Aerobic Exercise Training Reduces Central Arterial Stiffness and Improves Cerebral Blood Flow in Older Adults

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Disclosure

I have no conflict of interest with the content of this presentation.

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Turning Discovery Into Health

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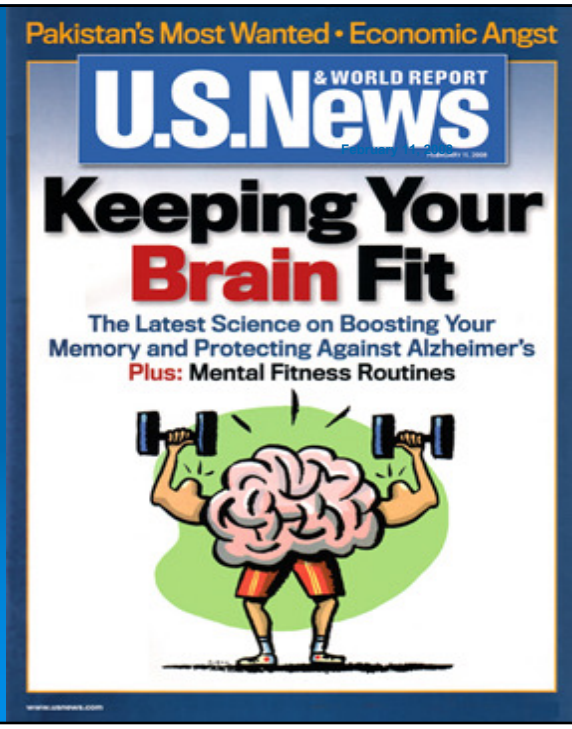

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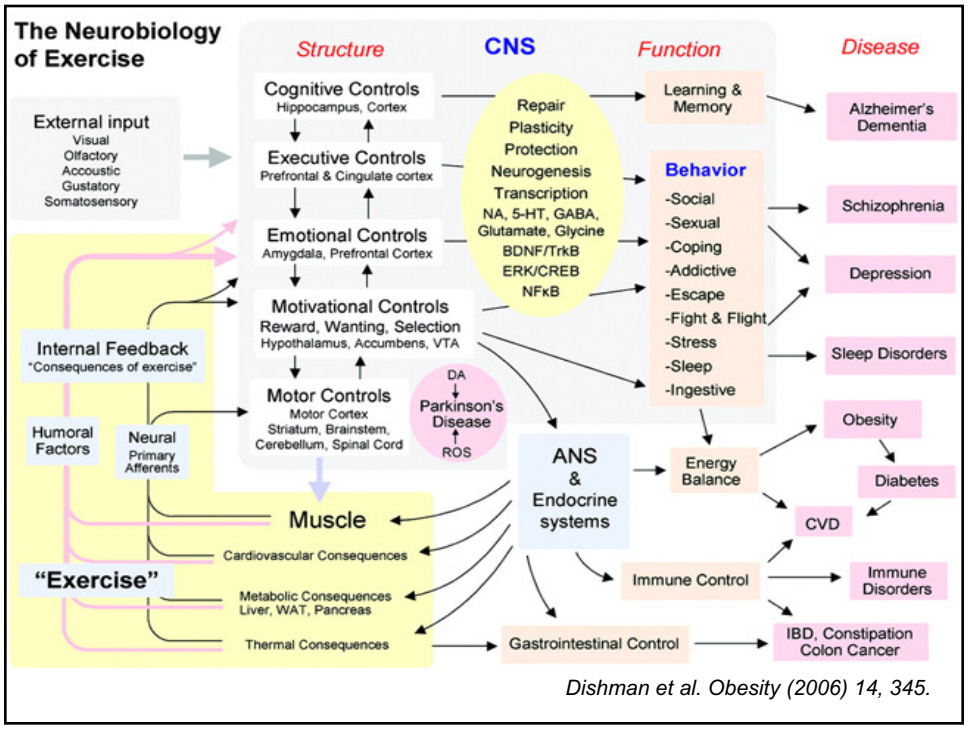

Dishman et al. Obesity (2006) 14, 345.

