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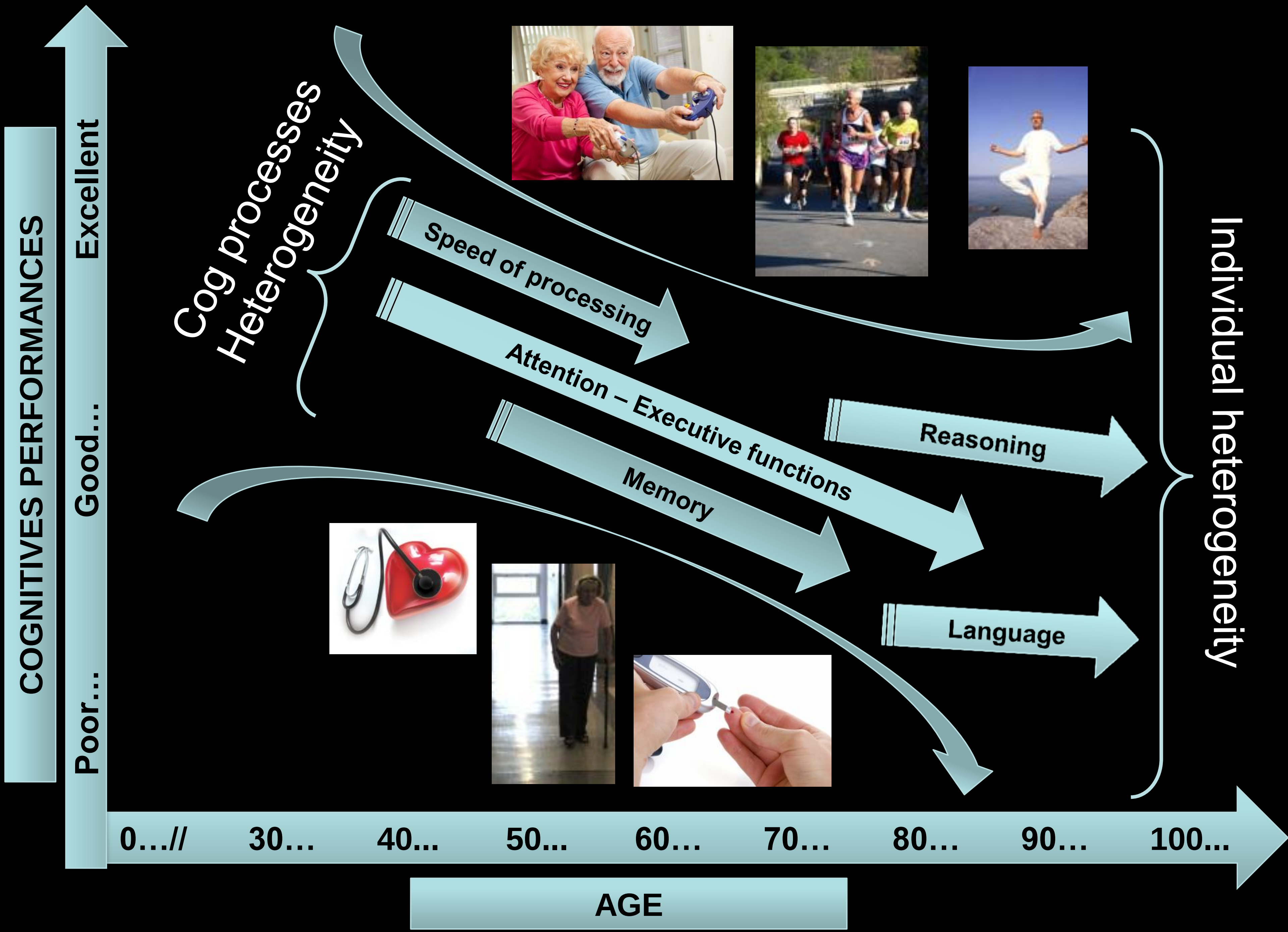
Impact of exercise on cognition, QofL and mobility

Louis Bherer, Ph.D.
PERFORM Centre, Concordia university
Centre de recherche, Institut universitaire de gériatrie de Montréal


COGNITIVES PERFORMANCES
Excellent
Good…
Poor…
Cog processes
Heterogeneity
Speed of processing
Attention – Executive functions
Memory
Reasoning
Language
Individual heterogeneity
0…//
30…
40...
50...
60…
70…
80…
90…
100...
AGE

Cognitive stimulation

-Cognitive training

-Physical activity and exercise

-Music and dance

Benefits of exercise

-Protective effects of exercise:
Physical exercise can help prevent cognitive decline and lower the risk of MCI and dementia (Sofi et al., 2011; up to 38%)

-**Effects of exercise interventions**:
After physical exercise training program older adults show enhanced cognitive performances (Colcombe & Kramer, 2003)

-**Effects of exercise interventions on the brain**
Exercise-related increase on hippocampus volume (Erickson et al., 2011), task-relevant activity and functional connectivity (Voss et al., 2011)

Bherer, L. (2012) Physical exercise in older adults. In Alcavado Ed. *The Oxford Handbook of exercise psychology.* Oxford University Press, New York, USA

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Renaud, M., Bherer, L., & Maquestiaux, F. (2010). A high level of physical fitness is associated with more efficient response preparation in older adults. *Journal of Gerontology: Psychological Sciences*, 10.1093/geronb/gbq004

A High Level of Physical Fitness Is Associated With More Efficient Response Preparation in Older Adults

Mélanie Renaud,[1,2] Louis Bherer,[1,2] and François Maquestiaux[3]

[1]Department of Psychology, University du Québec à Montréal (UQÀM), Montréal, Québec, Canada. [2]Centre de recherche, Institut Universitaire de Gériatrie de Montréal, Montréal, Québec, Canada. [3]UFR STAPS, Université Paris-Sud, Orsay, France.

M. Renaud

Older adults in an aerobic training session in Montreal.

110 Community dwelling older adults

Lower Fit (N=55)
60-69 yrs vs. 70-79 yrs

Higher Fit (N=55)
60-69 yrs vs. 70-79 yrs

Physical fitness is associated with better response preparation and have a protective effect on motor speed

Figure 1: Mean initiation time (ms) in the Low fit (- - - -) and the High fit groups (———) as a function of PI for each duration condition.

Figure 2: Mean execution time (ms) for the 60-69 (- - - -) and the 70-79 groups (———) as a function of fitness level.

