Active Lives, Healthy Brains: What Do Our Brains Need to Age Well?

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Director, Health, Brain & Cognition Lab

Co-Director Behavioral-Biomedical Interface Training Program

Healthspan is the period of life we are in good health

Lifespan

Healthspan **Age-related disease**

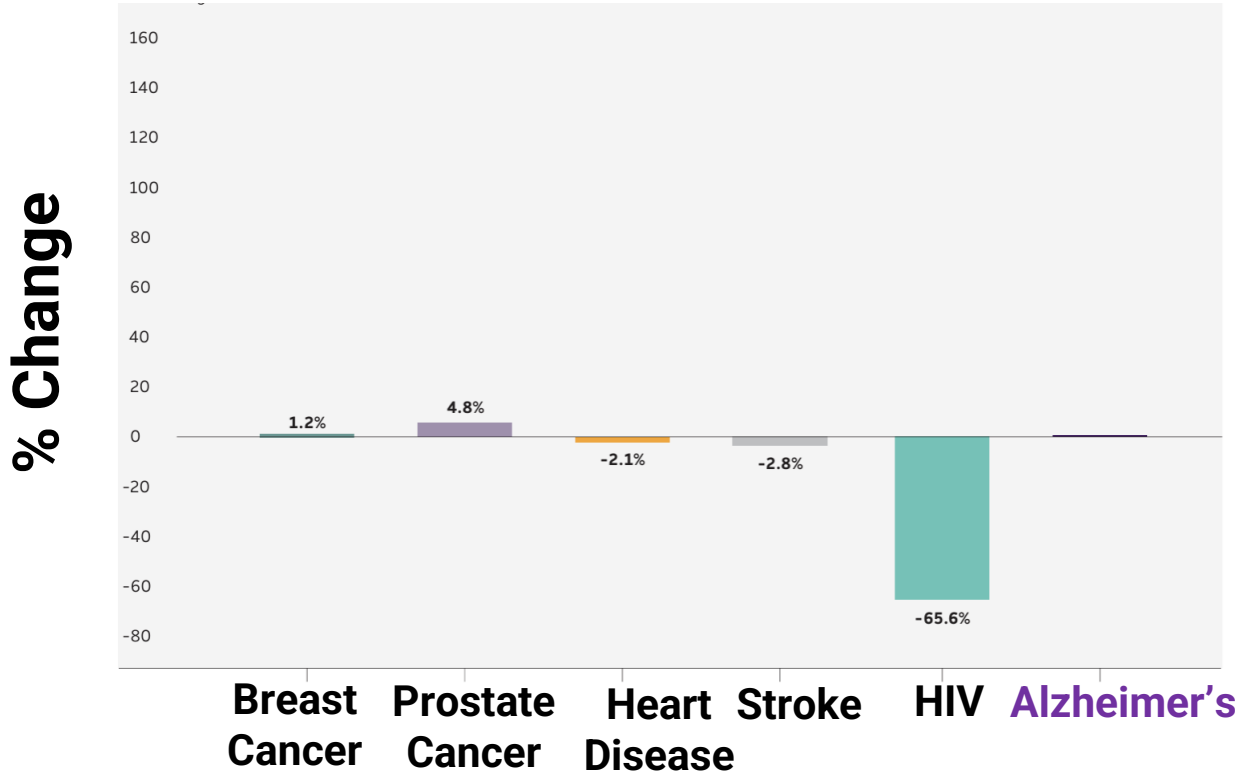
Mobility &
Cognitive health



Alzheimer's is our biggest threat to Healthspan

Death rates from Alzheimer's and related dementias continue to increase

Percentage Changes in Causes of Death 2000-2021



Aging Communities

After age 65, the risk of Alzheimer's doubles every five years.

Before Alzheimer’s and dementia, people can live up to 20 years with cognitive impairment affecting everyday life.



Cognitive Health Continuum

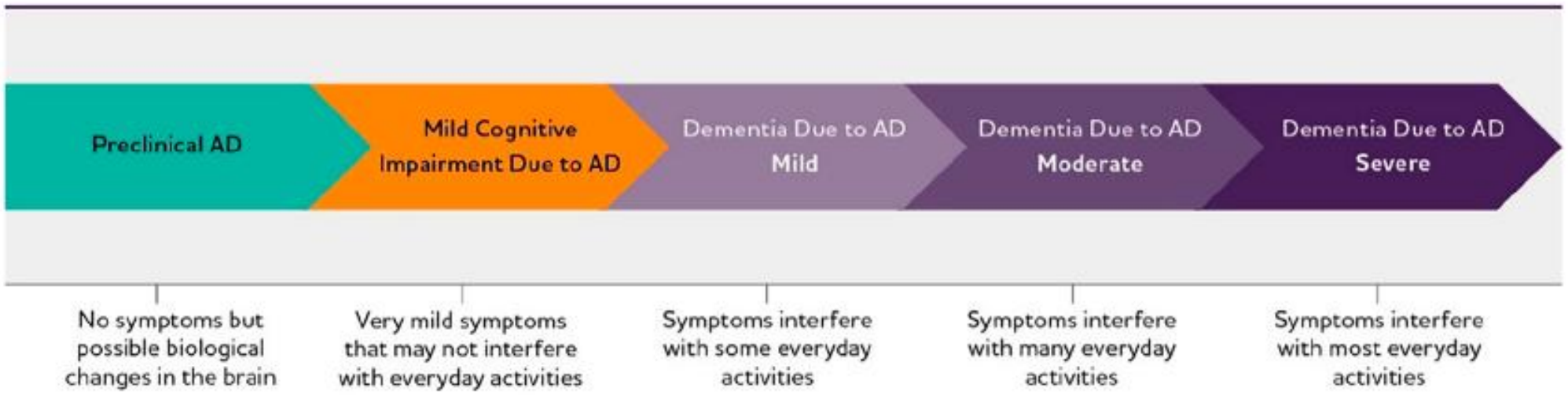
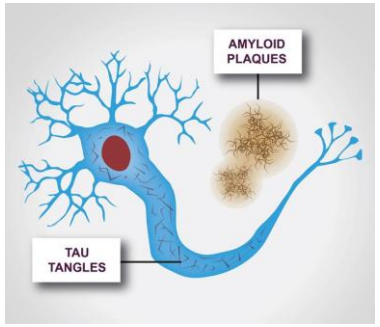


FIGURE 1 Alzheimer's disease (AD) continuum. Although these arrows are of equal size, the components of the AD continuum are not equal in duration.



Transition stage
Mild Cognitive Impairment

Cognitive Health Continuum

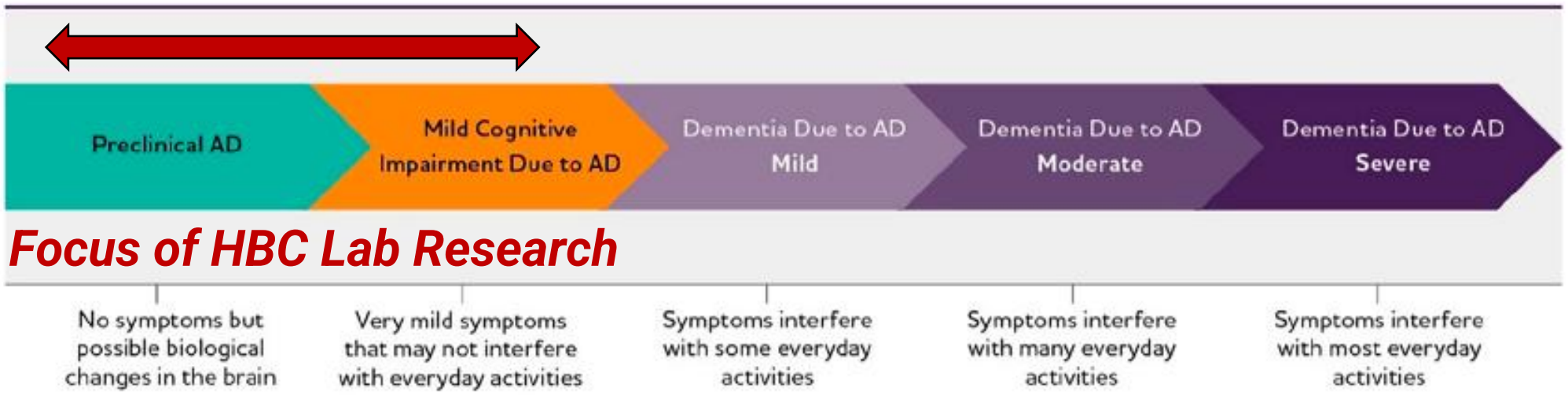
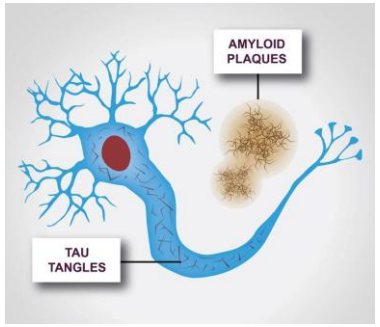


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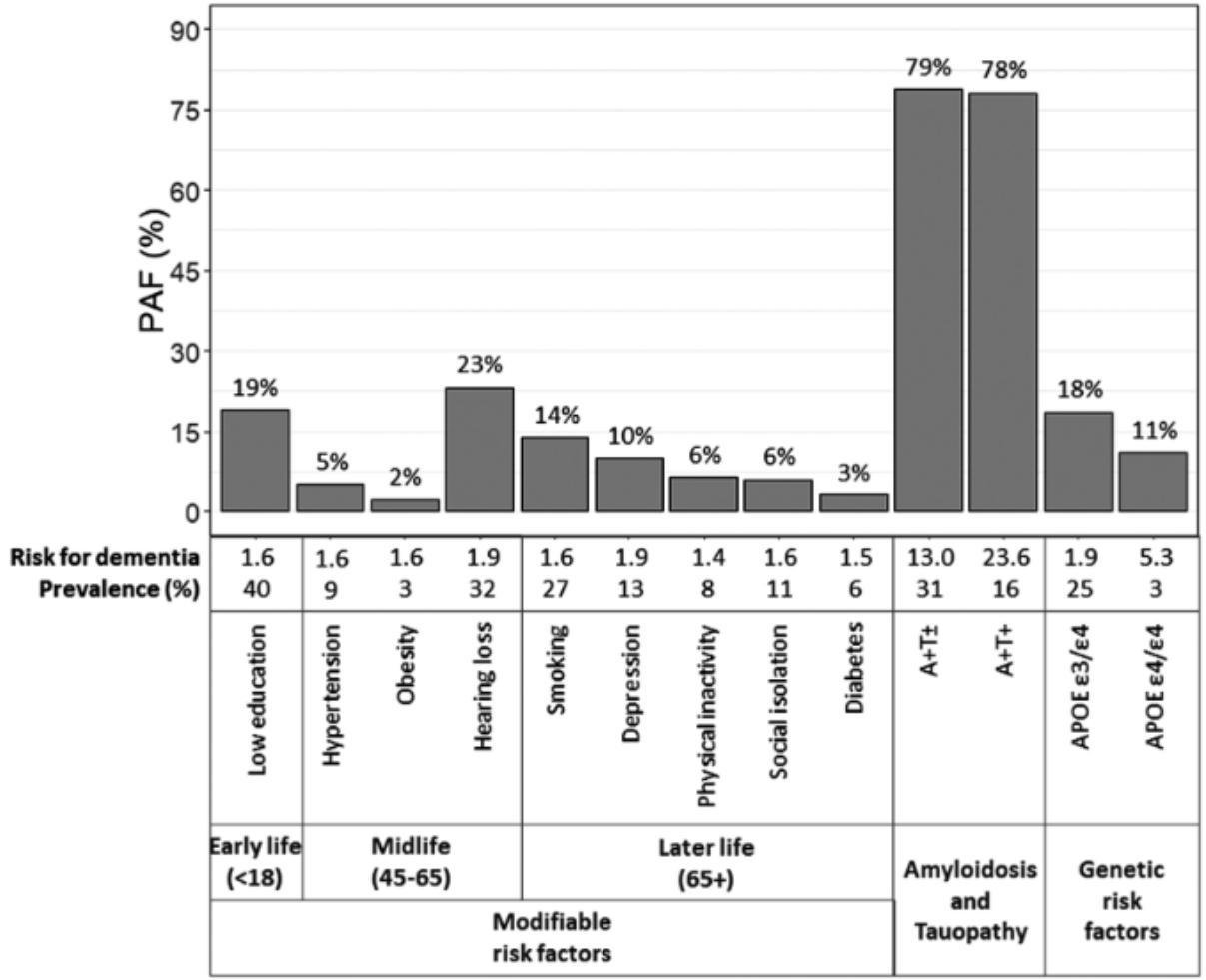