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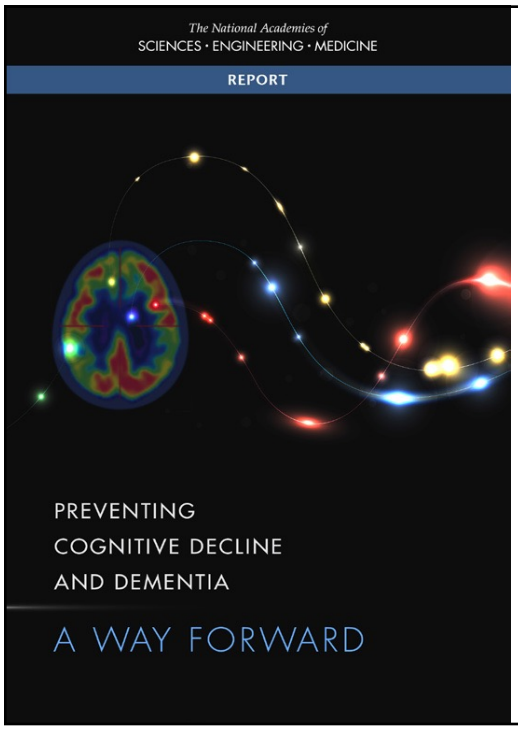

Recommendations to public:

- **Cognitive training**
- **Blood pressure management for people with hypertension**
- **Increased physical activity**

Beneficial effects of these interventions are supported by encouraging, although inconclusive evidence.

The committee recommends that the NIH and others support further research to strengthen the evidence base on these interventions.

National Academy of Sciences 2017

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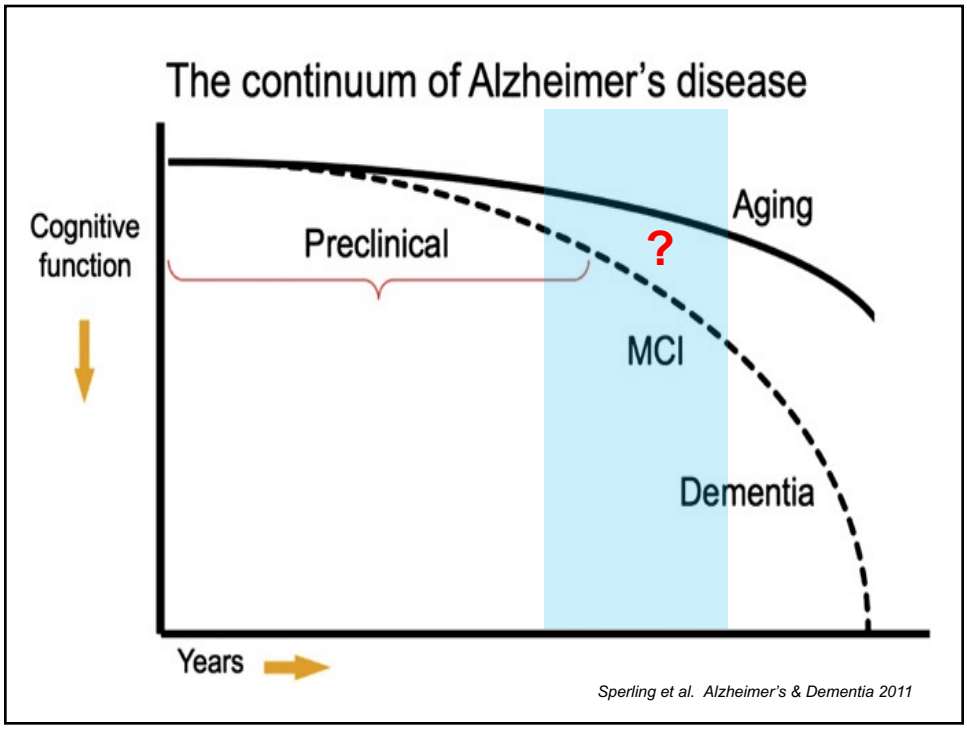
The continuum of Alzheimer's disease
Cognitive function
Preclinical
?
Aging
MCI
Dementia
Years
Sperling et al. Alzheimer's & Dementia 2011

