthenon US exercising | Wrist pathologies
| Functional ROM at hand and wrist | Knee impairments
| |

Approved by DeSales University IRB
Instrumentation

Active wrist JPS test
- Standardized protocol requiring eyes closed:
  1. Passive wrist positioning / memorization reference angle
  2. Active position away from reference angle
  3. Active reproduction of reference angle

Methodology

- Pre-Exercise Baseline measurements (mean of 2 trials)
  1. Wrist JPS deficit
  2. Grip strength
  3. Wrist extension strength

- Determined 10 RM values
  - Grip strength
  - Wrist Extension

- 5 min Brake

Instrumentation

- Jamar Dynamometer: Grip strength
- MicroFet Dynamometer: Wrist extension strength
- Standardized procedures

Methodology

- Exercise Session:
  - Calibrated grip (10-100 lbs)
  - Wrist EXT, CTR.
  - 25-75% of documented RM values
  - 3 sets, ≥ 10 reps till total fatigue
  - Metronome: consistent speed (10-2 sec)
  - Range of Motion (ROM) Scale (6/16)

- Post-Exercise Measurements
  1. Grip strength
  2. Wrist extension strength
  3. Wrist JPS deficit

Statistical Analysis

- Descriptive and inferential
  - Patient data for protocol
  - Independent t-test compared age groups
  - Pearson correlations

- A priori analysis (.05 ES, .05 α level): 40 participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scaled</th>
<th>Unscaled</th>
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</thead>
<tbody>
<tr>
<td>JPS Rate of Change</td>
<td>Total Muscle Fatigue (TMF) rate</td>
<td>grip Strength</td>
</tr>
</tbody>
</table>

- Categorized JPS rate of change & TMF rate
  - Low: Moderate - High levels
  - Best way to correlate 2 heterogeneous variables

- Common categorical scale

<table>
<thead>
<tr>
<th>Category Level</th>
<th>TMF Rate (%)</th>
<th>JPS Rate of Change (%)</th>
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</thead>
<tbody>
<tr>
<td>Range</td>
<td>Means</td>
<td>Range</td>
</tr>
<tr>
<td>Low</td>
<td>(0-79%)</td>
<td>5.03</td>
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<tr>
<td>Moderate</td>
<td>(80-189%)</td>
<td>55.28</td>
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<tr>
<td>High</td>
<td>(≥ 19%)</td>
<td>28.53</td>
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<tr>
<td>Combined</td>
<td>18.02</td>
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Primary Aim:
- Sig differences on JPS and strength deficit between pre- and post-exercise
- Regardless age levels

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-Exercise (mean)</th>
<th>Post-Exercise (mean)</th>
<th>p-Value</th>
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<tbody>
<tr>
<td>JPS Score (kg)</td>
<td>4.62</td>
<td>6.83</td>
<td>.000**</td>
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<tr>
<td>JPS Young</td>
<td>5.22</td>
<td>7.42</td>
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<tr>
<td>JPS Old</td>
<td>5.11</td>
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<td>Grip (kg)</td>
<td>76.5</td>
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<td>81.44</td>
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<td>Ext Old</td>
<td>16.85</td>
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* Sig at <0.001

Secondary Aim 1:
No sig age-group differences existed in all variables

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<th>Characteristics</th>
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<th>Older</th>
<th>All Ages</th>
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<td>Maximal isometric</td>
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<td>29.45</td>
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<td>Pre-ex, JPS score (mean)</td>
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<td>5.37</td>
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<td>Post-ex, JPS score (mean)</td>
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* Sig at <0.05

Discussion
- Post-ex, JPS scores sig higher among all participants
  * Primary Aim Hypothesis accepted
- No significant difference between younger and older groups
  * Secondary Aim 1 Hypothesis accepted
- Significant correlation between JPS rate of change and total fatigue rate
- Near 20% muscle fatigue associated with near 200% JPS deficit
  * Secondary Aim 2 Hypothesis accepted

Designated
- Strengths:
  - Pioneer study & sig effects
  - Uninjured - stable population
  - Standardized methodology
  - Sig physiological muscle fatigue
  - Sig self-reported fatigue (RPE > 15)
  - MicroFet Intra ICC = .95

Limitations:
- Healthy population
- Small sample
  * Post hoc power analysis
  - ES = 2.6; Power = .8
- Calibrated gripper
  - Pre-ex, resistance increments
  - Exercise load were estimated
Conclusion

• Post-exercise induced fatigue
  • Associated with a sig JPS deficit
  • Causes sig decline on wrist proprioception
  • Regardless of age level

• Declined wrist proprioception post exercises requires caution
  • Possible increase of injury potential during function.

Future Directions

➢ JPS deficit post exercise among injured populations
➢ JPS deficit recovery time at the wrist

Acknowledgements

• All research team members
• Volunteer participants for their valuable contributions