Aging and Skeletal Muscle Work Efficiency

OUTLINE:

• Work efficiency

• Work efficiency and “typical” aging (70 yrs)

• Work efficiency and the “oldest-old” (>85 yrs)

• Maximal Strength Training (MST) as a countermeasure for changes with normal aging
Work Efficiency

**Work Rate (Watts)**

**VO₂**

**Gross Efficiency**

**Net Efficiency**

**Delta Efficiency**

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Poole et al. *J. Appl. Physiol.*, 1992

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Poole et al. *J. Appl. Physiol.*, 1992
Work efficiency and typical aging

Typical elderly and walking efficiency

Ortega et al. J. Appl. Physiol., 2007
Cycling efficiency and the typically old

Young: 39 yrs (n=9)
Old: 69 yrs (n=40)

Two components of work efficiency

\[ \text{ATP} \rightarrow \text{Work} \]

\[ \text{O}_2 \rightarrow \text{P/O x 2} \rightarrow \text{Work/ATP} \rightarrow \text{Work/O}_2 \]

Mitochondrial Efficiency

Contractile Efficiency

Work Efficiency

Conley K E et al. Exp. Physiol. 2013
Contractile efficiency and the typically old

Plantar flexion - dynamic
120% of max power
$^{31}$P MRS
Young 22 yrs (n=18)
Old 74 yrs (n=18)

Contractile efficiency (non contractile processes) and the typically old

Continuous contraction (cross-bridge cycling)
Intermittent contractions (ion pumping)

Knee-extensor - isometric
Typical aging and skeletal muscle fiber type

Typical Healthy Aging

Skeletal Muscle Fiber Type:
Type II -> Type I

Young

Old


Skeletal Muscle Fiber Type and Work Efficiency

Coyle et al. J. Appl. Physiol., 1992
Work efficiency and exceptional aging....the oldest-old

Limitations to exercise in female centenarians: evidence that muscular efficiency tempers the impact of failing lungs

Massimo Venturelli • Federico Schena • Renato Scarsini • Ettore Muti • Russell S. Richardson

Table 2  Maximal work rate, oxygen consumption, and heart rate in centenarians and young controls at the end of a graded exercise test to maximum effort

<table>
<thead>
<tr>
<th></th>
<th>Centenarians (N=8)</th>
<th>Young (N=8)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD</td>
<td>Range</td>
<td>Mean±SD</td>
</tr>
<tr>
<td>Maximal work rate (watts)</td>
<td>33±4</td>
<td>(25–35)</td>
<td>179±24</td>
</tr>
<tr>
<td>VO_{2peak} (ml min^{-1} kg^{-1})</td>
<td>7.5±1.1</td>
<td>(6.1–9.3)</td>
<td>39.6±3.5</td>
</tr>
<tr>
<td>HR_{peak} (beats min^{-1})</td>
<td>102±4</td>
<td>(97–109)</td>
<td>178±10</td>
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Exercise in Centenarians
evidence of failing lungs, but......

Skeletal muscle:
oldest-old and inactivity
Subject Selection

Y

Oldest-old (>85 yr)

Skeletal muscle, the oldest-old, and inactivity

Young Old mobile Old immobile
Fiber type, the oldest-old, and inactivity

<table>
<thead>
<tr>
<th>Fiber type (%)</th>
<th>CSA (µm²)</th>
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<tbody>
<tr>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>100%</td>
<td>2000</td>
</tr>
<tr>
<td>200%</td>
<td>4000</td>
</tr>
<tr>
<td>300%</td>
<td>6000</td>
</tr>
<tr>
<td>400%</td>
<td>8000</td>
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Arm

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
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<tbody>
<tr>
<td>Y</td>
<td>OM</td>
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<tr>
<td>Y</td>
<td>OM</td>
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</table>

Leg

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
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<tbody>
<tr>
<td>Y</td>
<td>OM</td>
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<tr>
<td>Y</td>
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Work efficiency, the oldest-old, and inactivity

Exercise: dynamic flexion and extension

Maximal Strength Training (MST) as a countermeasure for typical aging

HIGH RATE OF FORCE DEVELOPMENT STRENGTH TRAINING

YIELDS 5-20% IMPROVEMENTS IN WORK EFFICIENCY
Maximal strength training and increased work efficiency: contribution from the trained muscle bed

Knee-extensor exercise
Pre and Post MST
4x4 85-90% of 1RM
3 x week

Fig. 3. Changes in pulmonary and 2-legged VO₂ after 8 wk of MST. Values are means ± SE; n = 5.

Old: 70 yrs
Young: 23 yrs
n = 22
Walking
5 mins
4.5 km/hr
3° inclination

Baseline

Eivind Wang

Effect of MST

Eivind Wang
Key Points:

- Normal aging (~ 60-75 yrs) attenuates work efficiency

- With exceptional aging (>85 yrs) work efficiency is improved

- Inactivity has a major impact on skeletal muscle aging

- MST appears to be a good countermeasure for both decreased work efficiency and Type II fibers