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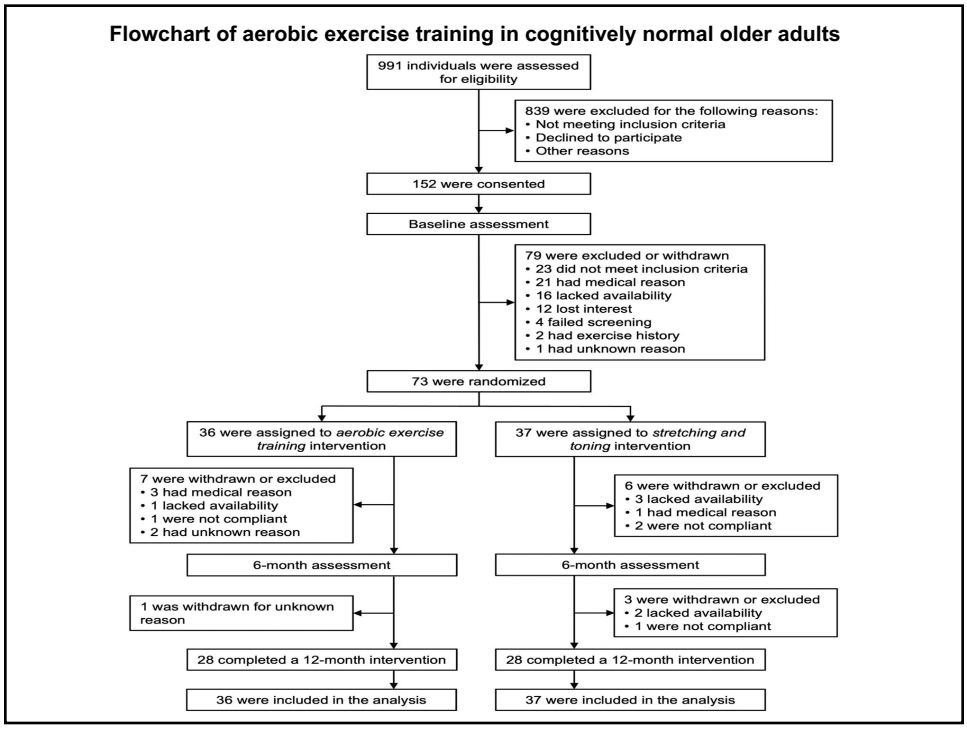
Flowchart of aerobic exercise training in cognitively normal older adults
991 individuals were assessed for eligibility
839 were excluded for the following reasons:
• Not meeting inclusion criteria
• Declined to participate
• Other reasons
152 were consented
Baseline assessment
79 were excluded or withdrawn
• 23 did not meet inclusion criteria
• 21 had medical reason
• 16 lacked availability
• 12 lost interest
• 4 failed screening
• 2 had exercise history
• 1 had unknown reason
73 were randomized
36 were assigned to aerobic exercise training intervention
37 were assigned to stretching and toning intervention
7 were withdrawn or excluded
• 3 had medical reason
• 1 lacked availability
• 1 were not compliant
• 2 had unknown reason
6 were withdrawn or excluded
• 3 lacked availability
• 1 had medical reason
• 2 were not compliant
6-month assessment
6-month assessment
1 was withdrawn for unknown reason
3 were withdrawn or excluded
• 2 lacked availability
• 1 were not compliant
28 completed a 12-month intervention
28 completed a 12-month intervention
36 were included in the analysis
37 were included in the analysis

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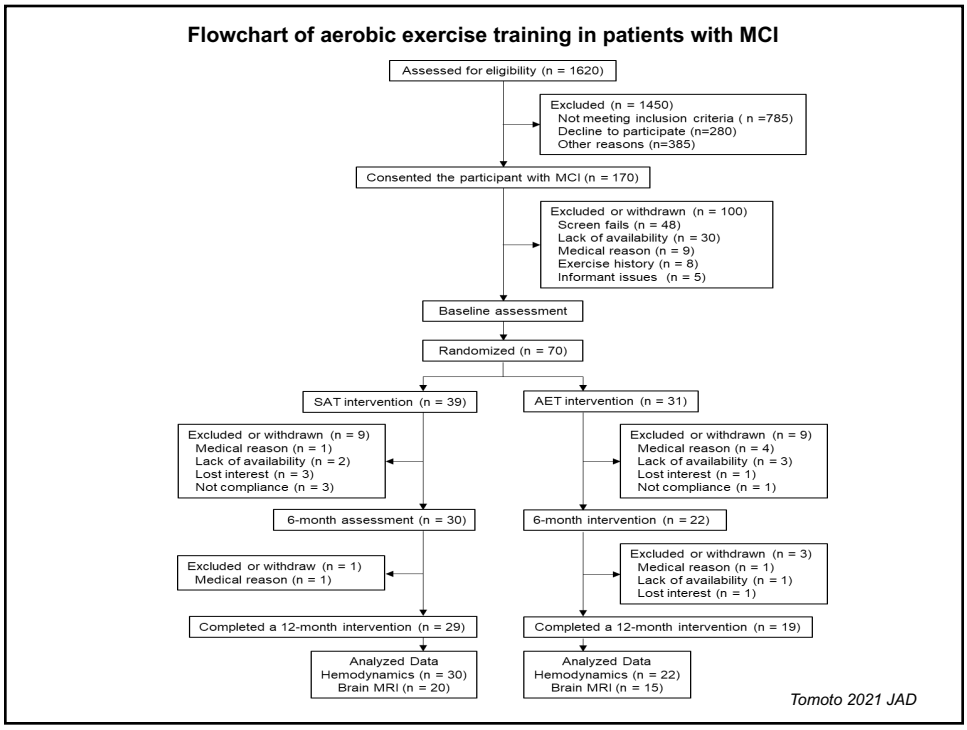

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Outcome measures

- Global and domain specific neurocognitive function
- Cerebral blood flow (CBF) and CBF pulsatility
- Brain tissue volume and cortical thickness
- Central arterial stiffness (cfPWV and carotid β-stiffness index