Transition stage
Mild Cognitive Impairment

Risk factors for cognitive impairment and AD

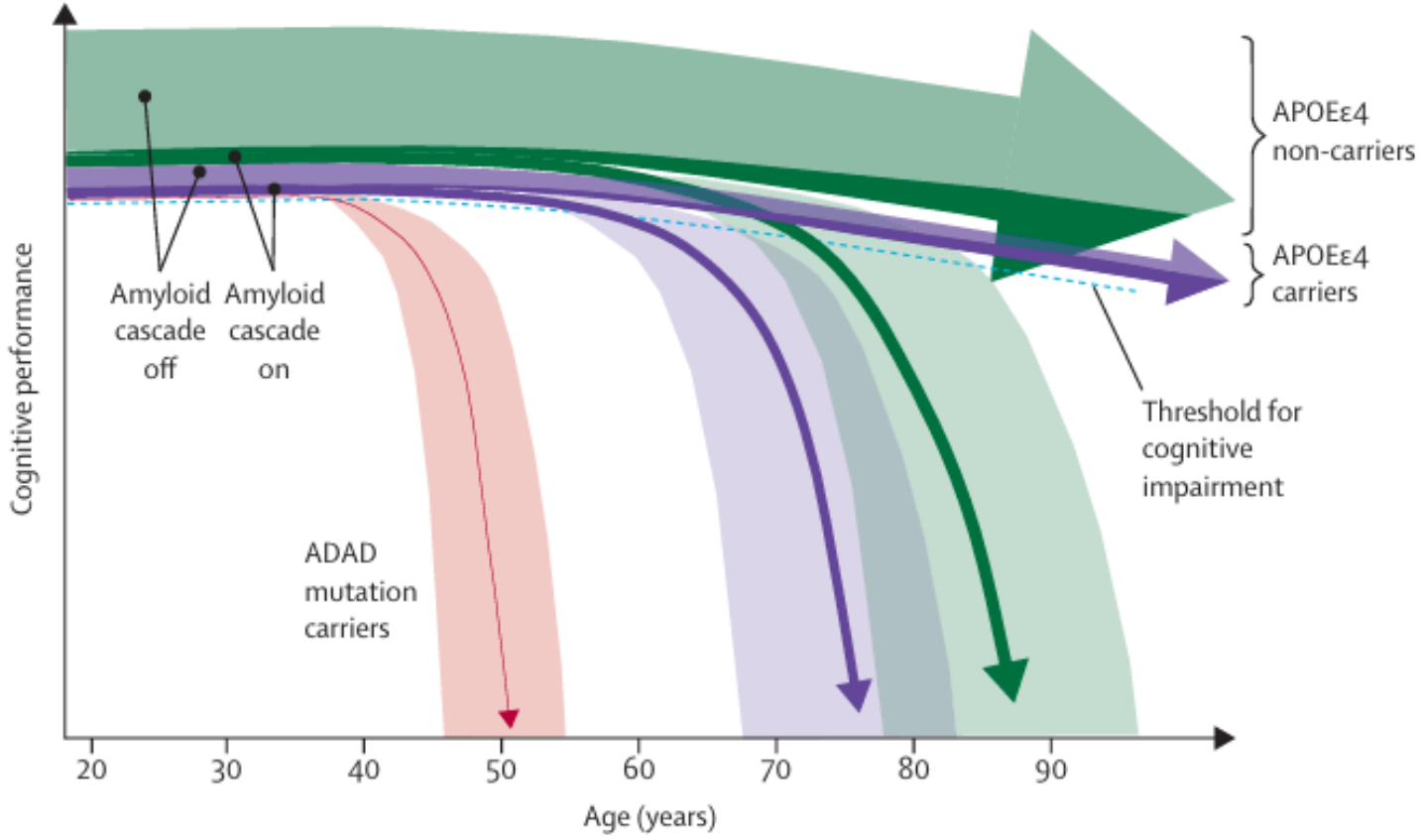


Risk factors for cognitive impairment and AD



Frisoni et al., 2020, Alzheimer's & Dementia

Risk factors for cognitive impairment and AD



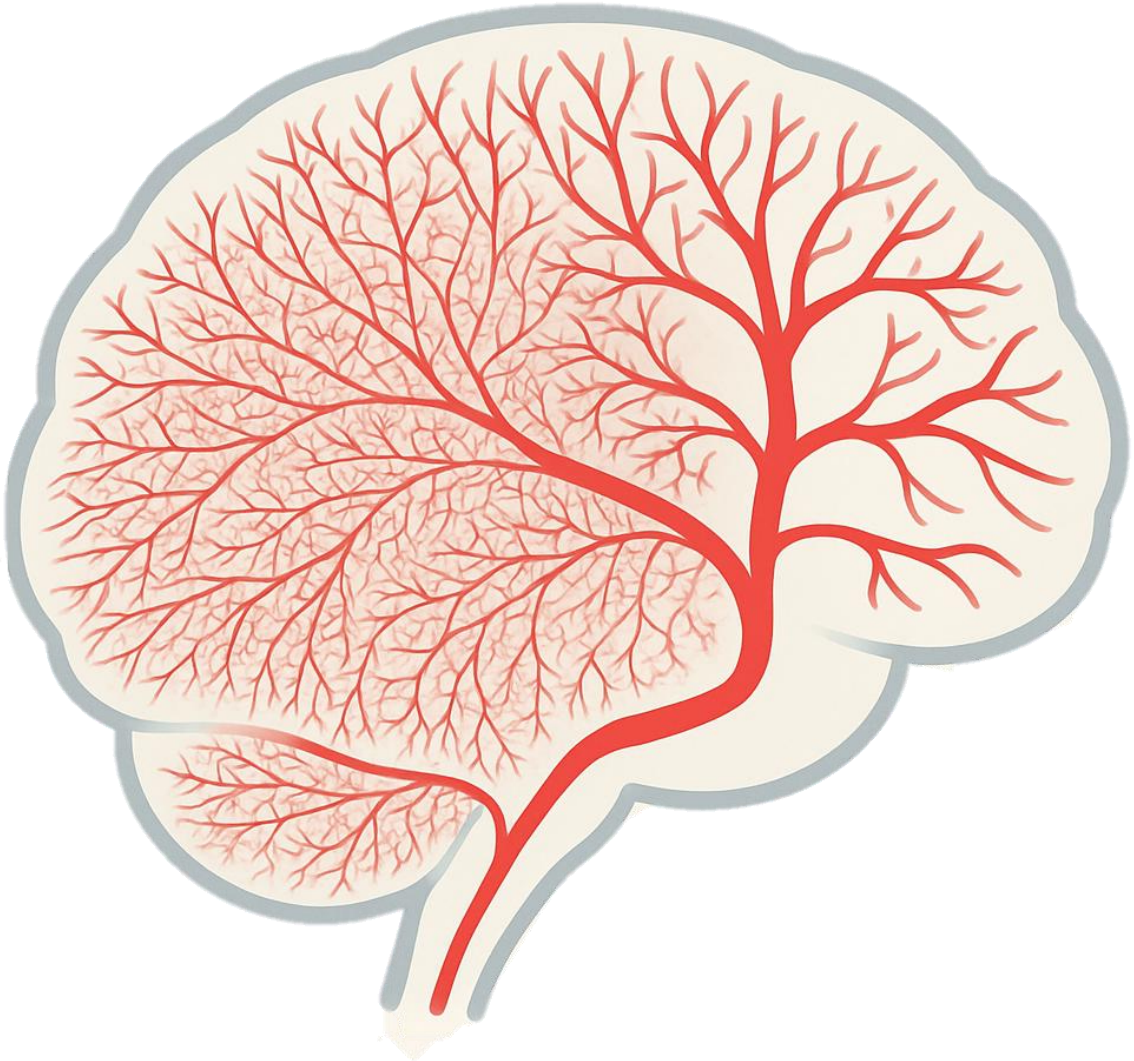
IOWA

Frisoni et al., 2025, The Lancet

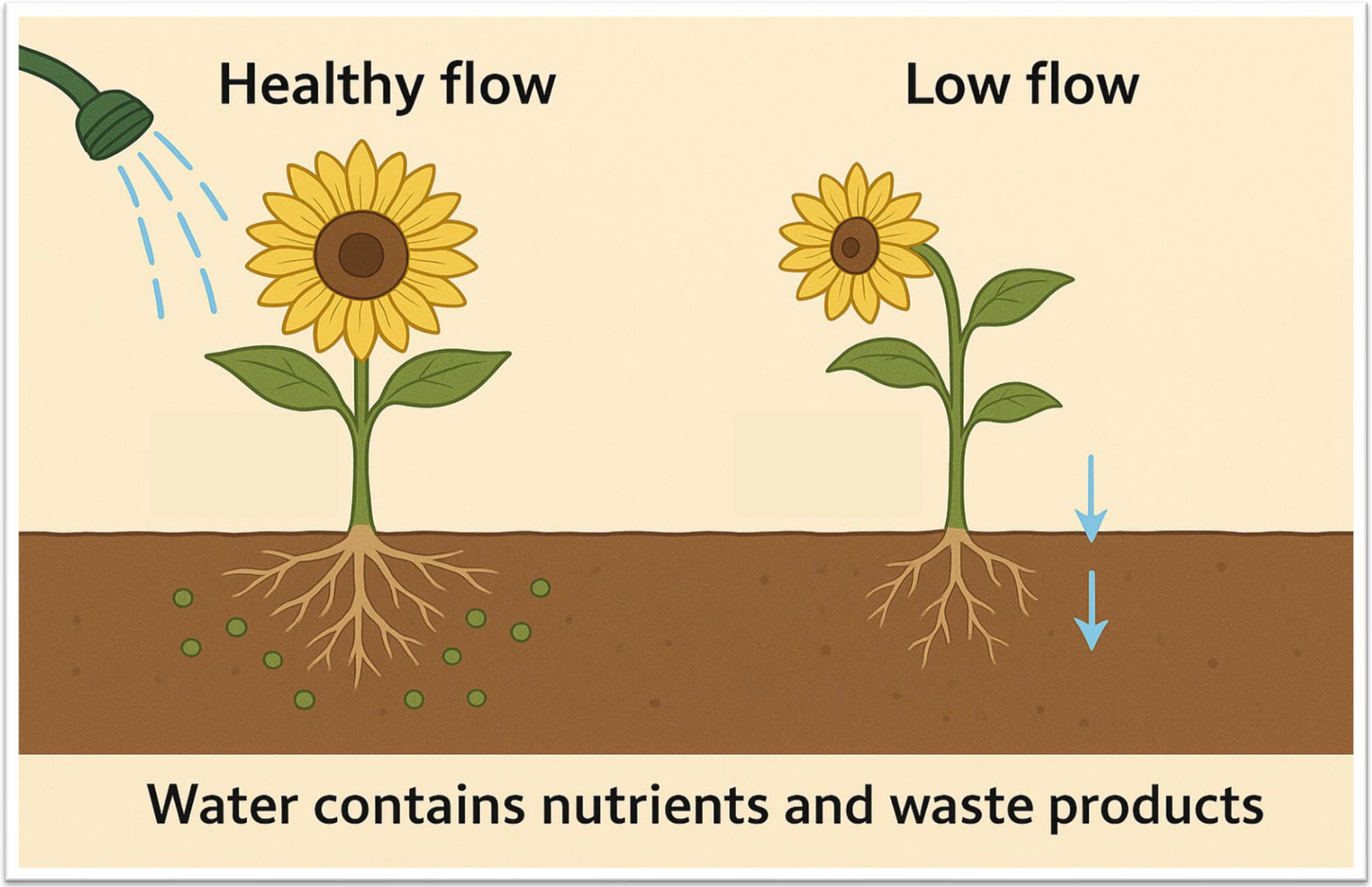
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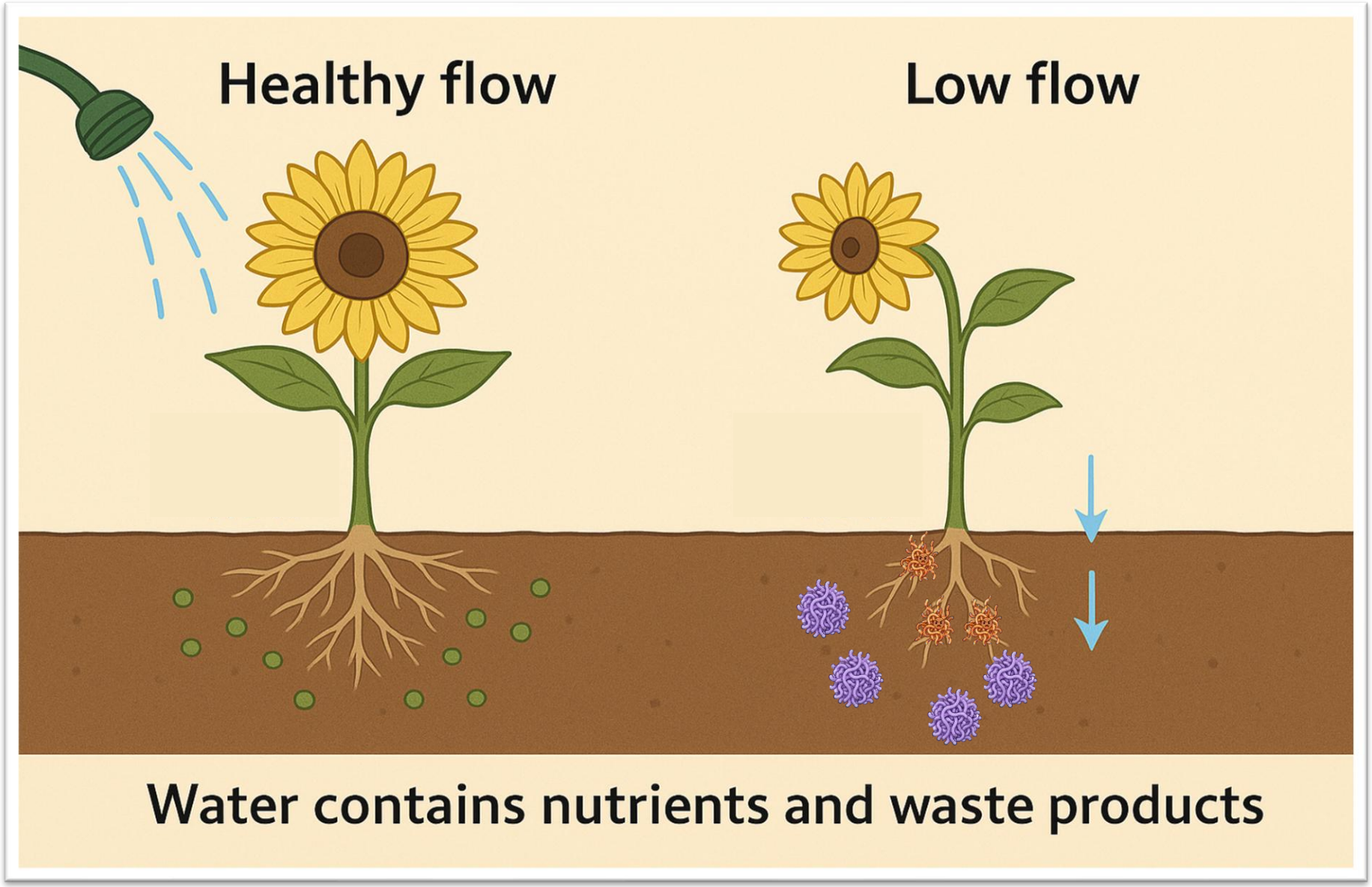
Healthy blood flow supports brain cells by delivering energy and clearing waste



Water does the same for your garden



Water does the same for your garden

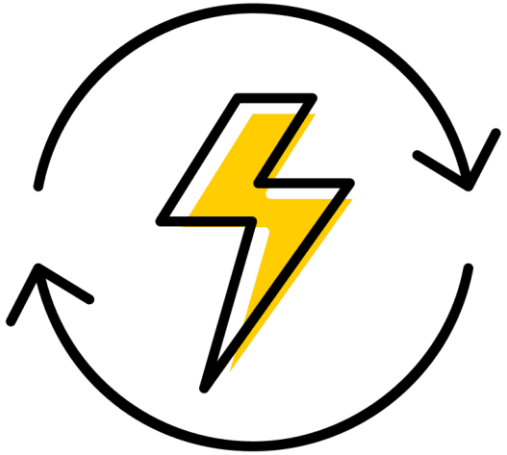


Healthspan: What can W.E. do?

Work your heart: What is good for your heart is good for your brain



Engage your brain: Find new things to learn that challenge you



Health, Brain & Cognition Lab at the University of Iowa

Department of Radiology



Department of Psychological and Brain Sciences

Department of Health, Sport, and Human Physiology







