Physical Activity to Promote Brain Health

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Age and Cognitive Decline

Schaie, 1994
Age and Brain Atrophy
Is Decline Inevitable?

- Much variability in the rate and degree of decline
- Significant decline is not an absolute consequence of aging

Wilson, 2002
Significant CognitiveDecline is **not** Inevitable

- Brain is plastic throughout the lifespan
  - Both brain structure and function adapt to experience
  - Akin to your muscles responding positively to exercise
    - i.e., stronger, more toned
Road Map

Physical Activity & Brain Health

- Relationship
- Mechanisms
- Relevance to Healthy Aging
Types of Studies

• “Cohort”
  – Track people over time
  – No prescribed treatment/intervention
  – Describes relationships

• “Randomized Trials” (RCT)
  – Track people over time
  – Treatments/interventions are randomly prescribed
  – Describes relationships
Cohort Study

• Weuve et al., JAMA, 2004
  – 18,766 US women aged 70 to 81 years
  – 8 to 15 years of follow-up
  – Higher levels of long-term regular physical activity were strongly associated with higher levels of cognitive function and less cognitive decline.
    • 3 years younger in age
    • 20% lower risk of cognitive impairment
Cohort Study

• Benefits were not restricted to those at the highest level of physical activity
• Those who walked ≥ 1.5 hr/week at a pace of 21–30 min/mile showed significantly less cognitive decline than those who walked for less than 38 min/week.
  • 21-30 min/mile = walking 4 times around a standard track in 30 minutes
  • ~13 minutes/day versus ~5 minutes/day
  – Or, walking 2 times around a standard track in 15 minutes per day is neuroprotective.
Randomized Trials

- Exercise Training
  - Aerobic Training
    - Running, walking, swimming
  - Resistance Training
    - Lifting weights
  - Balance/Agility Training
  - Others: Yoga, Tai Chi, dance
Aerobic Exercise Promotes Cognitive Function in Older Adults

Colcombe and Kramer, 2002
Meta-Analysis of Aerobic Training

  - Exercise training positively benefits different cognitive abilities
  - Most beneficial for executive functions
    - Planning, decision making, multi-tasking
  - Studies with more women show a larger effect of training on cognition
  - Benefit of training is similar for both normal and cognitively impaired adult
What are the effects of aerobic exercise on cognitive function, brain function, and brain structure in older adults?
Study Design

Colcombe, 2004 & 2006
Voss, 2010
Erickson, 2011
RCT of Aerobic Training

- A 6-month, 3x/week walking program improved:
  - Cognitive performance of executive functions
  - Brain function as assessed by fMRI (Flanker)
    » Colcombe et al., 2004
RCT of Aerobic Training

• A 6-month, 3x/week walking program increased:
  – Brain volume as assessed by MRI
    » Colcombe et al., 2006
RCT of Aerobic Training

• A 12-month, 3x/week walking program improved/increased:
  – Cognitive performance of memory
  – Hippocampus volume by 2%
    • Reversing age-related loss in volume by 1 to 2 yrs
      » Erickson et al., 2011
Higher aerobic fitness was associated with larger hippocampal volumes.
RCT of Aerobic Training

• Among older women with Mild Cognitive Impairment (MCI), a 6-month, 4x/week walking program:
  – Improved cognitive performance of executive functions
  – Reduced fasting plasma levels of insulin and cortisol

» Baker et al., 2010
Walking Improves Network Connectivity

Voss, 2010
Improved Connectivity Related to Increased Levels of Growth Factors

- Growth factors: a protein or a steroid hormone
- Stimulate cellular growth, proliferation, and cellular differentiation
What are the effects of resistance exercise on cognitive function, brain function, and brain structure in older adults?
What about Resistance Training?

• To date, less studied than aerobic training

• Resistance training:
  – Moderates sarcopenia
    • Falls and fracture risk
  – Promotes bone health
RCT of Resistance Training

• Both 3x/week moderate- and high-intensity resistance training for 6 months significantly improved:
  – Cognitive performance of memory (verbal and spatial) & executive functions
  – Men aged 65 to 75 years old

  » Cassilhas, 2007
Brain Power Study

Liu-Ambrose, 2010 & 2011

- Baseline Measurement
  - Randomization
    - 1x/week Resistance Training
      - Follow-Up Measurement
    - 2x/week Resistance Training
      - Follow-Up Measurement
    - 2x/week Balance & Tone Exercises
      - Follow-Up Measurement
Who Participated

- Women (N=155)
- 65 to 75 year-old
- Community dwelling
- Not partaking in resistance training
- No contraindications to exercise
- No history of stroke or neurodegenerative disease
- MMSE > 24/30
Intervention

• Resistance Training
  – 2x/week or 1x/week
  – Certified instructors
  – 60-minute classes (40 minutes of training)
  – Progressive loading using 8RM
    • 2 sets of 8 reps

• Balance and Tone
  – 2x/week
  – 60-minute classes
Resistance Training Improves Attention and Decision Making

After 12 months of training, significant improvement in executive functions in both 1x/week and 2x/week RT compared with BAT.
Resistance Training is Cost-Effective