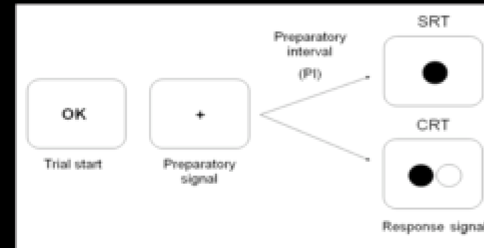
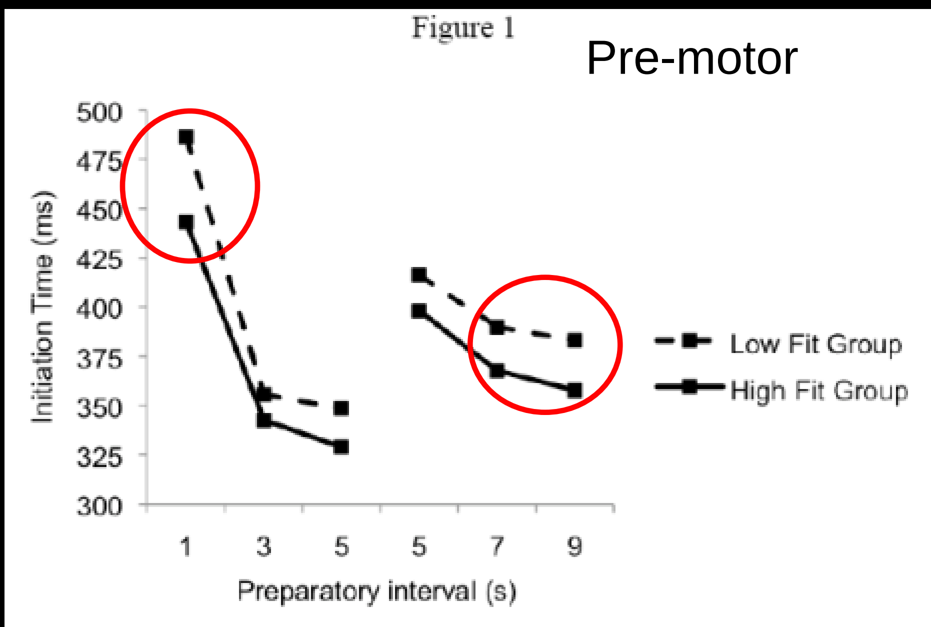
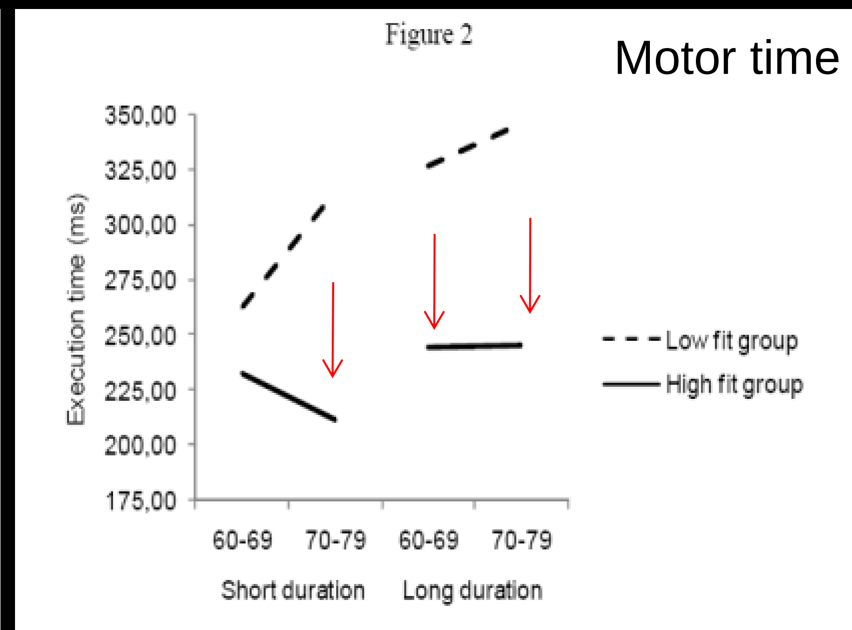


FIGURE 1 | Figural description of the response preparation task.





Renaud, Bherer & Maquestiaux (2010)
Journal of Gerontology: Psych. Sciences.

Benefits of exercise

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Meta-analyses on intervention studies

Etnier JL, Salazar W, Landers DM, Petruzzello SJ, Han M, Nowell P.
Journal of Sport & Exercise Psychology, 1997;19:249 –77.

Colcombe S, Kramer AF
Psychol Sci 2003;14(2):125–30.

Heyn P, Abreu BC, Ottenbacher KJ.
Arch Phys Med Rehabil 2004;85(10):1694 –704.

Etnier JL, Nowell PM, Landers DM, Sibley BA.
Brain Res Rev. 2006 Aug 30;52(1):119-30. Epub 2006 Feb 20

Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L.
Physical activity and enhanced fitness to improve cognitive function in COCHRANE Review, 2008

Aerobic training leads to larger improvement in executive control tasks
Mainly shown with inhibition and switching

Table 1. *Results for significant moderating variables*

Moderator variable	Effect size	*SE*	*n*	*p*
Overall				
Control	0.164	0.028	96	*
Exercise	0.478[1]	0.029	101	*
Exercisers				
Training characteristics				
Training type				
Combined	0.59[2]	0.049	49	*
Cardiovascular only	0.41	0.037	52	*
Program duration				
Short (1–3 mo)	0.522[2]	0.067	38	*
Medium (4–6 mo)	0.269	0.047	36	*
Long (6+ mo)	0.674[1,2]	0.048	27	*
Session duration				
Short (15–30 min)	0.176	0.089	11	
Moderate (31–45 min)	0.614[1,2]	0.052	24	*
Long (46–60 min)	0.466[1]	0.041	53	*
Participants' characteristics				
Sex				
High female (>50% female)	0.604[2]	0.036	67	*
High male (≥50% male)	0.150	0.055	27	*
Age				
Young-old (55–65)	0.298	0.044	31	*
Mid-old (66–70)	0.693[1,3]	0.056	37	*
Old-old (71–80)	0.549[1]	0.058	33	*

Note. All listed categorical effects were, as a group, reliably different from zero. A superscript 1, 2, or 3 indicates that the effect size was statistically greater (after Bonferroni correction) than the effect size for the 1st, 2nd, or 3rd item, respectively, listed in that category (e.g., a "1,3" superscript means that the value in that cell was statistically greater than the 1st and 3rd listed items in that category). Asterisks indicate which categories were significantly different from zero.