Cognition (e.g., memory) and brain structure and function



Cardiorespiratory Fitness (CRF)



Figure 1. Cardiopulmonary exercise testing (CPEX) is generally performed on a cycle ergometer. Ventilatory ga exchange is measured in addition to electrocardiogram (ECG), blood pressure (BP) and O saturation







Cardiorespiratory fitness (CRF) links the heart and brain



Exhale CO_2

CO_2 enriched, O_2 depleted blood back to the heart

Inhale O_2

O_2 rich blood from lungs to body

Exercising muscle uses O_2

cellular respiration

mitochondria

glucose
fat

Cardiorespiratory fitness (CRF) links the heart and brain

Measured as maximal volume of oxygen you can use to generate energy, relative to your body weight: ml/kg/min



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O_2 rich blood from lungs to body

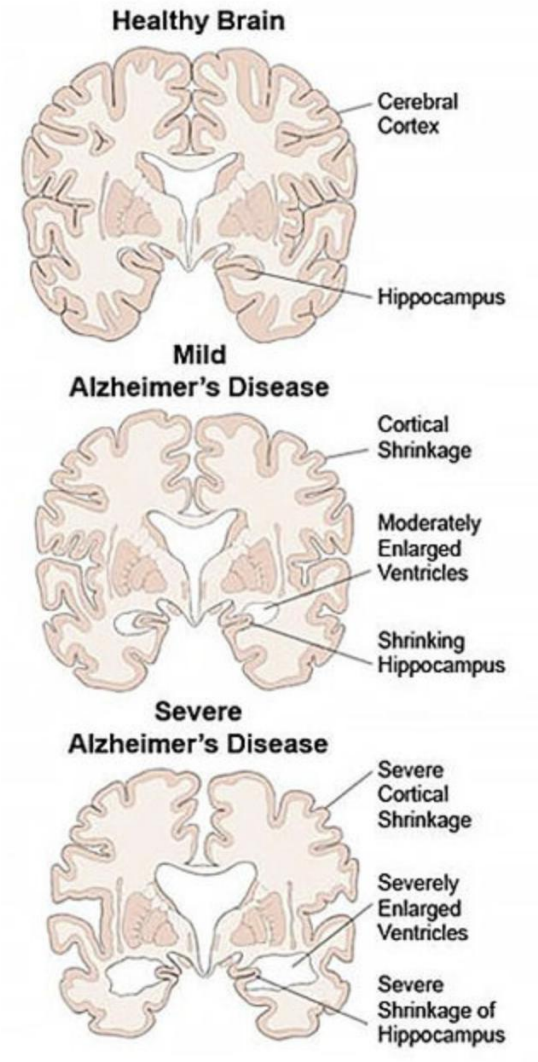
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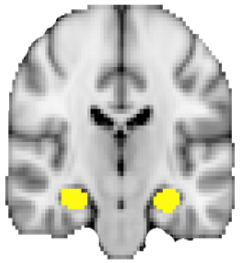
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Work your heart: Maintain brain structure