Existing treatment dominates

New treatment more effective but more costly

New treatment less costly but less effective

New treatment dominates

Davis, 2011

1xRT

2xRT
EXCEL Study: Promoting Cognitive Function in MCI

Nagamatsu, 2012 & 2013

Baseline Measurement

Randomization

2x/week Aerobic Training
Follow-Up Measurement

2x/week Resistance Training
Follow-Up Measurement

2x/week Balance & Tone Exercises
Follow-Up Measurement
Who Participated

• Women (N=86)
• 70 to 80 year-old
• Community dwelling
• Not partaking in resistance training or aerobic training
• No contraindications to exercise
• No history of stroke or neurodegenerative disease
• Have objective cognitive deficits
• Have not been diagnosed with dementia
• Subjective memory complaints
Resistance Training Improves Executive Functions in MCI

- After 6 months of 2x/week resistance training, significant improvement in attention and decision compared with BAT.
  - 17% vs. 11 to 13% observed in cognitively intact older adults
  - 6 months vs. 12 months
Resistance Training Improves Associative Memory

![Bar Graph](change_in_dprime.png)

- Change in d'prime
  - BAT: 0.3
  - AT: 0.0
  - RT: 0.5

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UBC a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Coastal Health

Aging, Mobility, and Cognitive Neuroscience Lab
Aerobic Training Improves Memory Recall in MCI

5 trials with List A

List A
- Violin
- Tree
- Scarf
- Ham
- Suitcase
- Cousin
- Earth
- Stairs
- Etc.
- Total

List A
- Violin
- Tree
- Scarf
- Ham
- Suitcase
- Cousin
- Earth
- Stairs
- Etc.
- Total

List A
- Violin
- Tree
- Scarf
- Ham
- Suitcase
- Cousin
- Earth
- Stairs
- Etc.
- Total

List A
- Violin
- Tree
- Scarf
- Ham
- Suitcase
- Cousin
- Earth
- Stairs
- Etc.
- Total

List A
- Violin
- Tree
- Scarf
- Ham
- Suitcase
- Cousin
- Earth
- Stairs
- Etc.
- Total

List B | List A
---|---
Orange | Violin
Table | Tree
Toad | Scarf
Corn | Ham
Bus | Suitcase
Chin | Cousin
Beach | Earth
Soap | Stairs
Stairs | Etc.
Etc. | Total
Total | Total

Recall after delay

AT showed reduced loss compared with BAT

<table>
<thead>
<tr>
<th>Change in loss after interference (trial completion - baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
</tr>
<tr>
<td>-2</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
</tr>
</tbody>
</table>

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Vancouver Coastal Health
C O G M O B
Aging, Mobility, and Cognitive Neuroscience Lab
Summary

• Moderate physical activity is beneficial for cognitive function
  – Even among those at greater risk for dementia
• Starting to exercise in late life is not futile: even those who are sedentary can improve function
Summary

• Physical activity induces changes in brain structure, brain function, growth factor levels, glucometabolic & stress responses
  – Other pathways include: sleep, mental wellness, self-efficacy
Summary

• More research is needed to refine the prescription of physical activity for maximum benefit
  – Frequency, intensity, type, and duration of physical activity
  – Target population
Road Map

Physical Activity & Brain Health

- Relationship
- Mechanisms
- Relevance to Healthy Aging
What are the Long-Term Consequences of Regular Physical Activity?

- The Cardiovascular Health Study – Pittsburgh Site
- Cohort study of heart disease and dementia
- “How many city blocks do you walk per week?”
Consequences of Regular Physical Activity: 9 Years Later

• Walking greater distances in 1989/90 was associated with greater brain volume in 1998/99
  » Erickson, 2010
Consequences of Regular Physical Activity: 9 Years Later

- Walking greater distances in 1989/90 was associated with greater brain volume in 1998/99
- Greater gray matter was related to reduced risk of cognitive impairment

» Erickson, 2010
How Much Regular Physical Activity is Necessary?

• Participants divided into 4 groups based on blocks walked:
  – Q1 = 0 to 12 blocks/week
  – Q2 = 13 to 24 blocks/week
  – Q3 = 25 to 70 blocks/week
  – Q4 = 72 to 300 blocks/week

• ≥ 72 city blocks/week required for neuroprotection
How Much Regular Physical Activity is Necessary?

• What does 72 city blocks/week look like?
  – 1 city block ~80 to 100 meters
  – Assuming 100 meters, then 72 blocks/week = 7200 meters/week, or 7.2 km/week
  – 7.2 km/week = 1.03 km/day
How Much Regular Physical Activity is Necessary?

• What does 1.03 km/day look like?
  – 2.6 laps around a standard track
    • Concurs beautifully with the findings of Weuve et al., 2004
  – 10.3 city blocks
  – A 12.7 minute walk for an otherwise healthy older adults (gait speed of 1.35 m/sec).
  – A 26.4 minute walk for more frail older adults (gait speed of 0.65 m/sec).
Adopting Physical Activity Later in Life: Still Beneficial?

- 9344 women aged ≥ 65 and older self-reported teenage, age 30, age 50, and late-life physical activity
- Those who were physically active at any age, particularly as teenagers, had better cognitive performance and lower likelihood of cognitive impairment in late life than women who were physically inactive.
- Women who were physically inactive as teenagers and became active in later life had lower risk than those who remained inactive.

» Middleton, 2010
Summary

• Regular physical activity is sufficient for maintaining brain health
  – Moderate level of activity
• It’s never too late to start, although the earlier the better!

“A sound mind in a healthy body”
Overall Conclusion

• Physical activity is a legitimate medical therapy.

• It is a magic bullet and polypill to health and overall well-being.
Physical Activity: Key to Quantity and Quality of Life
Aging, Mobility & Cognitive Neuroscience Lab

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