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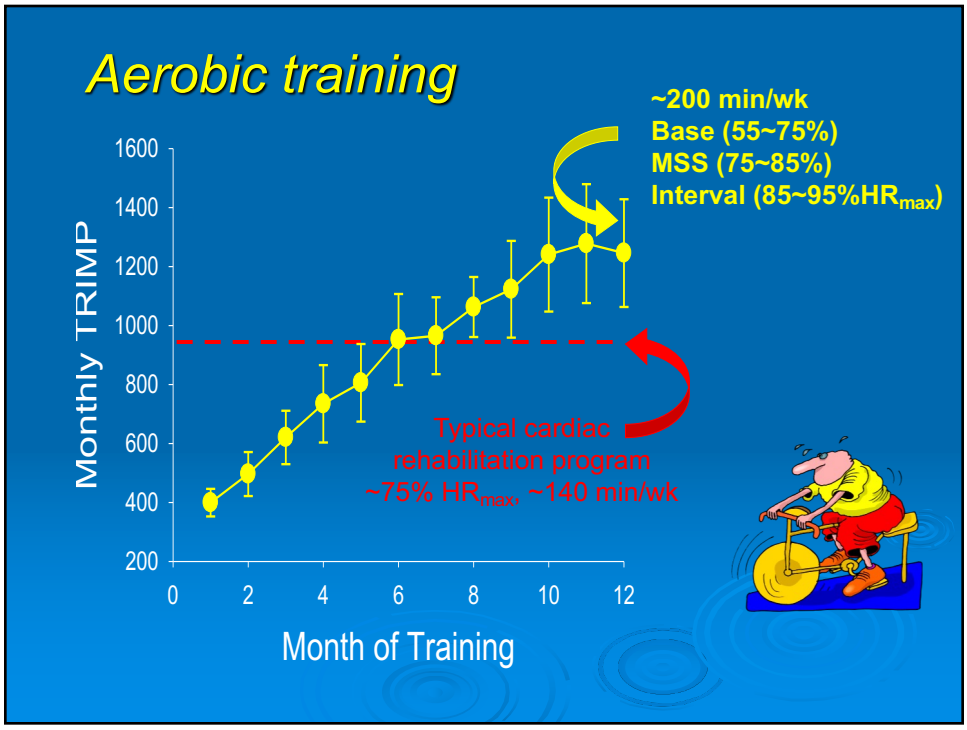
Aerobic training
~200 min/wk
Base (55~75%)
MSS (75~85%)
Interval (85~95%HRmax)
Monthly TRIMP
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
Month of Training
Typical cardiac rehabilitation program
~75% HRmax, ~140 min/wk

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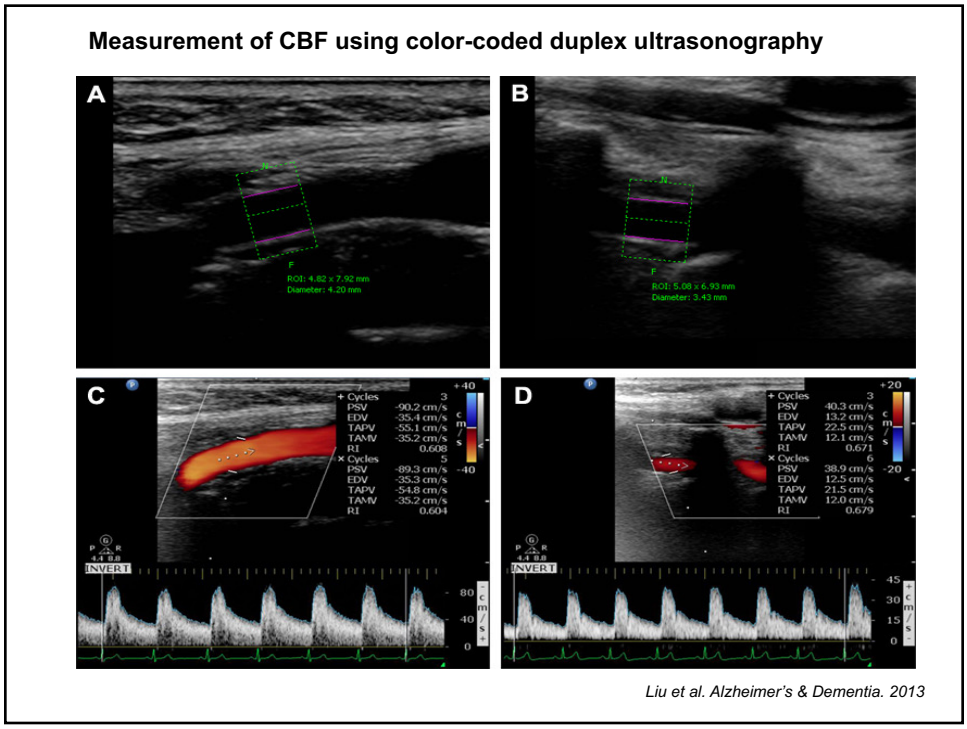
Measurement of CBF using color-coded duplex ultrasonography
A
B
C
D
Liu et al. Alzheimer's & Dementia. 2013

