Exercise Tolerance in Growing Rod “Graduates” – New Respiratory Functional Outcome Measure

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BACKGROUND

• Pulmonary function test (PFT) used as a primary outcome measure of respiratory capacity are highly dependent on patient effort and technical variations – making test of ?value

• EOS patients perceived to have physical limitations in spite of treatment, supported by generally underwhelming PFT results

TSRH GR grads
SRS 2015 eposter 220

\[ \text{FEV}_1 \text{pred} \quad 52\% \ (36-62) \]

\[ \text{FVC} \text{ pred} \quad 57.5\% \ (39-76) \]
EXERCISE EVALUATION

• To evaluate exercise \( \text{O}_2 \) consumption during a graded exercise test
• Characterize respiratory capacity in EOS patients who are \( \geq 1 \) year since last GR/definitive fusion surgery
METHODS: VO₂ CONSUMPTION TEST

• VO₂ collected breath by breath by gas exchange portable system
• Heart Rate monitor
• Variables
  • Ventilation:
    • Breaths/min (f)
    • Tidal volume (VT)
    • Ventilation (VE)
  • Cardiovascular:
    • HR, HR% - percent of age predicted HR max
• Metabolic :
  • VO₂ Rate (ml/kg/min)
  • VO₂ Cost (ml/kg/m)
  • respiratory exchange ratio (R) VCO₂/VO₂
  • VO₂ max predicted
• Velocity (mph)
METHODS: PROTOCOL

A. Oxygen consumption
   • Over-ground walking – self-selected velocity

   • Submaximal graded exercise test
     • Progressive treadmill protocol

   • VO₂ max predicted
     • reaching 85% 5% age-predicted heart rate (HR) max

B. Student t-test compared EOS patients to control group
RESULTS GR GRADUATES

EOS group diagnoses:
- 4 congenital
- 3 idiopathic
- 2 syndromic
- 2 neuromuscular

- Age at most-recent visit: 13.6 (9.8 – 17)
- Months since last surgery: 42.2 (23.9-66.6)
- Definitive fusions: 6
- Still lengthening: 1
- No lengthenings, observation only: 4

Preop, 5 years old

Most-recent 16.2 yo
8 lengthenings
0 complications
62.1 months since last surgery
### PATIENTS: EOS VS. CONTROL

<table>
<thead>
<tr>
<th></th>
<th>EOS</th>
<th>Control</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>11</td>
<td>20</td>
<td>--</td>
</tr>
<tr>
<td>Age at test</td>
<td>12.6</td>
<td>13.1</td>
<td>0.592</td>
</tr>
<tr>
<td>Height</td>
<td>150</td>
<td>157</td>
<td>0.215</td>
</tr>
<tr>
<td>Weight</td>
<td>38.8</td>
<td>52.2</td>
<td>0.090</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>FVC&lt;sub&gt;abs&lt;/sub&gt;</th>
<th>FVC %</th>
<th>FEV&lt;sub&gt;1 abs&lt;/sub&gt;</th>
<th>FEV&lt;sub&gt;1 %&lt;/sub&gt;</th>
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</thead>
<tbody>
<tr>
<td>EOS</td>
<td>1.2 (.48-2.04)</td>
<td>48.4 (23-80)</td>
<td>1.2 (.40-2.59)</td>
<td>50.5 (15-77)</td>
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</tbody>
</table>
OVER-GROUND WALKING

<table>
<thead>
<tr>
<th></th>
<th>VO₂ Rate ml/kg/min</th>
<th>HR bpm</th>
<th>VO₂ Cost ml/kg/m</th>
<th>Velocity mph</th>
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</thead>
<tbody>
<tr>
<td>EOS</td>
<td>21.0</td>
<td>131</td>
<td>0.28</td>
<td>2.8</td>
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<tr>
<td>Control</td>
<td>17.5</td>
<td>117</td>
<td>0.22</td>
<td>3.0</td>
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<tr>
<td>p value</td>
<td>0.107</td>
<td><strong>0.021</strong></td>
<td><strong>&lt;0.000</strong></td>
<td>0.083</td>
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</table>

- At self-selected walking velocity
  - EOS group had a higher HR and increased VO₂ Cost
  - Velocity was not significantly different \( p>ns \)
- **Able to keep up with peers**
END OF TEST (eg 85% HR_{Max})

- Compared to controls, the EOS group takes:
  - 36% higher resp rate
  - Achieving 50% the Volume at
  - 70% Ventilation rate
END OF TEST (eg 85% HR_{\text{Max}})

<table>
<thead>
<tr>
<th></th>
<th>VO_{2} Rate ml/kg/min</th>
<th>HR bpm</th>
<th>% HR max</th>
<th>Velocity mph</th>
<th>R* VCO_{2}/VO_{2}</th>
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</thead>
<tbody>
<tr>
<td>EOS</td>
<td>28.2</td>
<td>164</td>
<td>79%</td>
<td>2.8</td>
<td>1.02</td>
</tr>
<tr>
<td>Control</td>
<td>34.2</td>
<td>174</td>
<td>84%</td>
<td>3.6</td>
<td>0.90</td>
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<tr>
<td>p value</td>
<td>0.035</td>
<td>0.231</td>
<td>0.433</td>
<td><strong>0.000</strong></td>
<td><strong>0.004</strong></td>
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</table>

- Heart rate is similar, but EOS group consumes less VO_{2} while walking at a slower velocity.
- EOS group is working harder than controls (R = 1.02) 
  *R > 1.1 anaerobic metabolism (nearly at VO_{2} max)*
CAVEAT: VO₂ MAX \textsubscript{PRED}

- VO₂ max was predicted in 9/11 EOS patients
- EOS group showed a lower predicted VO₂ max than controls, but this was not significant
+VE CONCLUSION

• PFT suggests poor function  ~50% pred

• VO₂ test demonstrates that GR graduates are able to keep up with their peers with typical everyday walking velocity

• They have the capacity to exercise but at a lower work load (slower speed) due to respiratory limitations
NEXT STEP – EXERCISE TESTING FOR PATIENTS WITH “BETTER” PFT’S (>65%_{PRED})

Thank You