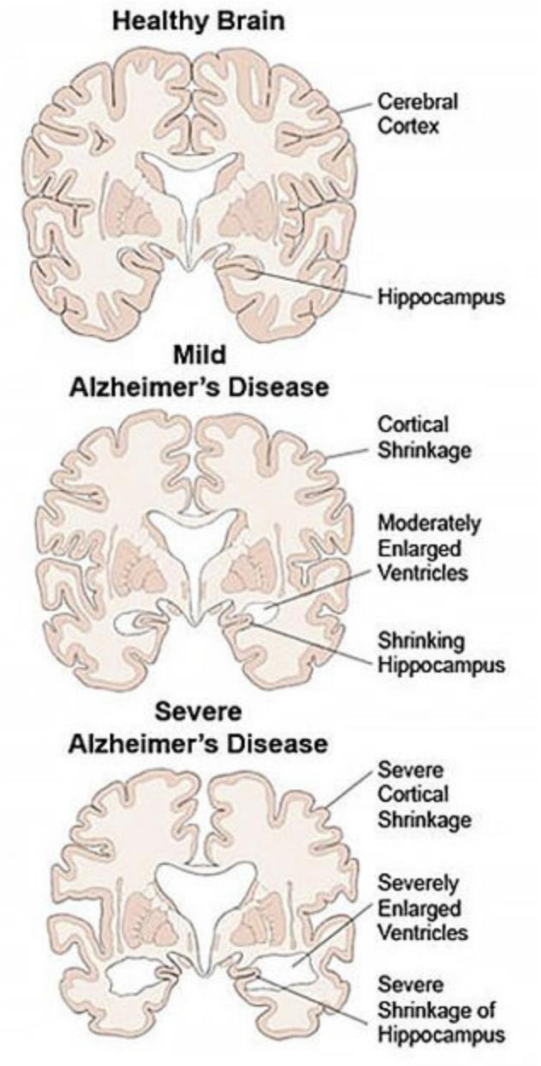
Hippocampus



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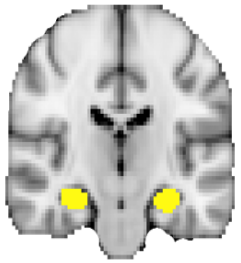
Erickson, Voss, et al, 2011

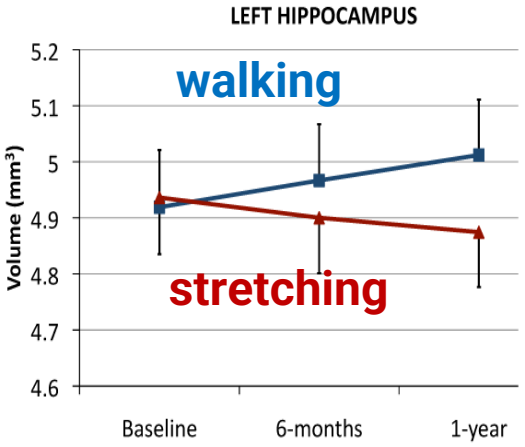
Exercise training slows hippocampal atrophy

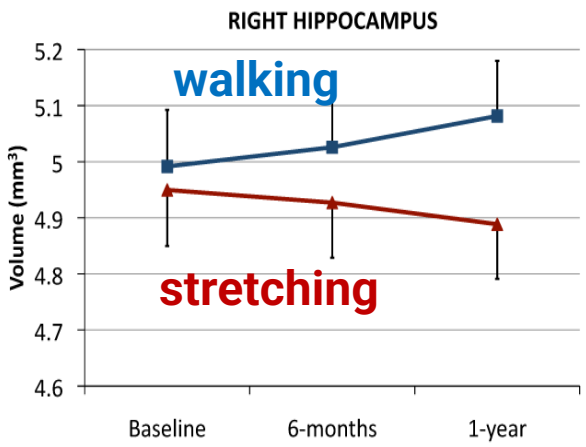




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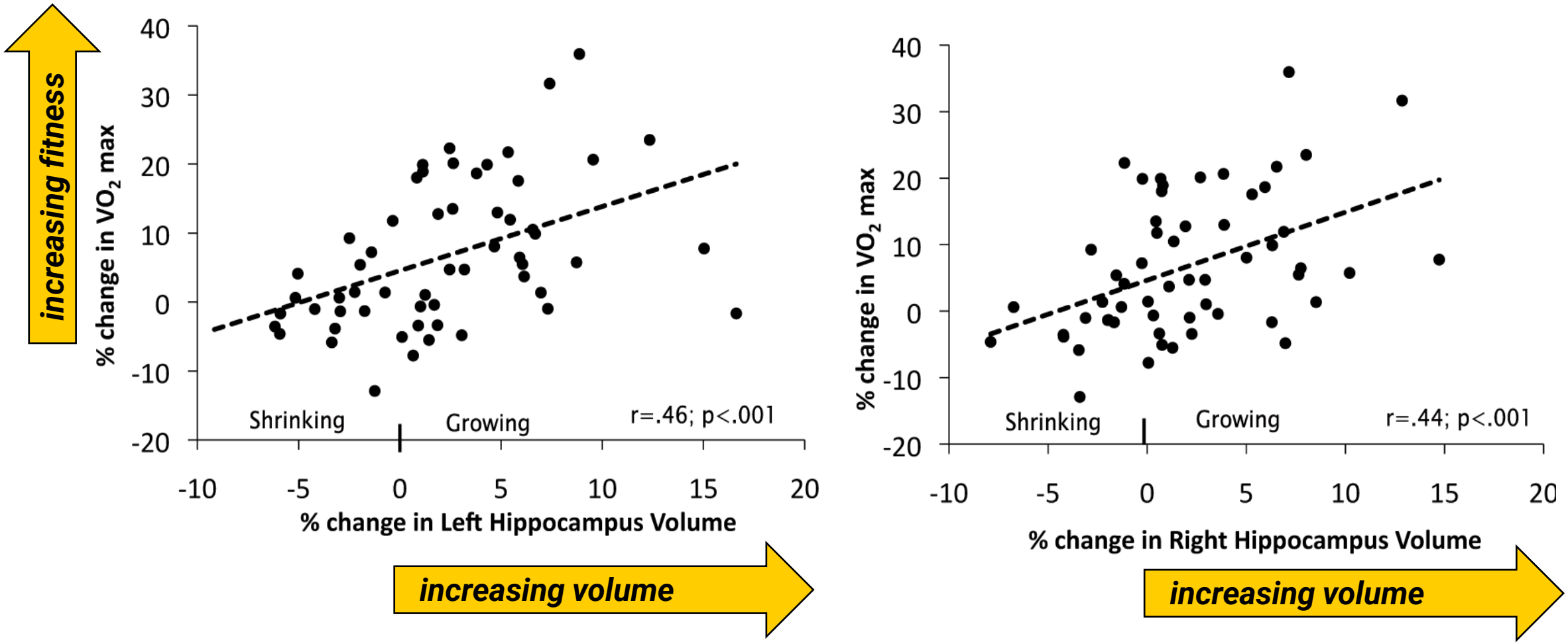




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Erickson, Voss, et al, 2011

Brain benefits linked to cardiorespiratory fitness



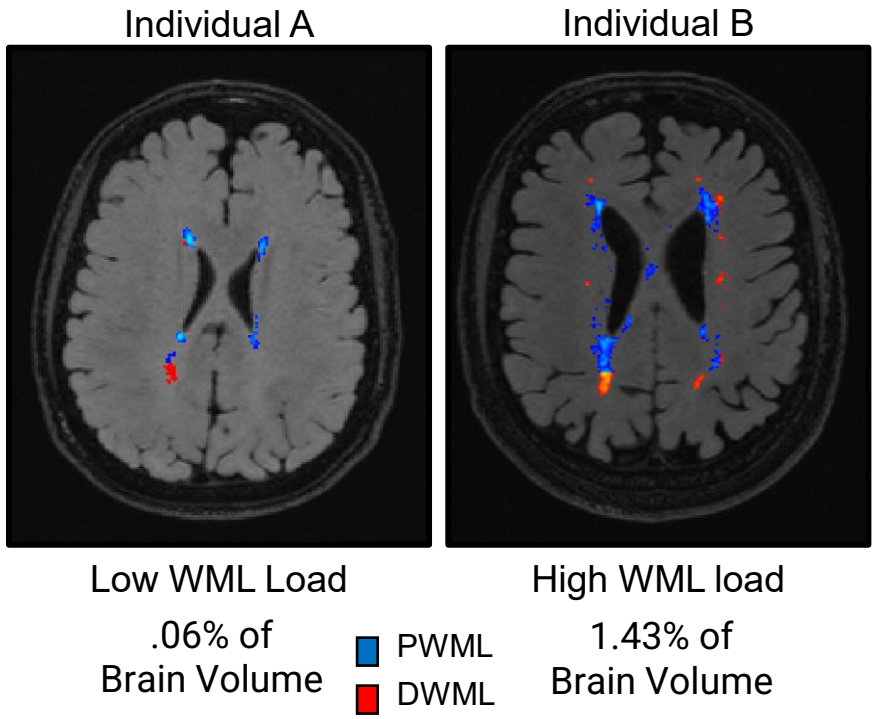
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Work your heart: Maintain brain structure

White Matter Lesions (WMLs)