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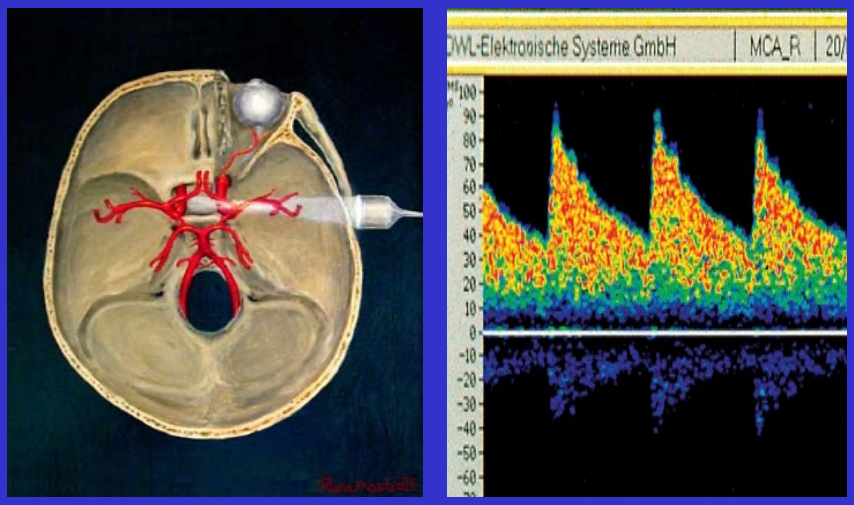
Transcranial Doppler measurement of CBF pulsatility



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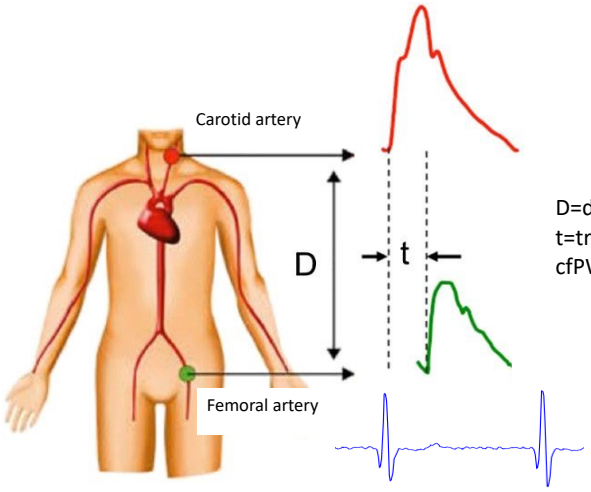
Central arterial stiffness is measured with pulse wave velocity



D=distance
t=transit time
cfPWV= D/t

Bruno et al 2014 *Cardiovascular Ultrasound*

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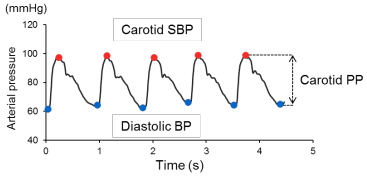
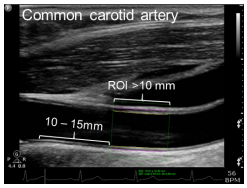
Carotid ß-stiffness Index

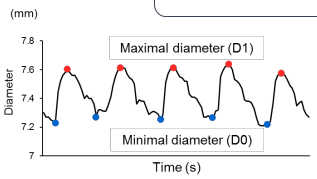
Carotid arterial pressure
(using Applanation Tonometry)



Carotid arterial wall distension
(using ultrasonography)



Carotid β-stiffness index = $\frac{ln\frac{Carotid\ SBP}{DBP}}{\frac{(D_1 - D_0)}{D_0}}$