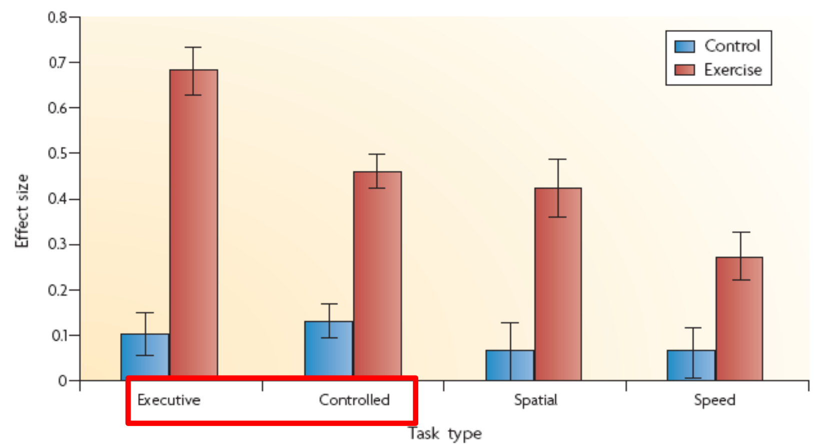
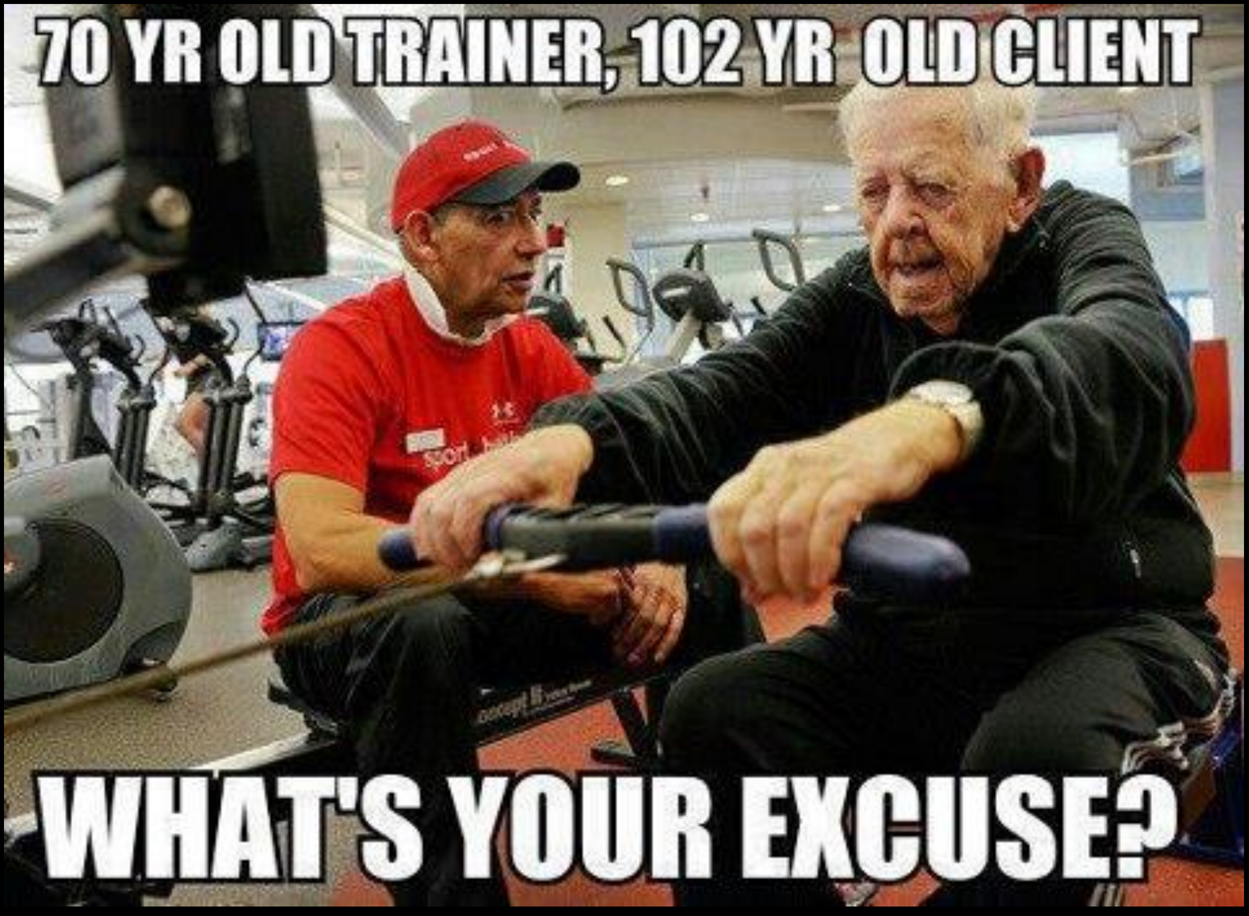


Figure 1 | **Meta-analytic findings of exercise-training effects on cognition in older adults.** The results of a meta-analysis of the effects of fitness training on cognition showed that the benefits of fitness training on four different cognitive tasks were significant. As illustrated in the figure, fitness training has both broad and specific effects. The effects are broad in the sense that individuals in aerobic fitness training groups (represented by the red bars) showed larger fitness training effects across the different categories of cognitive processes illustrated on the x-axis. They are specific in the sense that fitness training effects were larger for some cognitive processes, in particular executive control processes, than for other cognitive processes. Figure reproduced, with permission, from REF. 32 © (2003) Blackwell Publishers.

(Colcombe & Kramer, 2003 Meta-analyse).

How long ?   Any age limit ?
Physical condition (frailty) ?



frontiers in
AGING NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
published: 11 November 2010
doi: 10.3389/fnagi.2010.00148

The effect of three months of aerobic training on response preparation in older adults

Mélanie Renaud[1,2], François Maquestiaux[3], Steve Joncas[4], Marie-Jeanne Kergoat[2] and Louis Bherer[1,2]*

[1] Department of Psychology, University of Québec at Montréal, Montréal, QC, Canada
[2] Centre de Recherche, Institut Universitaire de Gériatrie de Montréal, Montréal, QC, Canada
[3] Unité de Recherche Complexité, Innovation, Activités Motrices et Sportives, Université Paris-Sud 11, Paris, France
[4] Bruyere Continuing Care, Ottawa, ON, Canada

50 older adults (60-80yrs)

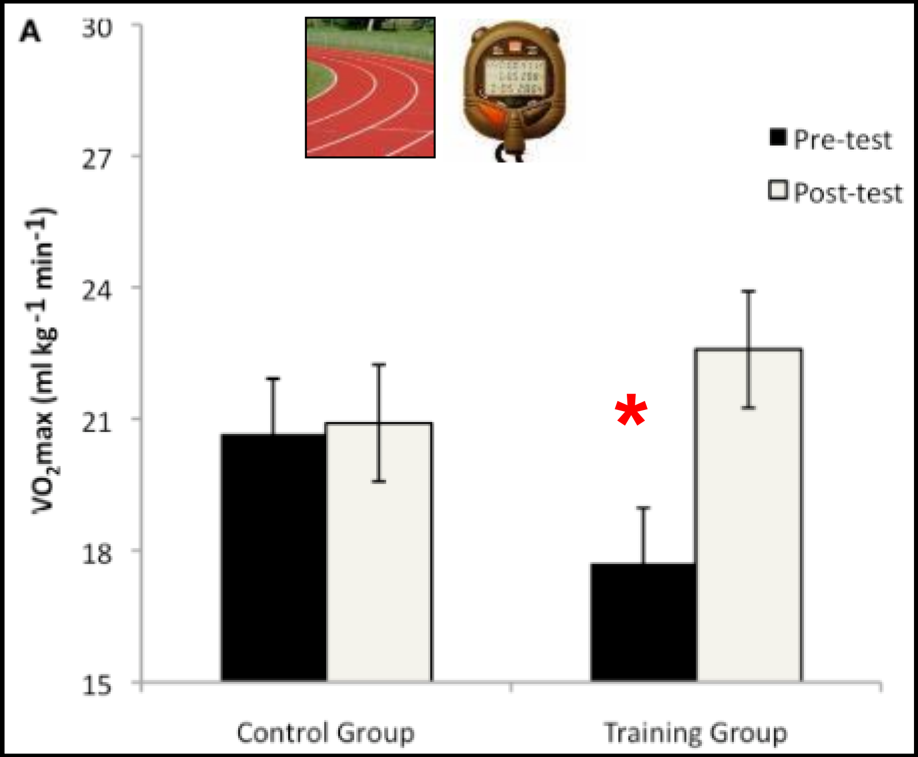
3-month aerobic training
Lower Fit vs. Higher Fit

Passive control group
Lower Fit vs. Higher Fit

Basic principles and guidelines for exercise programming from the American College of Sports Medicine (ACSM) were followed, including adequate warm up and cool down periods, progressive and gradual increments in exercise duration and energy expenditure.