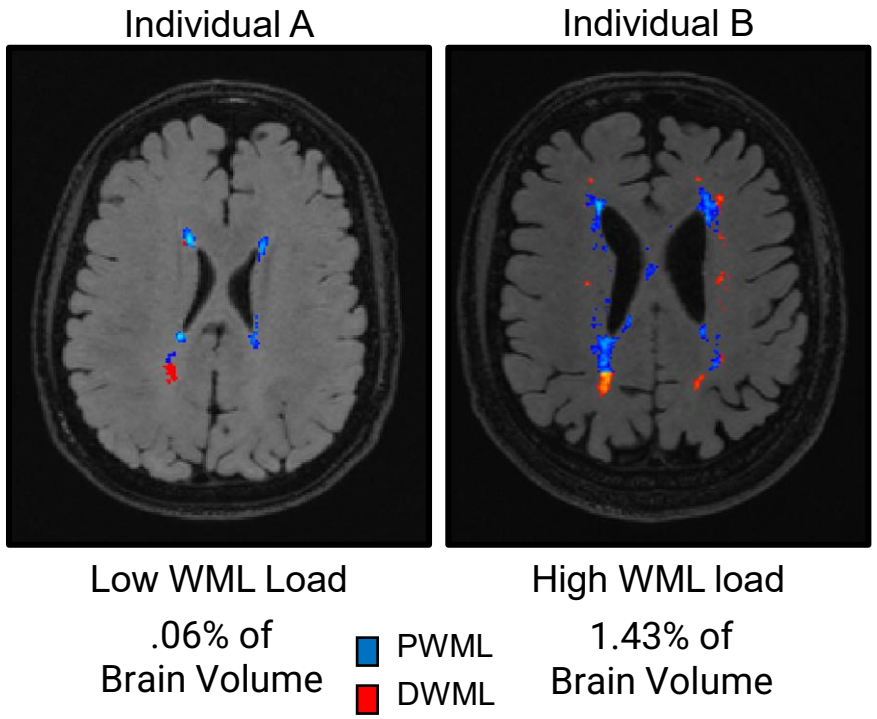


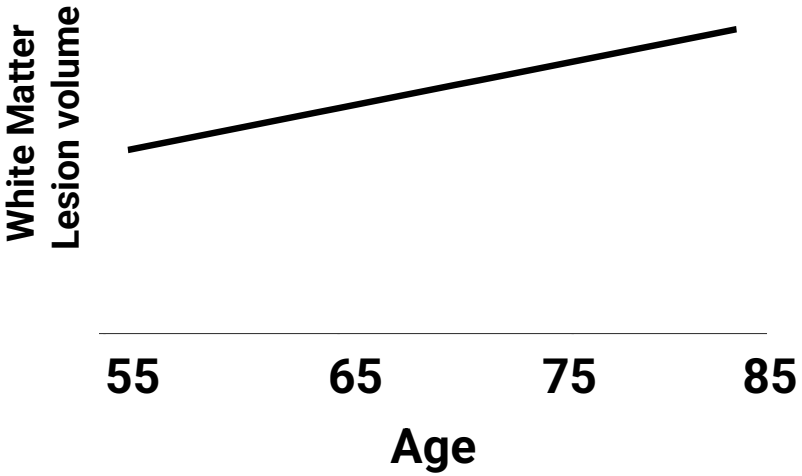


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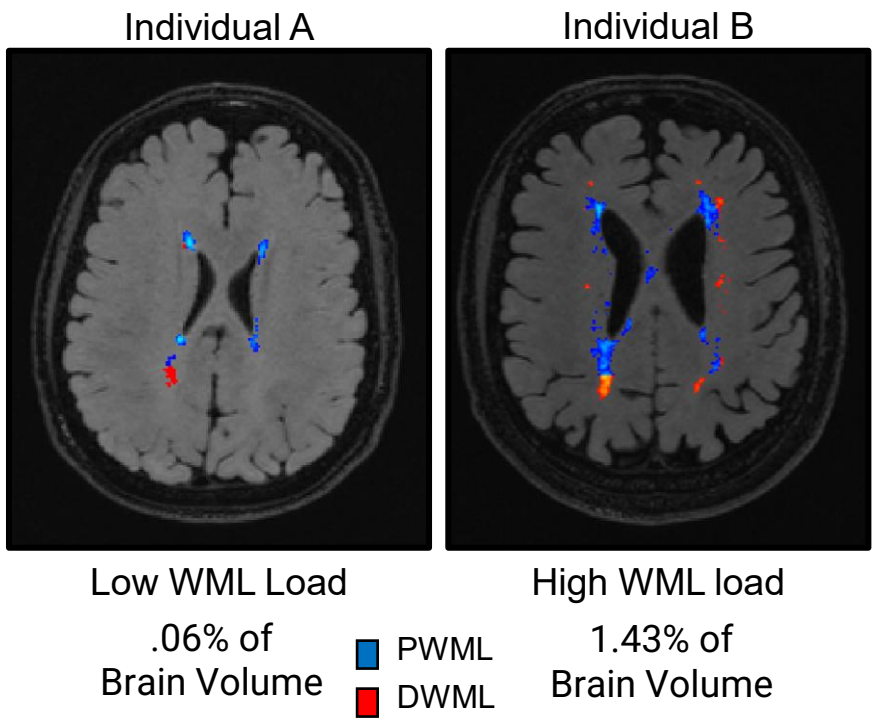


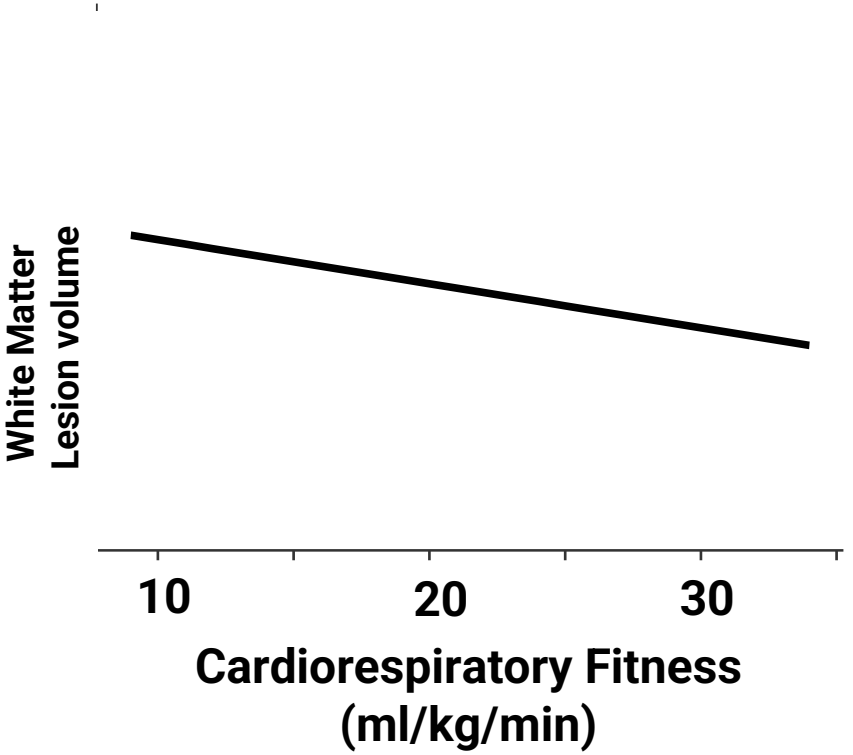


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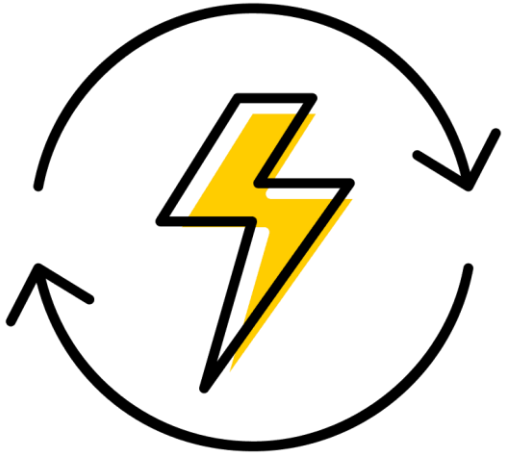


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Risk factors for cognitive impairment and AD



1. Basic perceptual processing

Extract reliable features from sensory input



Vision

Detect and discriminate visual features



Orientation | Contrast | Spatial frequency | Texture



Audition

Detect and discriminate auditory features



Pitch/ frequency | Temporal structure | Spectral detail | Speech sounds

Accurate and efficient perceptual processing provides high-quality input for higher cognitive functions.

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2. Perceptual representations

Build structured, meaningful representations



Visual cortex
(occipital cortex, V1–V3)



Auditory cortex
(Heschl's gyrus, superior temporal cortex)



Multimodal sensory representations

Objects, sounds, events, and their features

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3. Working memory

Maintain and manipulate information over seconds



Frontoparietal network
Maintain, integrate, and manipulate information

Active representations

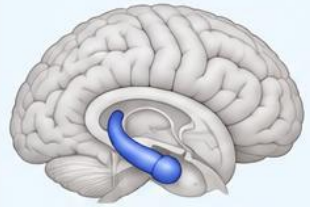
Hold, integrate, and update perceptual information



Representations are maintained and combined with other information to support ongoing cognition.

4. Long-term memory

Store integrated information for the future



Medium temporal lobe (hippocampus)
Store integrated information for long-term memory

Durable, structured memory

Link perceptual information with meaning, context, and prior knowledge



Information is consolidated into long-term memory, supporting knowledge, episodic memory, and future learning.

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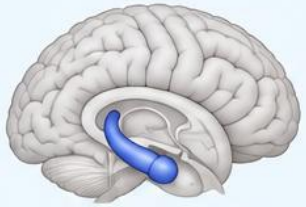
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Intervention at the perceptual level

Train basic sensory discrimination to improve the quality and efficiency of perceptual representations.

Visual perceptual training
(e.g., same–different gratings)



Same or different?

Auditory perceptual training
(e.g., pitch or temporal discrimination)



Same or different?

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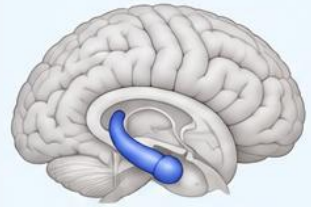
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Potential downstream benefits

Improved perceptual precision may:

1. Reduce cognitive load and listening/seeing effort
2. Improve the fidelity of representations
3. Support more efficient working memory
4. Enhance encoding into long-term memory
5. Increase engagement with the environment

Possible long-term impact

By strengthening the foundation of perceptual processing, we may support:

- Better everyday communication and perception
- More efficient cognitive function
- Greater cognitive reserve
- Potentially lower risk of age-related cognitive decline

Engage your brain: keep it challenging



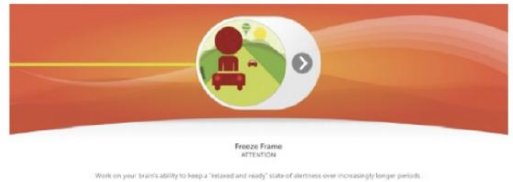
A) Dashboard: User progress this week, start training button



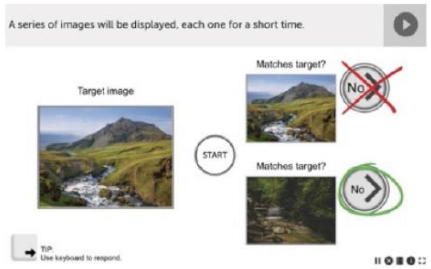
B) Training Levels: Levels to be performed in this session