Hirai et al., *Circulation*, 1989

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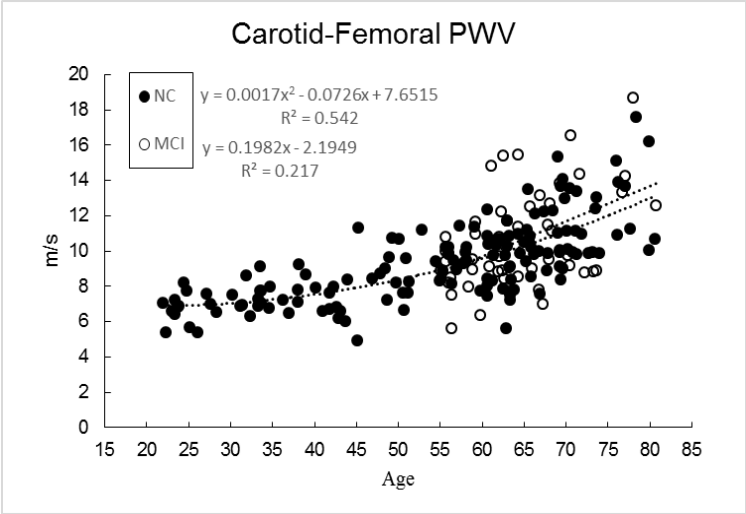
Increase in central arterial stiffness with aging



Unpublished data

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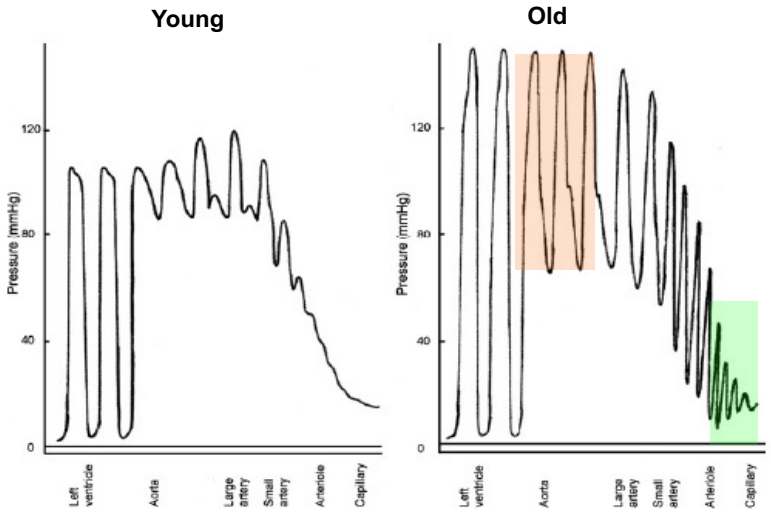
Increase in central arterial stiffness with age leads to increase in arterial pressure pulsatility in the arterioles and capillary vascular beds



Michael F. O'Rourke et al. JACC 2007

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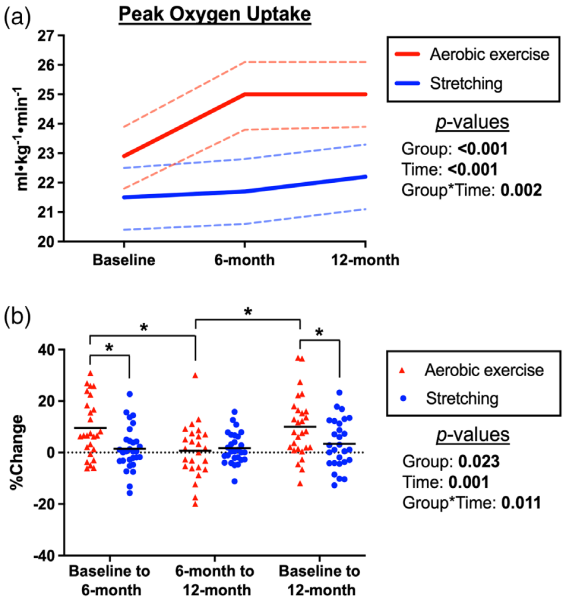
Increases in cardiopulmonary fitness (VO2peak) with aerobic exercise training in cognitively normal older adults



Tarumi et al. JIM 2022

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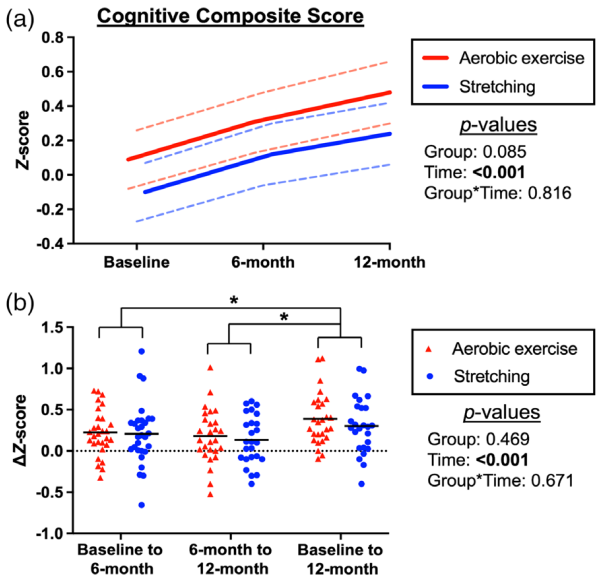
Changes in neurocognitive function with aerobic exercise training in cognitively normal older adults