Improvement in physical condition (VO2max estimate)

Group x Time



Sometimes fitness level matters…sometimes it does not !

Fitness x Training

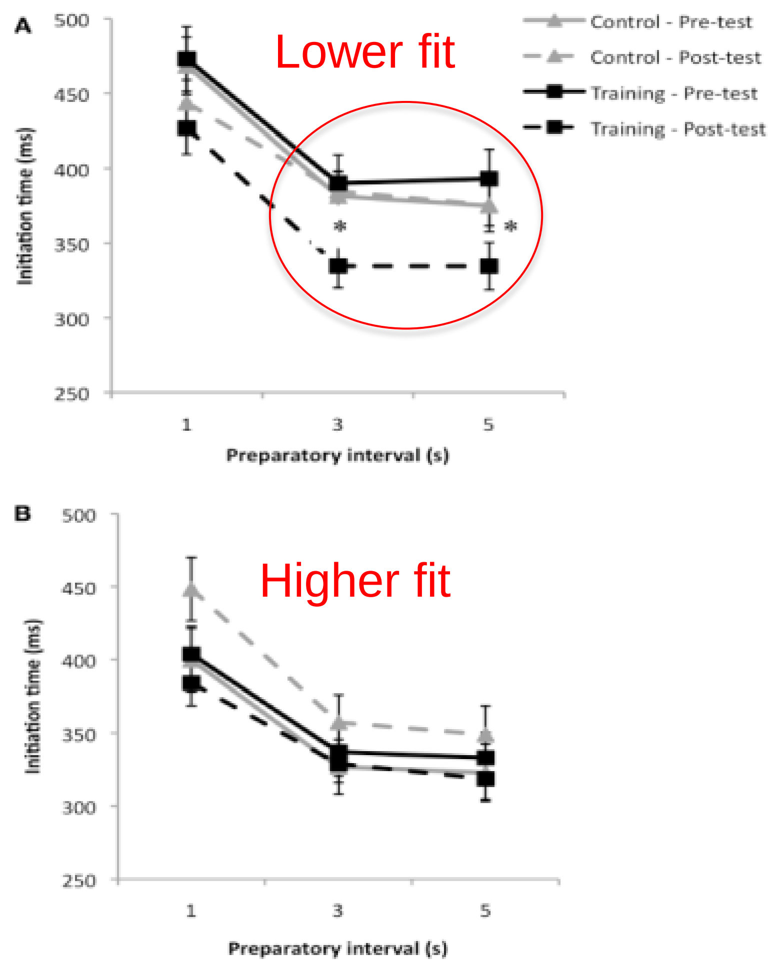


FIGURE 4 | Mean initiation time (ms) in the short temporal window of the choice RT task as a function of preparatory intervals at pre-test (solid line) and post-test (dashed line), in the lower fit (A) and the higher fit groups (B) (Bars represent standard errors).

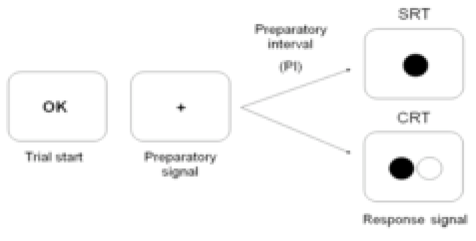


FIGURE 1 | Figural description of the response preparation task.

Equivalent improvement in Fit+ and Fit-

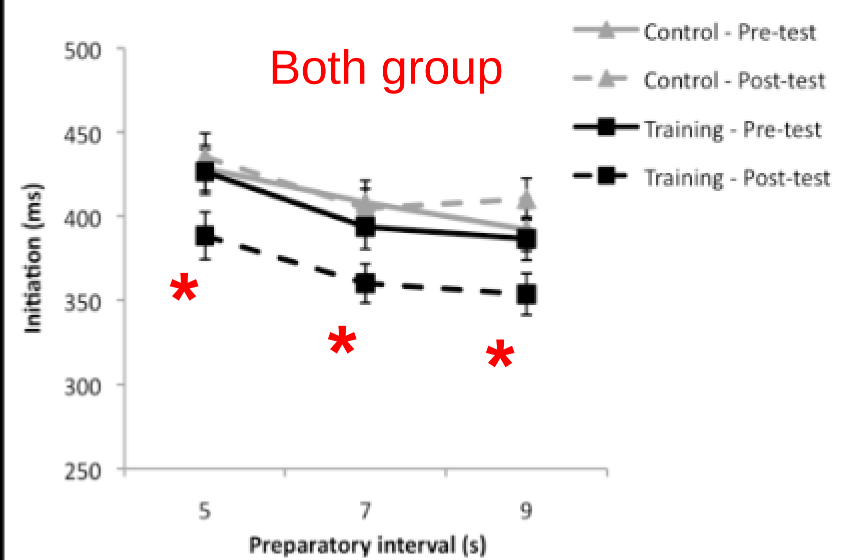


FIGURE 5 | Mean initiation time (ms) in the long temporal window of the choice RT task as a function of preparatory intervals at pre-test (solid line) and post-test (dashed line) (Bars represent standard errors).

Renaud et al., (2010) Frontiers in Aging Neurosciences

Journal of Aging Research
Volume 2012, Article ID 269815, 7 pages
doi:10.1155/2012/269815

Only 3 months make a difference !