C) Exercise Overview: Reminder of exercise goals and content



D) Exercise: Perform cognitive training



E) Level Completion: Review progress and performance

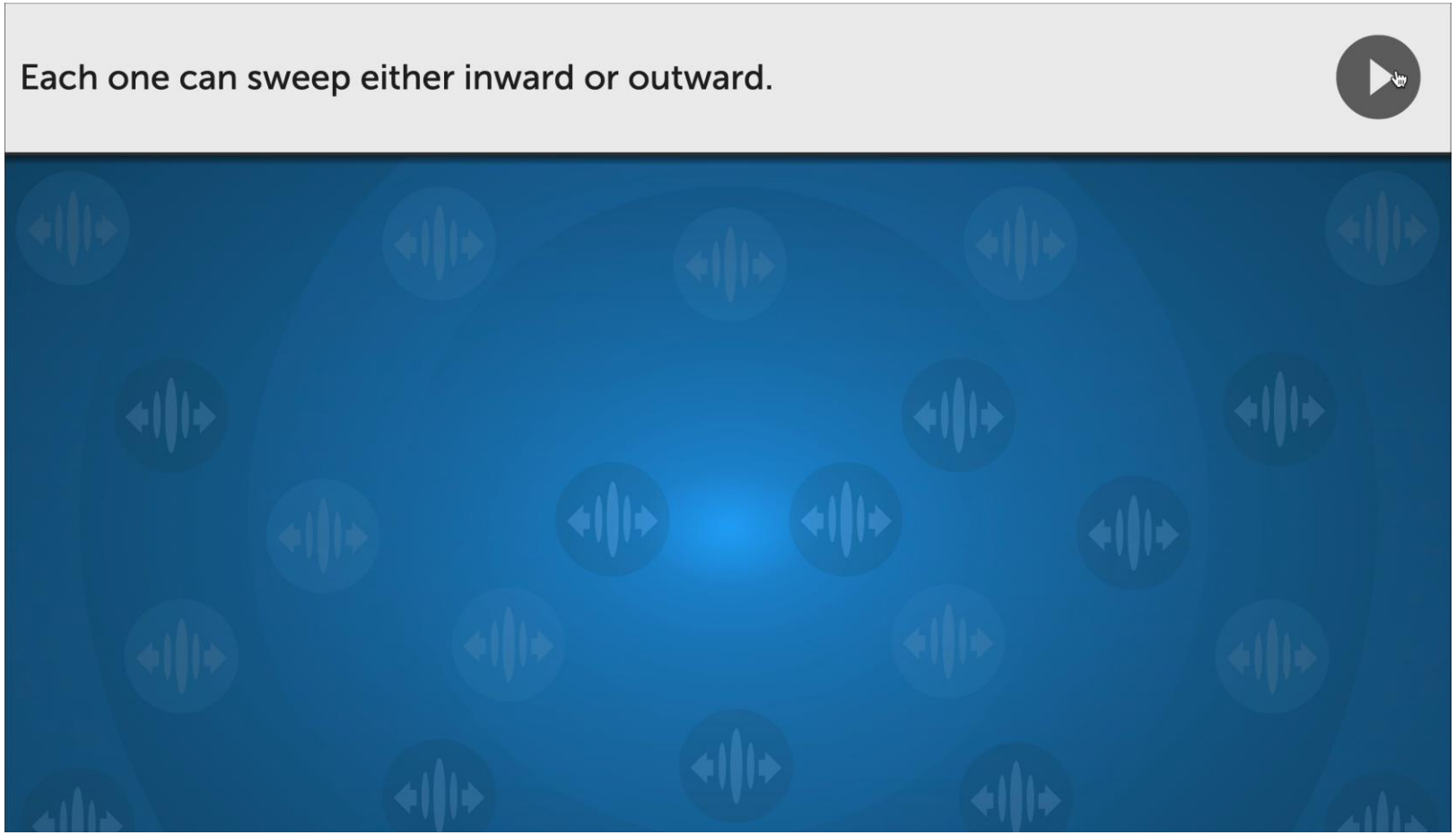


F) Session Completion: Review accomplishments from session



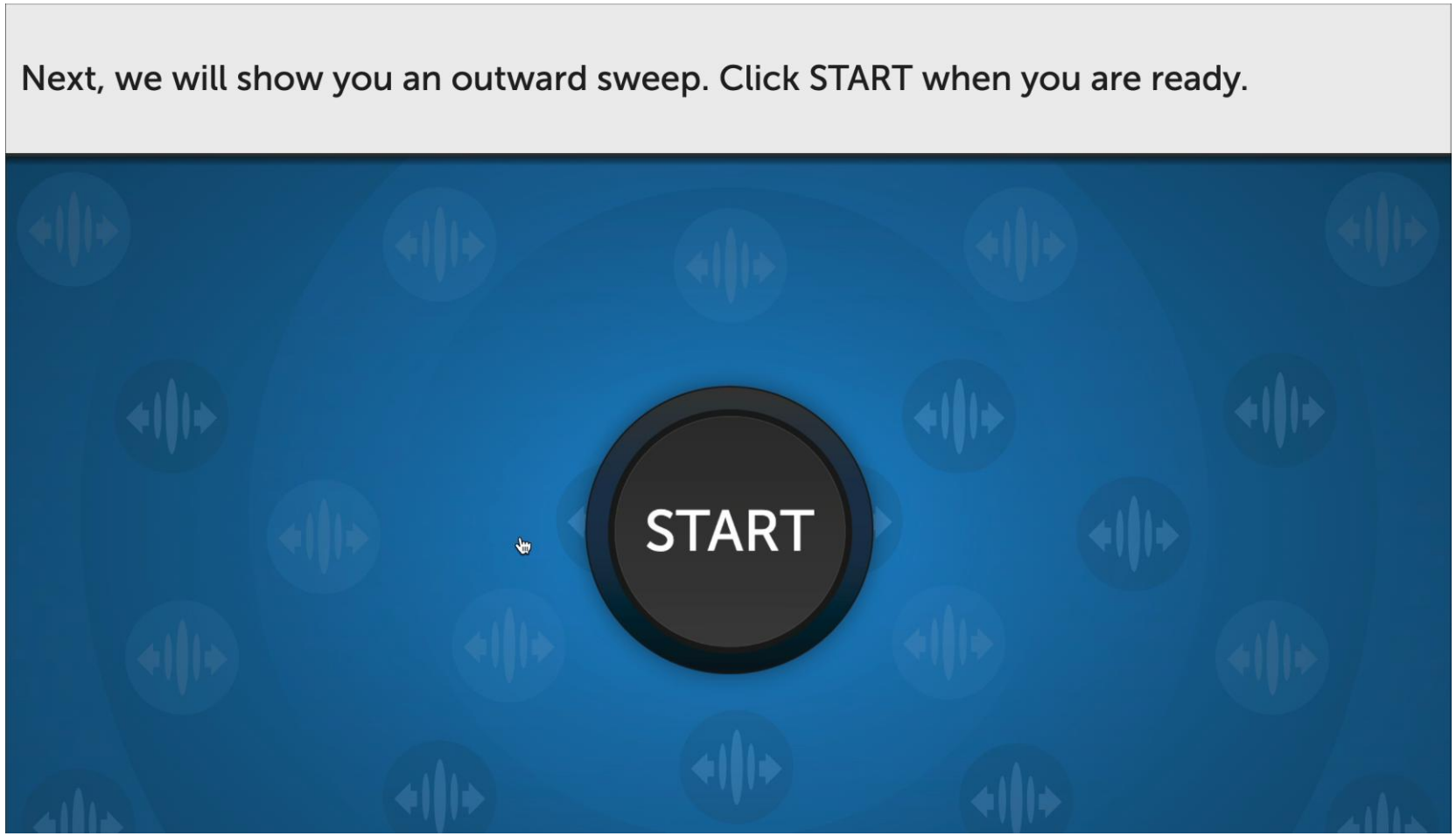
Engage your brain:
Foundations with sensory processing





Engage your brain:
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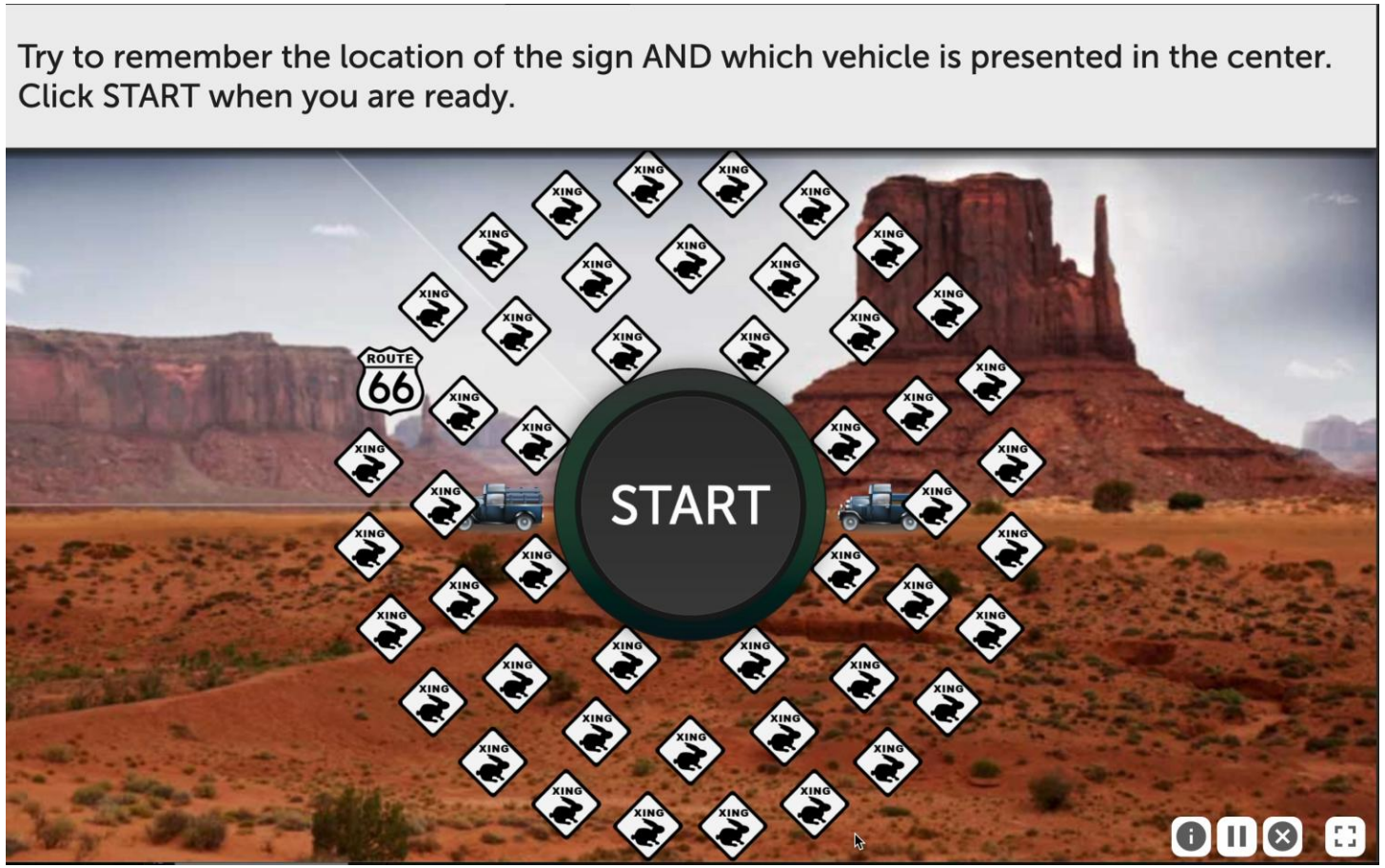
Engage your brain: keep it challenging