Tarumi et al. JIM 2022

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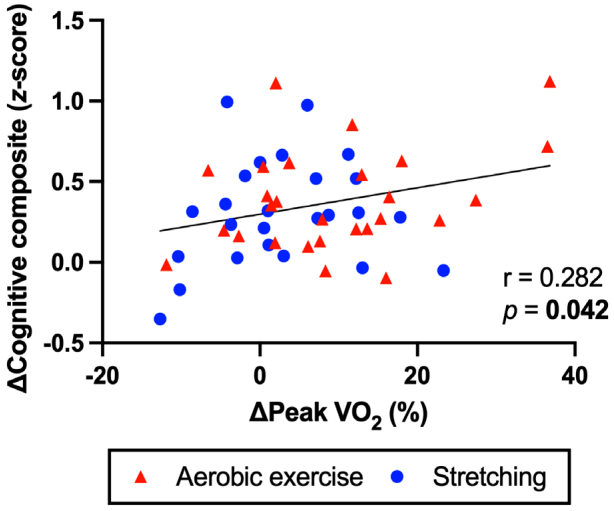
Correlation of changes in neurocognitive function with changes in peak VO_2



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Changes in brain volume and cortical thickness after one-year AET and SAT in cognitively normal older adults

		Aerobic exercise		Stretching		*p* values		
	Time	EMM	(95% CI)	EMM	(95% CI)	Group	Time	Group* Time
Total brain volume	Baseline	70.4	(68.8–72.0)	71.2	(69.7–72.8)	0.400	**<0.001**	0.327
	12-month	69.7	(68.1–71.2)	70.7	(69.2–72.3)			
Hippocampal volume	Baseline	0.528	(0.507–0.548)	0.522	(0.502–0.541)	0.918	**0.032**	**0.040**
	12-month	0.518	(0.498–0.539)[a]	0.521	(0.501–0.541)			
Mean cortical thickness	Baseline	2.469	(2.447–2.491)	2.466	(2.445–2.487)	0.876	**0.001**	0.336
	12-month	2.444	(2.421–2.466)	2.452	(2.429–2.474)			
Prefrontal cortical thickness	Baseline	2.593	(2.568–2.619)	2.582	(2.557–2.607)	0.934	**0.004**	0.091
	12-month	2.566	(2.540–2.593)	2.575	(2.548–2.601)			
Entorhinal thickness	Baseline	3.403	(3.333–3.472)	3.309	(3.241–3.377)	0.171	0.292	0.069
	12-month	3.391	(3.319–3.463)	3.352	(3.280–3.423)			
Parahippocampal thickness	Baseline	2.794	(2.712–2.875)	2.725	(2.646–2.805)	0.265	0.273	0.710
	12-month	2.778	(2.695–2.860)	2.718	(2.636–2.799)			
Precuneus thickness	Baseline	2.387	(2.356–2.418)	2.382	(2.351–2.412)	0.913	**0.001**	0.699
	12-month	2.356	(2.323–2.388)	2.356	(2.324–2.389)			
Posterior cingulate thickness	Baseline	2.437	(2.402–2.472)	2.444	(2.41–2.479)	0.807	0.085	0.880
	12-month	2.423	(2.387–2.460)	2.428	(2.392–2.465)			
Precentral thickness	Baseline	2.532	(2.491–2.572)	2.538	(2.498–2.578)	0.873	**<0.001**	0.801
	12-month	2.497	(2.455–2.539)	2.499	(2.458–2.541)			
Pericalcarine thickness	Baseline	1.555	(1.516–1.594)	1.620	(1.582–1.657)	**0.011**	0.974	0.706
	12-month	1.551	(1.510–1.591)	1.623	(1.583–1.664)			

Tarumi et al. JIM 2022

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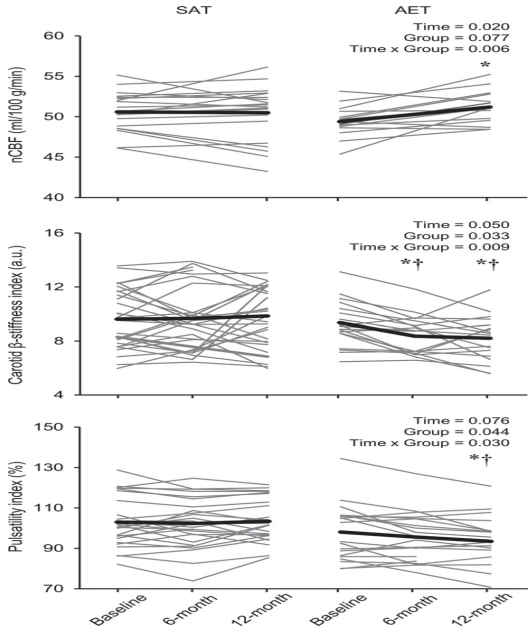
One-year aerobic exercise reduced carotid arterial stiffness and increased CBF in patients with MCI