D. Predovan

Research Article

The E

Stroo

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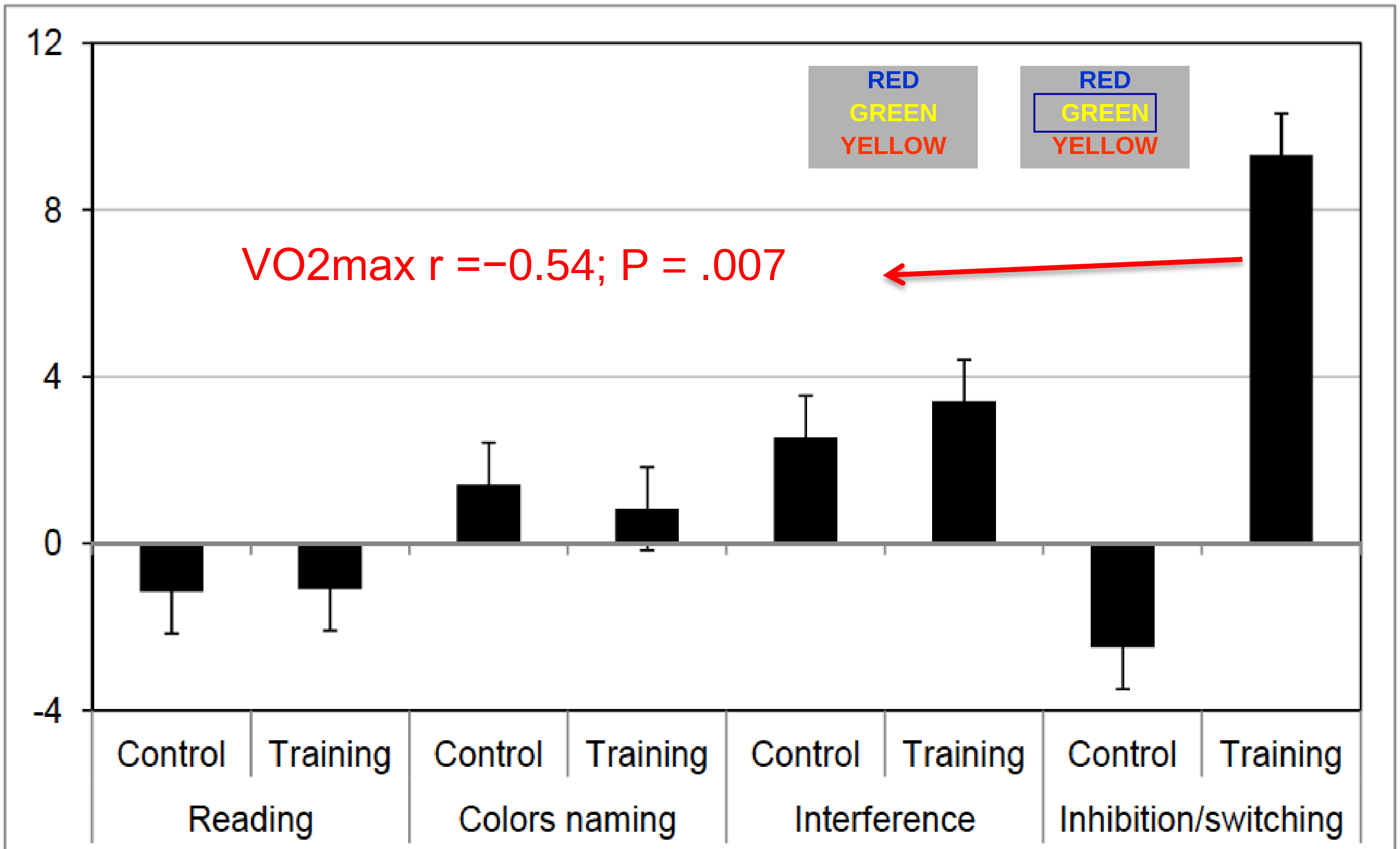
Figure 2 | Mean and SE for the change score on the Stroop test



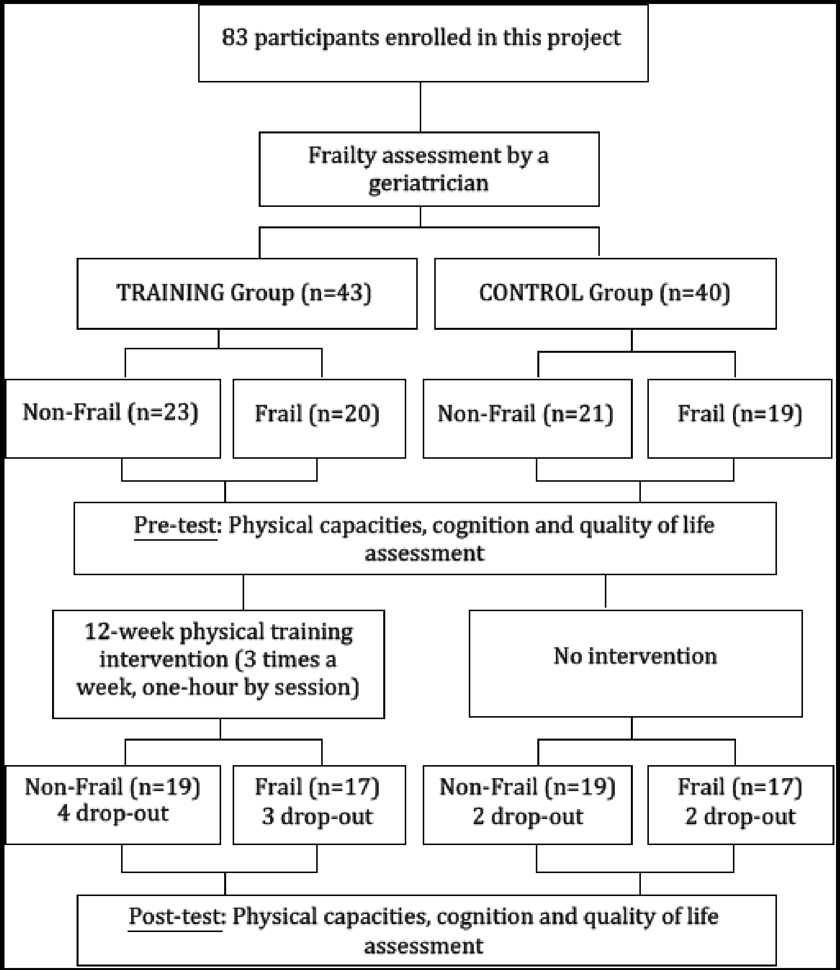
Baseline fitness and physical capacities status

Would frail elders benefit ?

Journal of Gerontology: Psychological Sciences, 2013

Benefits of Physical Exercise Training on Cognition and Quality of Life in Frail Older Adults

Francis Langlois,[1,2] Thien Tuong Minh Vu,[2,3] Kathleen Chassé,[2] Gilles Dupuis,[1,4] Marie-Jeanne Kergoat,[2] and Louis Bherer[1,2]



3/week x 12 weeks

Combined training exercises

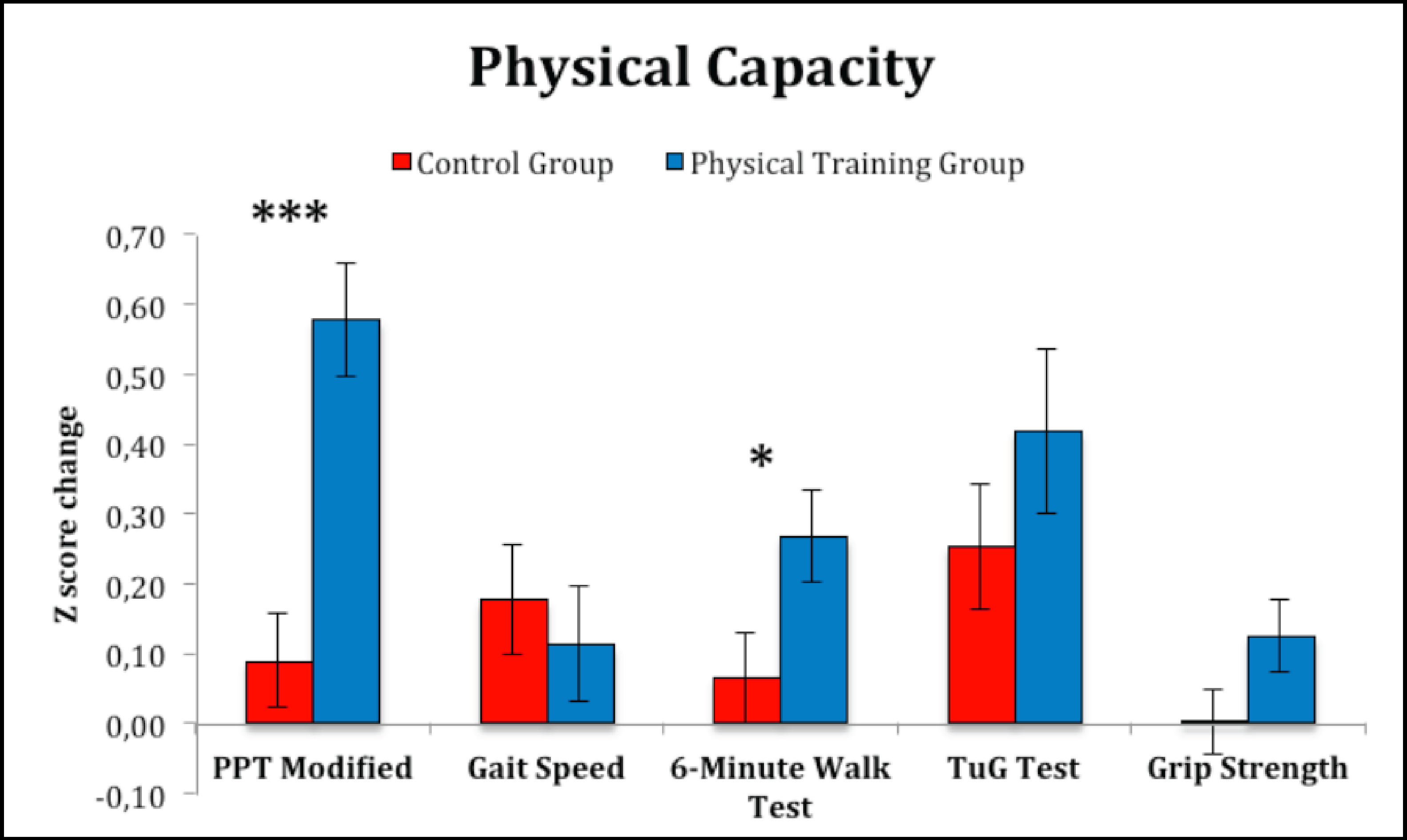
Table 1. Baseline Characteristics of Participants