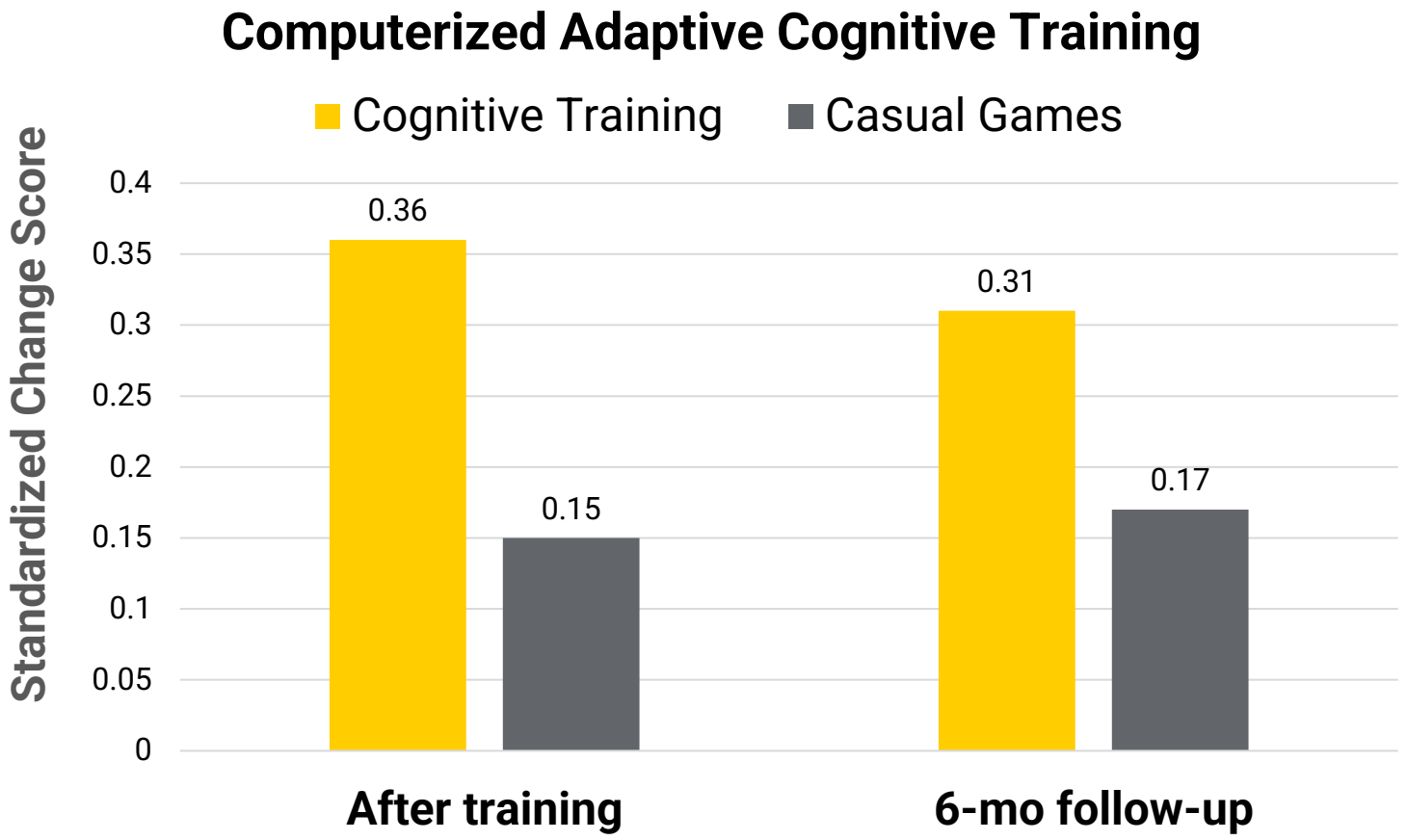
Engage your brain: keep it challenging





Engage your brain: keep it challenging





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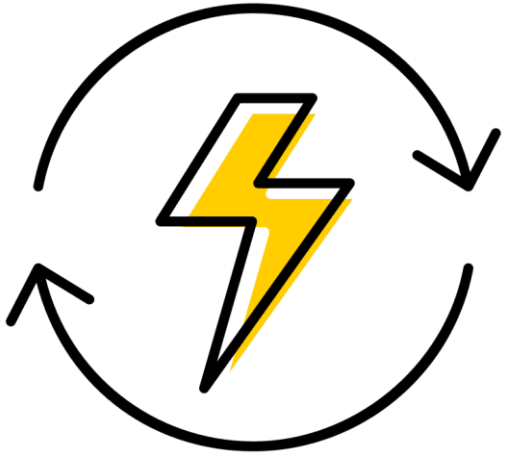
Lee et al., 2019 and Lee et al., 2024

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W.E. impacts half of modifiable risk factors



Thank you!

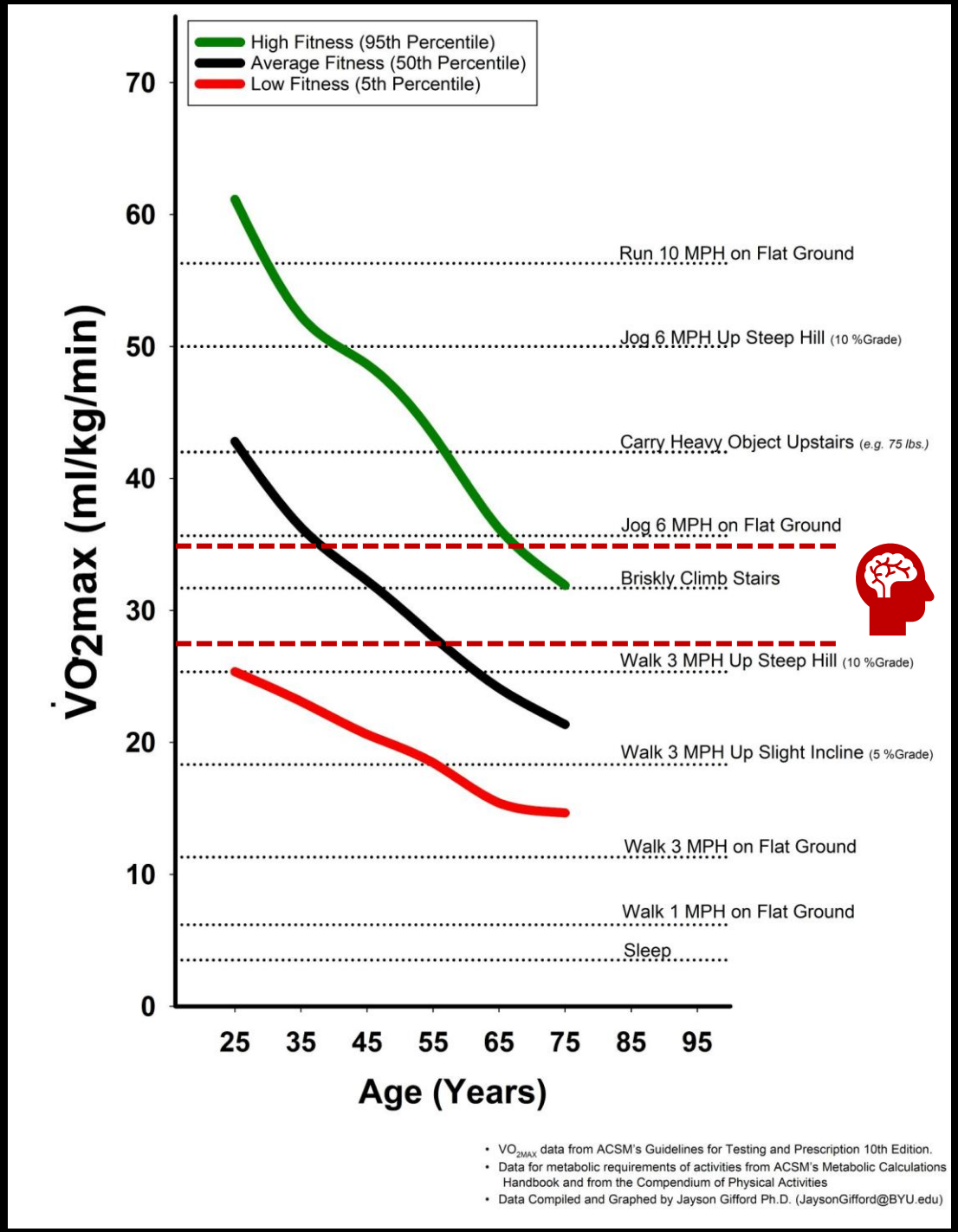


Funding
University of Iowa
Mid-Career Scholars Program
NIH/NIA, NINDS, NIGMS, NIMH, NIBIB
Iowa Neuroscience Institute
Ronnie Ketchel Faculty Fellowship

