Improving the Mind with a Hop, Skip, and a Jump

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Part 2: What works?

Exercise, Aging Brain, and Cognition

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Outline

- Does mental exercise work?
- Does physical exercise work?
Does mental exercise work?

- Training improves the performance on trained tasks.
- The benefits of training can be very narrow – difficult to transfer to other untrained tasks.
- Mental exercise may not spare age-related cognitive declines.
Effects of training and transfer of training effects:

Ball et al., 2002 – The ACTIVE Project

Advanced Cognitive Training for Independent and Vital Elderly

N=2832, Age range: 65-94

10 session of training on:
  Memory
  Reasoning
  Speed

Outcome measures: Cognitive demanding everyday measures
Data from Ball et al., 2002. Adapted in Salthouse, 2006
The effect of crossword puzzles:

Salthouse, 2006
Ackerman, Kanfer, & Calderwood, 2010

Training on:

Wii – Nintendo big brain academy task
Knowledge related reading

20 hours a month for two months

Results:

Significant improvement in each task but no transfer to general abilities.
Can mental exercises spare us from age-related declines?

Not really
Age-related changes in chess masters

Salthouse, 2006
Amount of cognitively stimulating activities engaged:

Salthouse, 2006
Need for cognition – People seek out cognitive stimulation:
What about physical exercise?

- Fitness effects are seen in a number of cognitive functions (e.g., Colcombe & Kramer, 2003).

- Aerobic exercise has been associated with enhancement in brain structures and functions.
  - Cell proliferation
  - Brain Volume
  - Hippocampal volume
  - Medial temporal lobe
  - Improved functions
    - Task switching Churchill et al., 2002
    - Attention control: Prakash et al., 2011

- Aerobic exercise in other areas:
  - Decrease the proportions of senescent blood T-cells (Spielmann, et al., 2011)
  - Insulin resistance and cognitive functions (Yanagwa, et al., 2010)
Colcombe & Kramer, 2003 - A Meta Analysis

All of the studies included in the analyses had:

- an aerobic fitness component
- a longitudinal design

The main findings are:

1. Fitness training increased performance 0.5SD on average.

2. Robust but process-specific benefits accrue with fitness training.
1. Fitness training increased performance 0.5SD on average

<table>
<thead>
<tr>
<th>Moderator variable</th>
<th>Effect size</th>
<th>SE</th>
<th>n</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>0.164</td>
<td>0.028</td>
<td>96</td>
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<tr>
<td>Exercise</td>
<td>0.478$^1$</td>
<td>0.029</td>
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<td>Exercisers</td>
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<tr>
<td>Training characteristics</td>
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<tr>
<td>Training type</td>
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<tr>
<td>Combined</td>
<td>0.59$^2$</td>
<td>0.049</td>
<td>49</td>
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<tr>
<td>Cardiovascular only</td>
<td>0.41</td>
<td>0.037</td>
<td>52</td>
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<tr>
<td>Program duration</td>
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<tr>
<td>Short (1–3 mo)</td>
<td>0.522$^2$</td>
<td>0.067</td>
<td>38</td>
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<tr>
<td>Medium (4–6 mo)</td>
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<tr>
<td>Long (6+ mo)</td>
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<td>Session duration</td>
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<td>Short (15–30 min)</td>
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<td>Moderate (31–45 min)</td>
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<td>Long (46–60 min)</td>
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<td>0.041</td>
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<td>Participants’ characteristics</td>
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<td>Sex</td>
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<tr>
<td>High female (&gt;50% female)</td>
<td>0.604$^2$</td>
<td>0.036</td>
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<td>High male (≥50% male)</td>
<td>0.150</td>
<td>0.055</td>
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<tr>
<td>Age</td>
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<tr>
<td>Young-old (55–65)</td>
<td>0.298</td>
<td>0.044</td>
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<tr>
<td>Mid-old (66–70)</td>
<td>0.693$^{1,3}$</td>
<td>0.056</td>
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<tr>
<td>Old-old (71–80)</td>
<td>0.549$^1$</td>
<td>0.058</td>
<td>33</td>
<td>*</td>
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</table>
2. Robust but process-specific benefits accrue with fitness training.
Aerobic exercise has been associated with enhancement in brain structures and functions.

- Cell proliferation
- Brain Volume
- Hippocampal volume
- Medial temporal lobe
Cell proliferation  
Van Praag, Kempermann, & Gage, 1999
- Cell proliferation was only associated with voluntary running.
- Both running and enrichment groups roughly doubled the total number of surviving new cells in the dentate gyrus.
Running enhances cell genesis in aged mice: Kannangara et al., 2011
Running reduces stress in aged mice: Kannangara et al., 2011
Brain Volume: Colcombe et al., 2006

59 healthy older adults, age between 60-79

6 months of randomized clinical trial

Aerobic training versus stretching & toning
   One hour training three times a week for six months.
   40-50% to 60-70% of maximum HR

Found increases in volume in the prefrontal and temporal regions.
Blue regions: Gray matter volume was increased for aerobic exercisers, relative to nonaerobic controls. Yellow regions: White matter volume was increased for aerobic exercisers, relative to controls.

Colcombe et al., 2006
Churchill et al., 2002

Task Switching Paradigm

Reaction Time (ms)

Switch pre-exercise
Switch post-exercise
Non-switch pre-exercise
Non-switch post-exercise

Exercise Group

Walking
Toning
Hippocampal volume:

Erickson et al., 2009

109 Female and 56 Male

Age: 59-81 years old
A training study - Erickson, et al., 2011

Increases size of hippocampus
Improves memory

Aerobic training: N=60

40 minute walking sessions – for a year
60-75% maximum heart rate

Stretching and tones –
yoga, dumbbells, resistant bands
The exercise group showed a selective increase in the anterior hippocampus and no change in the posterior hippocampus.
Aerobic fitness and hippocampal volume

Erickson, et al., 2011
Hippocampal volume and cell proliferation

Erickson, et al., 2011

Hippocampal volume and spatial memory
Erickson, et al., 2011
The medial temporal lobe:

Bugg & Head, 2011

N=52, 55-79 years old

Exercise history in the past 10 years
The Big Picture

Environmental Factors
(e.g., Available facilities, Social support, Climate)

→ Physical Activity → Fitness

→ Disease Reduction
(e.g., Cardiovascular Disease, Stroke, Diabetes, Hypertension)

→ Personal Factors
(e.g., Self-efficacy, Self-schema, Exercise history)

→ Enhancement in Brain Structure and Function
(e.g., Increased production & efficiency of neurotransmitters, Angiogenesis, Synaptogenesis, Neurogenesis)

→ Cognition

McAuley, Kramer, & Colcombe, 2004
Thank You