Characteristics	Control group (n = 36)		Training group (n = 36)		Frail vs. nonfrail	Control vs. training
	Nonfrail (n = 19)	Frail (n = 17)	Nonfrail (n = 19)	Frail (n = 17)	p Value	p Value
Age, $M \pm SD$	70.95 ± 5.38	75.41 ± 4.91	68.74 ± 5.52	74.47 ± 6.99	<.001	.25
Female, n (%)	17 (89.47)	13 (76.47)	14 (73.68)	12 (70.59)	.41	.26
Education, $M \pm SD$	13.00 ± 2.71	12.68 ± 4.33	15.47 ± 3.12	13.35 ± 4.92	.19	.09
Cardiovascular diseases, total $M \pm SD$	0.79 ± 0.92	1.53 ± 1.23	1.11 ± 1.29	2.12 ± 1.27	.003	.11
Hypertension, n (%)	7 (36.84)	10 (58.82)	8 (42.11)	14 (82.35)	.009	.24
Diabetes mellitus, n (%)	1 (5.26)	4 (23.53)	2 (10.53)	2 (11.76)	.21	.72
Dyslipidemia, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.04	.10
Heart failure, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.29	.32
Arrhythmia, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.55	.64
Valvular disease, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.13	.64
Musculoskeletal disorders, total $M \pm SD$	[illegible]	[illegible]	[illegible]	[illegible]	.001	.15
Head and neck problems, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.77	.29
Arthritis, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.50	.32
Osteoporosis, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.15	.02
History of fractures, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.17	1.00
Poor standing posture, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.003	.69
Irregular gait pattern, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.01	.55
Gastrointestinal, total $M \pm SD$	[illegible]	[illegible]	[illegible]	[illegible]	.07	.28
Swallowing difficulty, n (%)	[illegible]	[illegible]	[illegible]	[illegible]	.03	.04
Pyrosis or reflux, n (%)	2 (10.53)	3 (17.65)	6 (31.58)	5 (29.41)	.80	.09
Digestive problems, n (%)	5 (26.32)	6 (35.29)	2 (10.53)	7 (41.18)	.06	.60
Pulmonary disease, total $M \pm SD$	0.47 (0.96)	0.59 (0.94)	0.32 (0.48)	0.65 (1.00)	.27	.81
Asthma, n (%)	1 (5.26)	3 (17.65)	1 (5.26)	1 (5.88)	.32	.39
COPD, n (%)	2 (10.53)	3 (17.65)	1 (5.26)	1 (5.88)	.58	.23
History of depression, n (%)	2 (10.53)	2 (11.76)	5 (26.32)	7 (41.18)	.41	.02
Mobility aids, n (%)	1 (5.26)	4 (23.53)	1 (5.26)	4 (23.53)	.03	1.00
At least one ADL or IADL disability, n (%)	1 (5.26)	6 (35.29)	2 (10.53)	10 (58.82)	<.001	.18
Number of daily medications, $M \pm SD$	3.74 ± 2.71	6.12 ± 3.82	3.79 ± 2.96	6.71 ± 2.69	<.001	.66

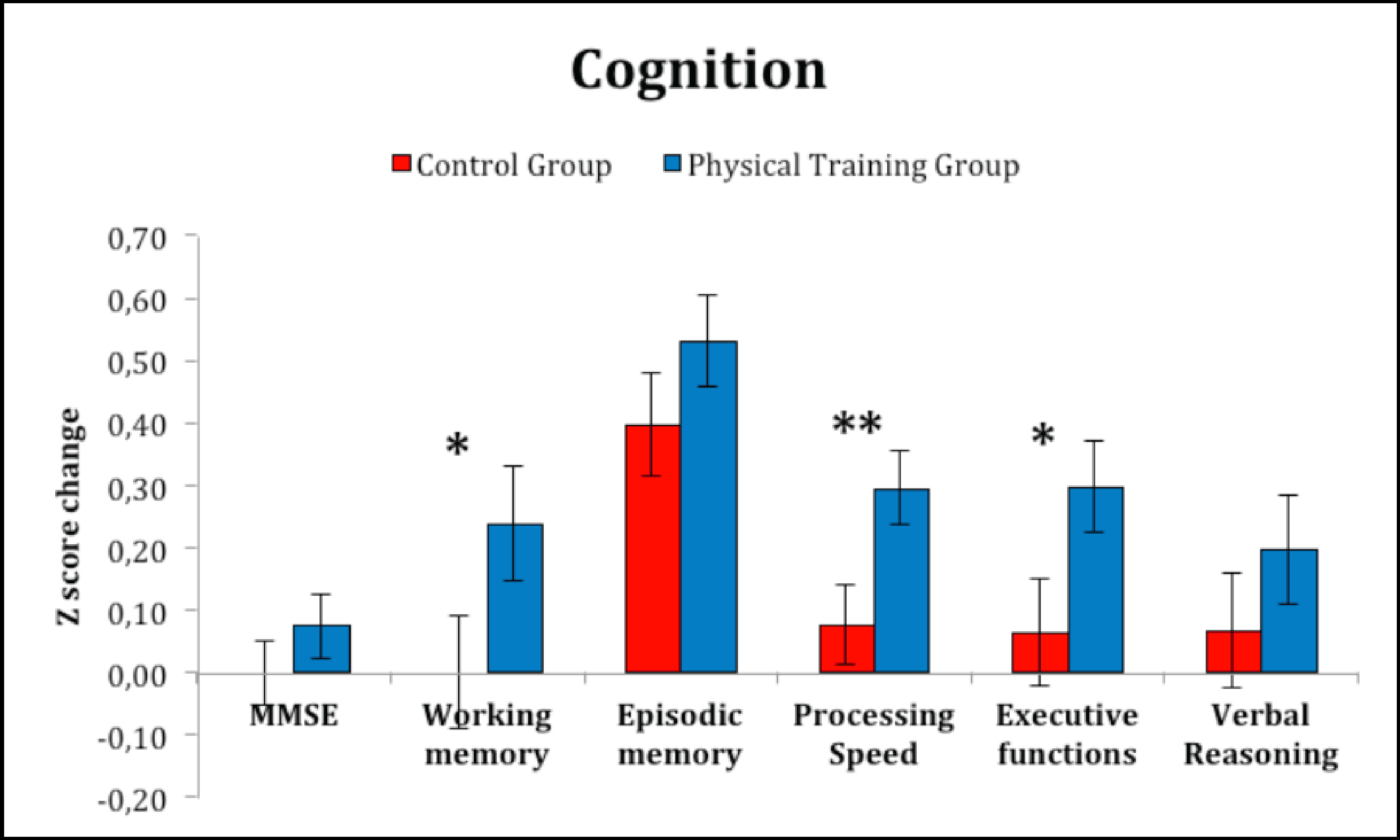
Notes. ADL = activity of daily living; COPD = chronic obstructive pulmonary disease; IADL = instrumental activity of daily living. Chi-square tests were used for categorical variables, and ANOVAs were used for continuous variables.