➔ **https://hbc.lab.uiowa.edu/**

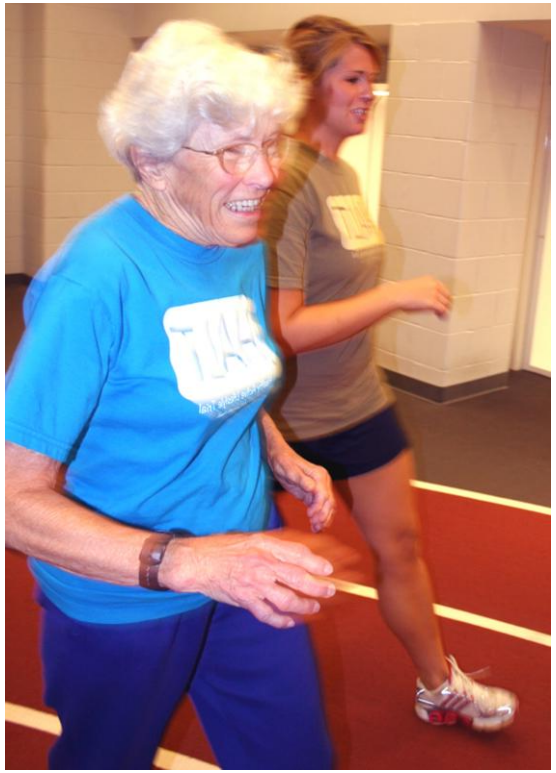
@healthbraincognitionlab

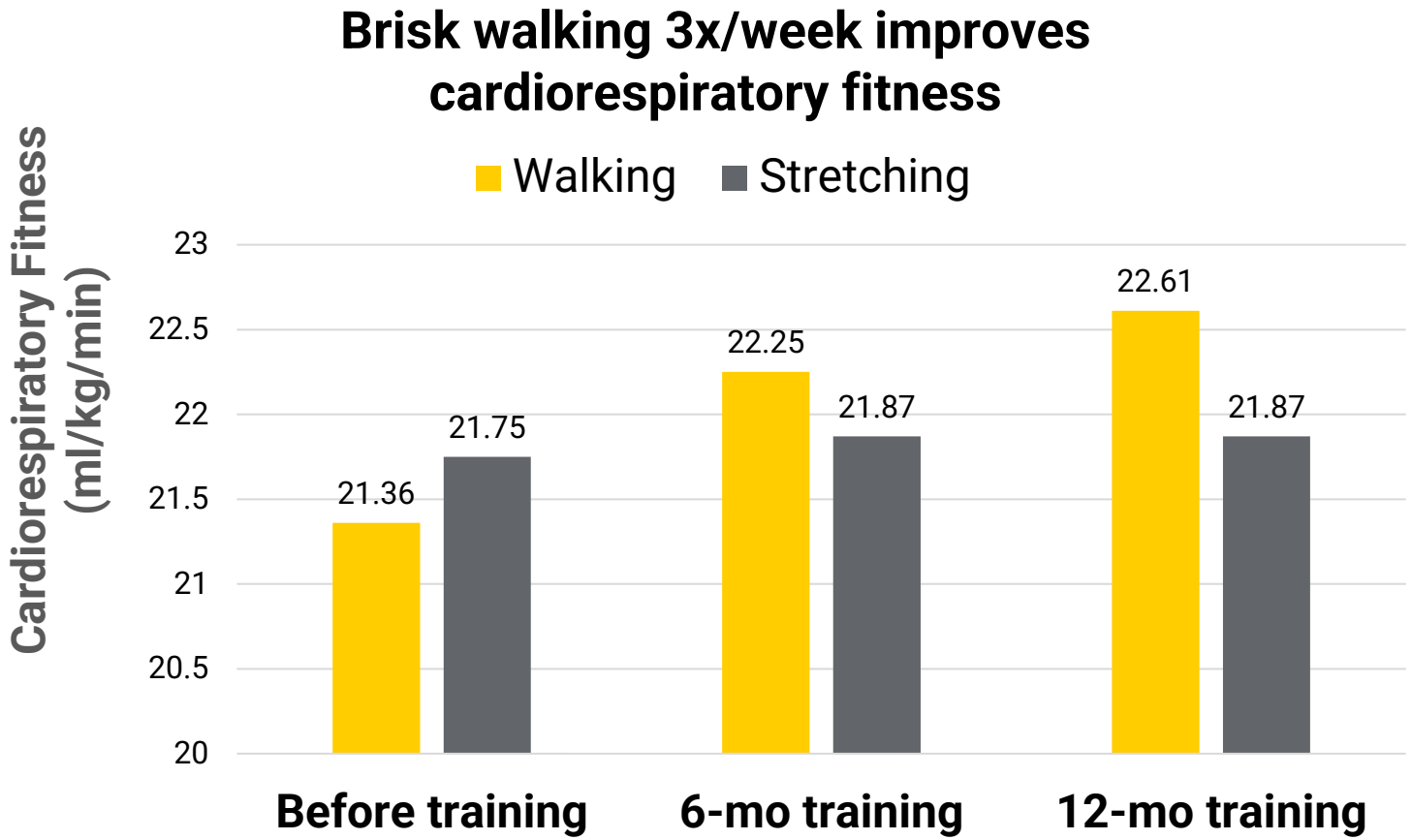
Fitness and healthspan



Adapted Figure by Jayson Gifford

Cardiorespiratory fitness is modifiable





Non-exercise equations to estimate CRF (eCRF)

QR Code



My eCRF: _____ ml/kg/min

This number represents your estimated cardiorespiratory fitness, or VO_2 max. It is the volume, or amount, of oxygen (in mL) per bodyweight (kg) that you could consume per minute, when you are working at your maximum level.

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Tools for *non-exercise* estimates of cardiorespiratory fitness (CRF)

Estimated Cardiorespiratory Score Calculator (Jurca et al., 2005)

User Inputs

Select biological sex:

Female

Enter age (years):

0

Enter weight (pounds):

0

Enter height (inches):

0

Enter resting heart rate (bpm):

0

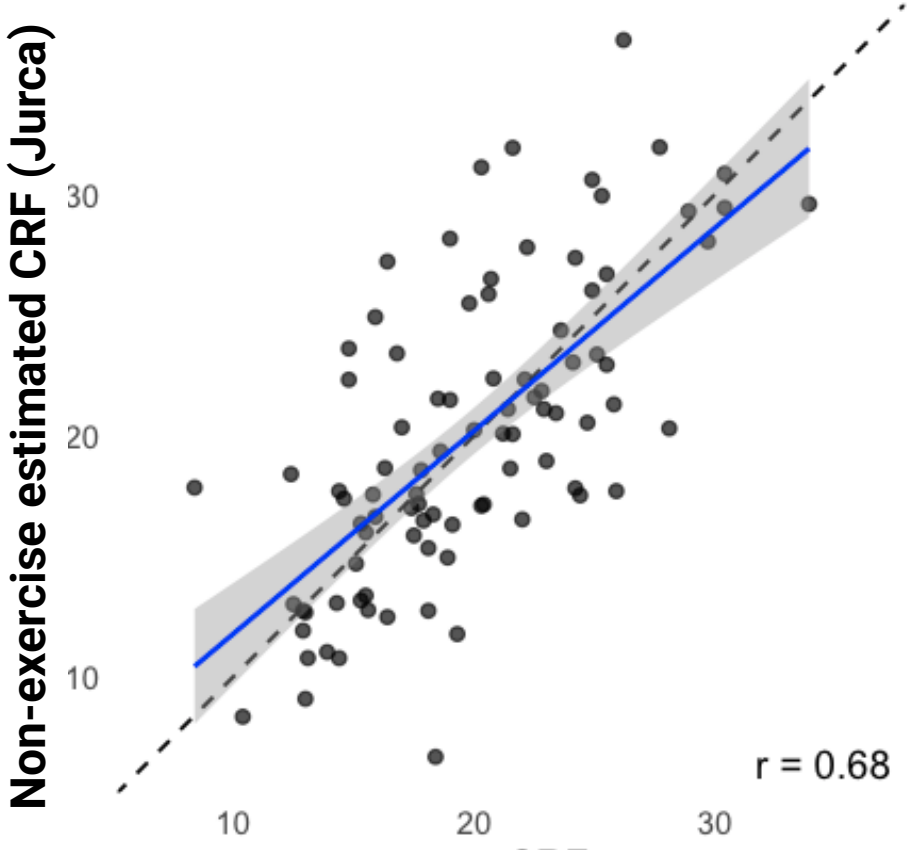
Choose one of five activity categories that best describes your usual pattern of daily physical activity, including activities related to home and family care, transportation, occupation, exercise and wellness, and leisure or recreation:

Level 1: inactive or little activity other than usual daily activities;
Level 2: Regularly (≥ 5d/wk) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least 10 minutes at a time;
Level 3: Participate in aerobic exercises such as brisk walking, jogging or running, cycling, swimming, or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for 20 to 60 minutes per week;
Level 4: Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for 1 to 3 hours per week; or
Level 5: Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for over 3 hours per week

Select self-reported PA level:

Level 1

Calculate Estimated CRF Score



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Figure 12. VO_2 Max by Age, Sex, Fitness

	Performance Group by VO_2 max (ml/kg/min)				
Age	**Low**	**Below Average**	**Above Average**	**High**	**Elite**
Women					
18-19	< 35	35-39	40-45	40-52	≥ 53
20-29	< 28	28-35	36-40	41-50	≥ 51
30-39	< 27	27-33	34-38	39-48	≥ 49
40-49	< 26	26-31	32-36	37-46	≥ 47
50-59	< 25	25-28	29-35	36-45	≥ 46
60-69	< 21	21-24	25-29	30-38	≥ 40
70-79	< 18	18-21	22-24	25-35	≥ 36
≥ 80	< 15	15-19	20-22	23-29	≥ 30
Men					
18-19	< 38	38-45	46-49	50-57	≥ 58
20-29	< 36	36-42	43-48	49-55	≥ 56
30-39	< 35	35-39	40-45	46-52	≥ 53
40-49	< 34	34-38	39-43	44-51	≥ 52
50-59	< 29	29-35	36-40	41-49	≥ 50
60-69	< 25	25-29	30-35	36-45	≥ 46
70-79	< 21	21-24	25-29	30-40	≥ 41
≥ 80	< 18	18-22	23-25	26-35	≥ 36

Source: Mandsager et al. (2018).

Tools for non-exercise estimates of cardiorespiratory fitness

Estimated Cardiorespiratory Score Calculator (Chappell)

Enter biological sex (female=0,male=1):

0

Enter age (years):

0

Enter waist circumference (inches):

0

Enter height (inches):

0

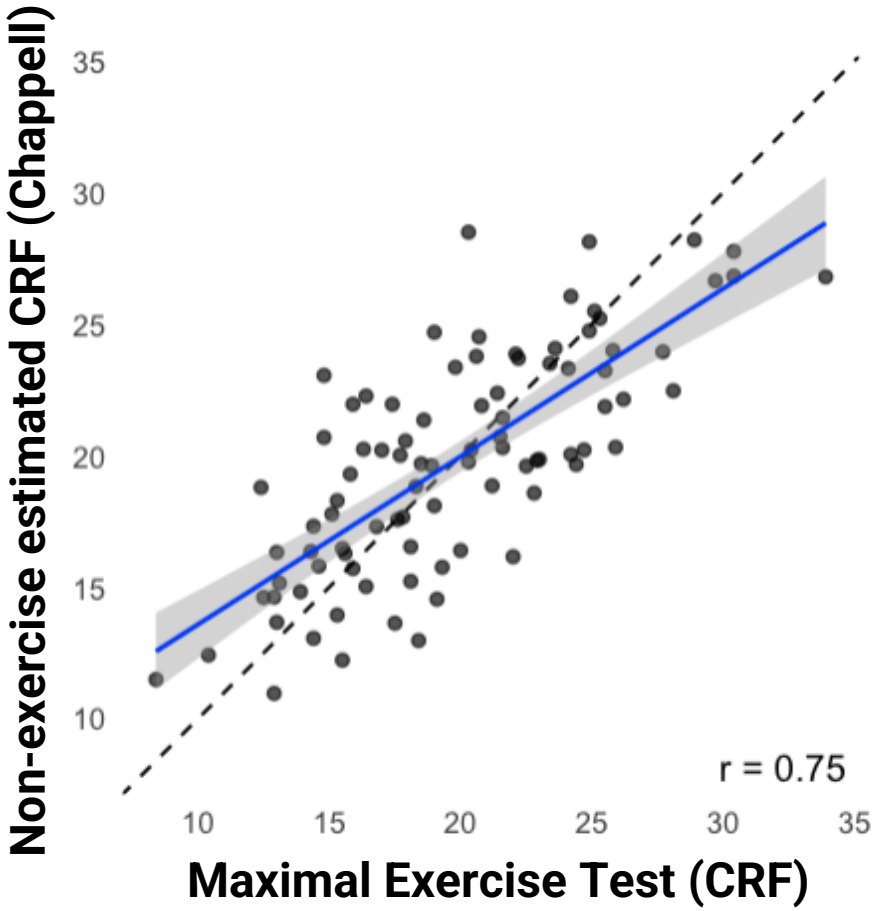
```
How many minutes of moderate-to-vigorous activity do you get most weeks?
Activity can be exercise training or related to home and family care, transportation,
occupation, and leisure or recreation:

Level 0: 0 minutes of moderate to vigorous activity per week
Level 1: 1-75 minutes of moderate to vigorous activity per week
Level 2: 76-150 minutes of moderate to vigorous activity per week
Level 3: 151-300 minutes of moderate to vigorous activity per week
Level 4: 301-500 minutes of moderate to vigorous activity per week
Level 5: >500 minutes of moderate to vigorous activity per week
```

Enter self-reported PA (0-5):

0

Calculate Estimated CRF Score





IOWA

Chappell et al., 2025, *Exercise, Sport, and Movement,* BIKE and EXTEND studies

What can you modify to increase your fitness?

Resting heart rate: higher with more prolonged sitting during your day, stress, caffeine, and alcohol; lower with increasing amounts of moderate and vigorous exercise and greater fitness.

Physical Activity Levels	
1	Inactive or little activity other than usual daily activities
2	Regularly (≥ 5d/wk) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least 10 minutes at a time
3	Participate in aerobic exercises such as brisk walking, jogging or running, cycling, swimming, or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for 20 to 60 minutes per week
4	Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for 1 to 3 hours per week
5	Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for over 3 hours per week