Tomoto 2021 JAD

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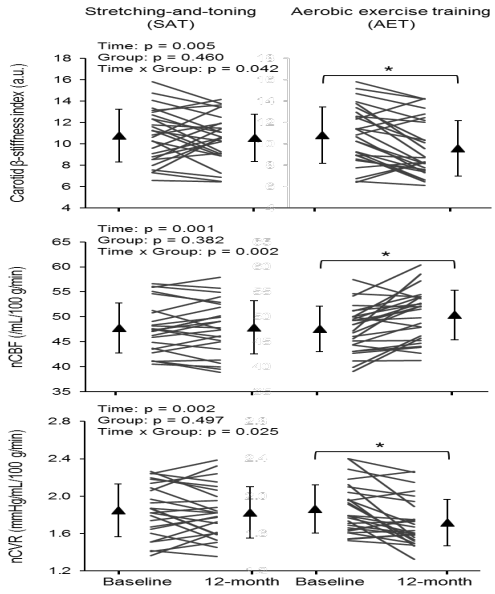
One-year aerobic exercise reduced carotid arterial stiffness and increased CBF in cognitively normal older adults



Tomoto 2022 in revision

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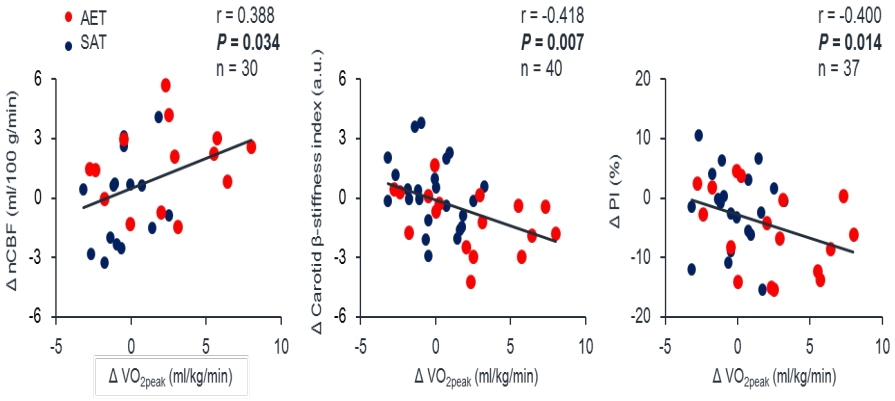
Association of changes in VO_{2peak} with changes in nCBF, carotid arterial stiffness, and CBF pulsatility



Tomoto et al. JAD 2021

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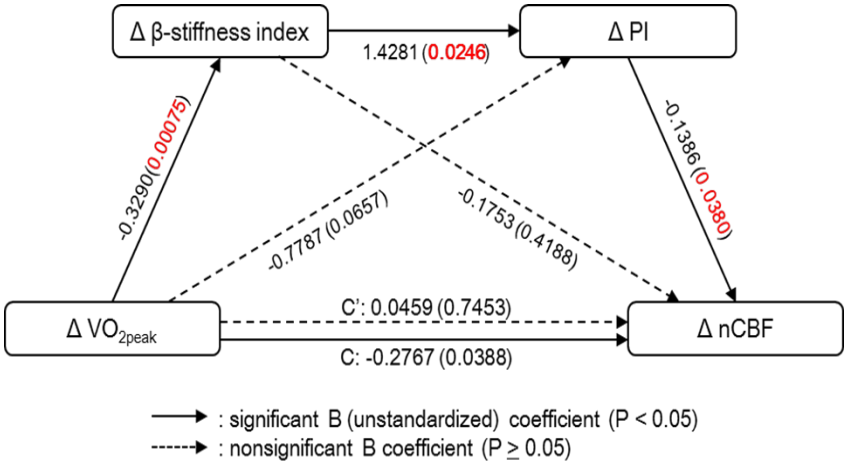
Mediation analysis of the effects of increases in VO_{2peak} on CBF



Tomoto et al. JAD 2021

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Conclusions

- One-year aerobic exercise training increased peak VO_2 by ~ 10% in older adults with or without MCI.
- Both aerobic (AET) and stretching-and-toning (SAT) training improved cognitive performance.
- One-year AET or SAT did not prevent reductions in brain tissue volume and cortical thickness in older adults.
- AET increased global cerebral blood flow (CBF) and reduced central arterial stiffness and CBF pulsatility.
- These findings suggest that that improvement in CBF/cerebrovascular function with AET is related to the attenuation of arterial aging which may precede potential effects of exercise training on brain structure and function in older adults.

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