Comprehensive medical investigation and control for potential confounding factors

Equivalent improvement in frail and non-frail older adults after 3 months



Equivalent improvement in frail and non-frail older adults after 3 months



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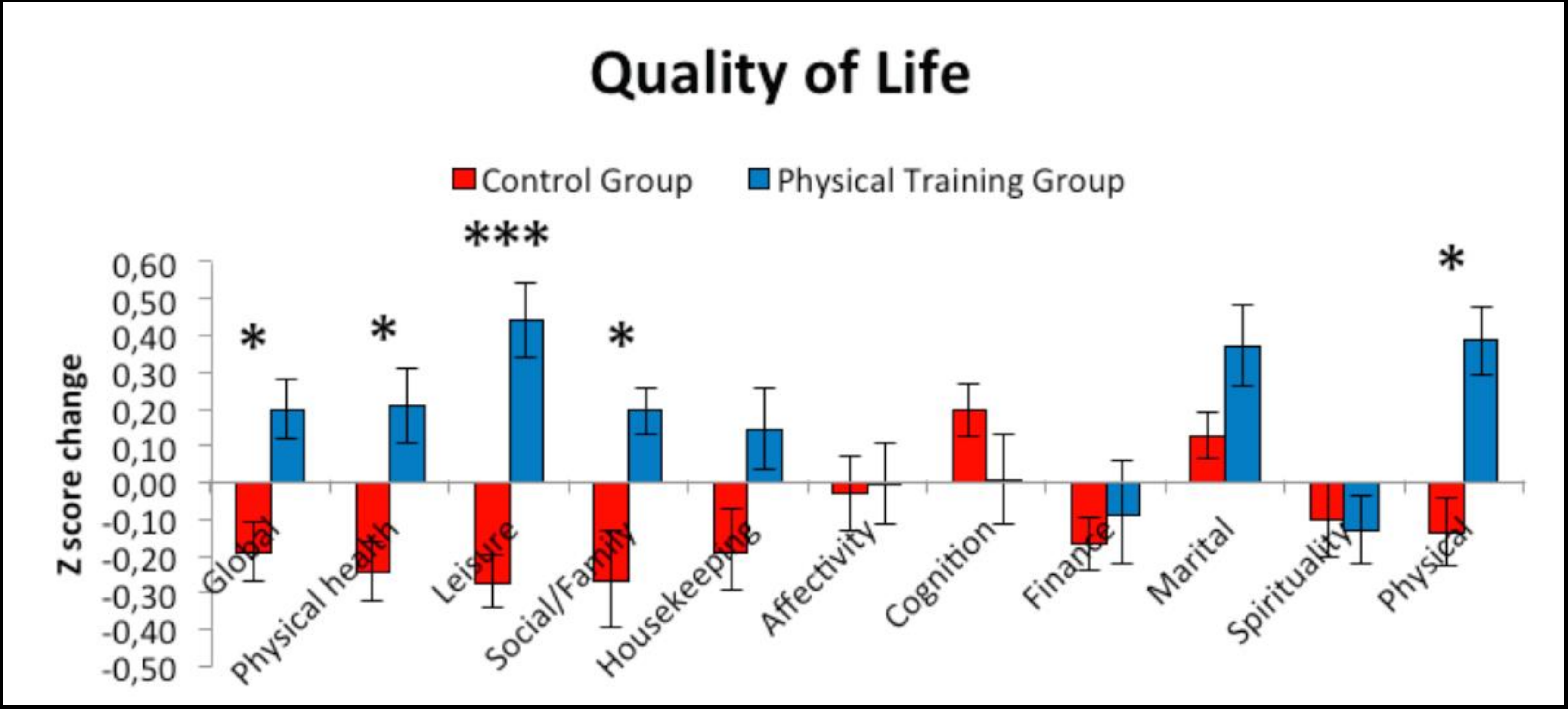


Neurosciences of exercise

Bherer, Erickson & Liu-Ambrose (2013). *A review of the Effects of Physical Activity and Exercise on Cognitive and Brain Functions in Older Adults.*
Journal of Aging Research

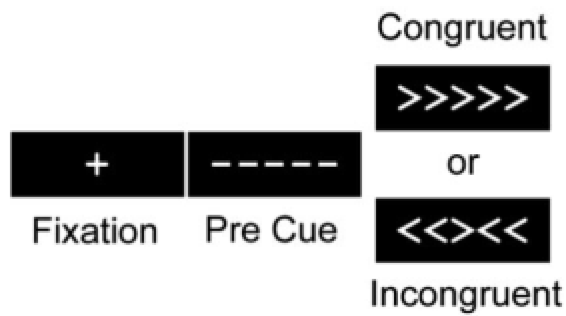
Impacts of physical activity on brain structures and functions

- Indirect effects
  - Stress, sleep, diet, etc.
  - Chronic diseases (coronary heart diseases).
- Direct effects
  - Angiogenesis, neurogenesis, synaptogenesis.
  - Increased plasma BDNF (neuroplasticity and protection) and production of insulin-like growth factor 1 (IGF-1) (neurgenesis and angiogenesis).
  - Neurotransmitter systems also seem to be modulated through exercise (see Lista & Sorrentino, 2010)

Physical activity and brain structures and functions in older adults

- Evidence of transient and permanent changes at the structural and functional levels in human
  - Erickson & Kramer, 2009; Hillman, Erickson, & Kramer, 2008; Kramer, Erickson, & Colcombe, 2006; Liu-Ambrose, Nagamatsu, Voss, Khan, & Handy, 2012; Voelcker-Rehage, Godde, & Staudinger, 2010; Voelcker-Rehage et al., 2013).

Colcombe, S. J., Kramer, A. F., Erickson, K. I., Scalf, P., McAuley, E., Cohen, N. J., Webb, A., Jerome, G. J., Marquez, D. X., & Elavsky, S. (2004) Cardiovascular fitness, cortical plasticity, and aging. Proc Natl Acad Sci USA, 101, 3316–3321.



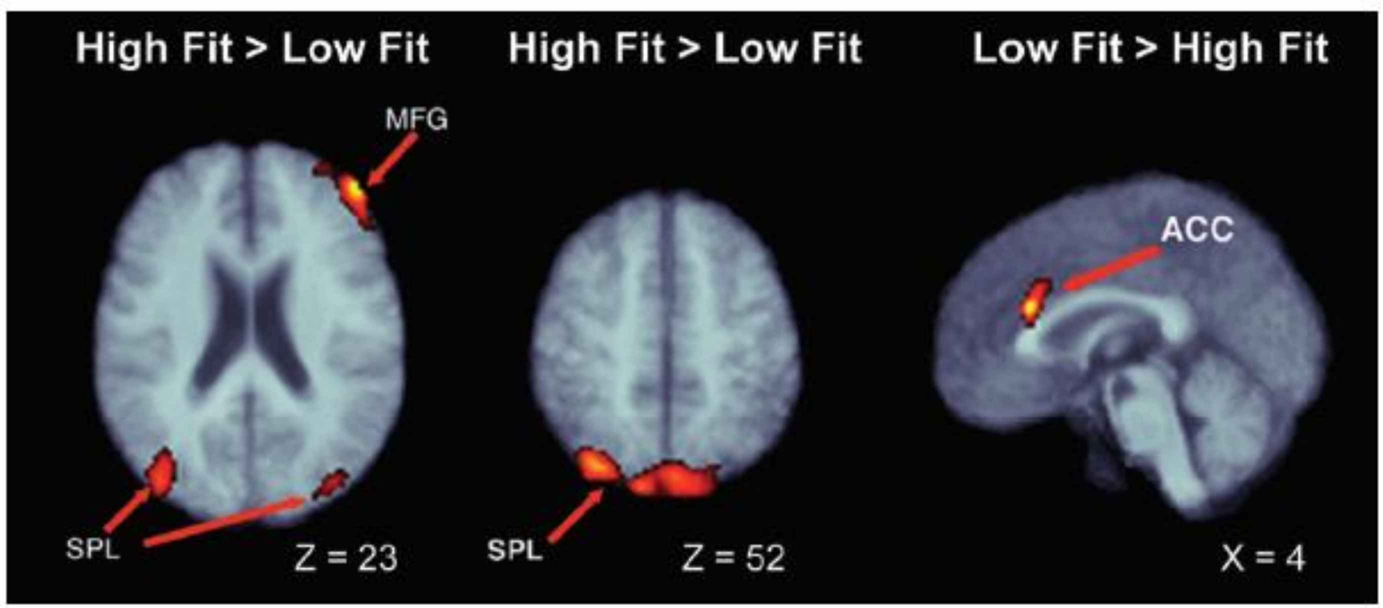


Fig. 2. Regional differences in cortical recruitment as a function of cardiovascular fitness. See Table 1 for cluster descriptions.

frontiers in
HUMAN NEUROSCIENCE
ORIGINAL RESEARCH ARTICLE
published: 18 February 2015
doi: 10.3389/fnhum.2015.00066

Higher levels of cardiovascular fitness are associated with better executive function and prefrontal oxygenation in younger and older women

Olivier Dupuy*[1,2,3], *Claudine J. Gauthier*[2,4], *Sarah A. Fraser*[2,5], *Laurence Desjardins-Crèpeau*[2], *Michèle Desjardins*[2,6], *Said Mekary*[2], *Frederic Lesage*[7], *Rick D. Hoge*[2,6], *Philippe Pouliot*[7] and *Louis Bherer*[1,2]

[1] *Centre PERFORM, Université Concordia, Montreal, QC, Canada*
[2] *Centre de Recherche de l'Institut de Gériatrie de Montréal, Montreal, QC, Canada*

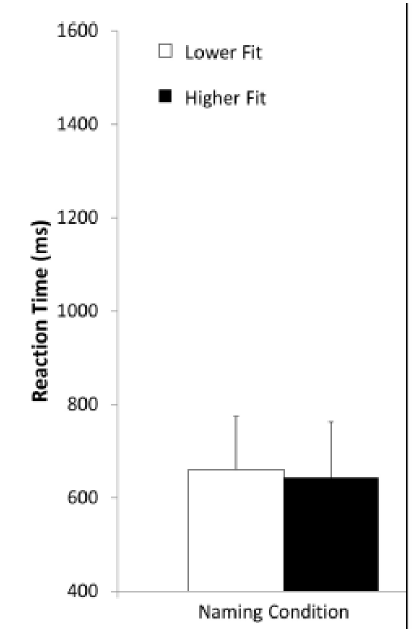


FIGURE 4 | Mean reaction time (ms
conditions for higher fit and lower f

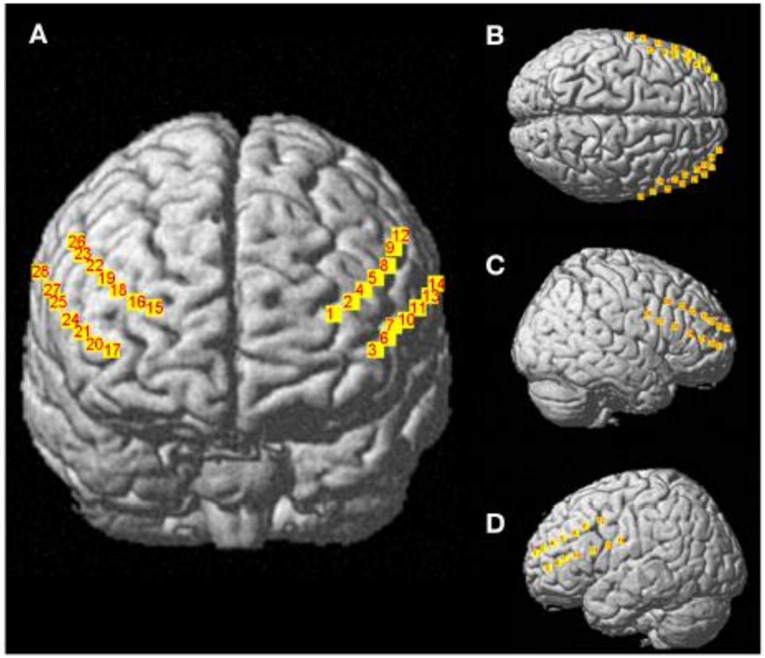
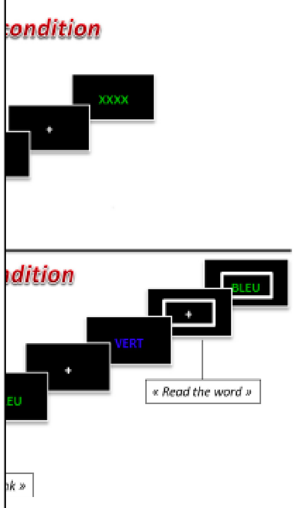


FIGURE 3 | Representations of 28 channels NIRS (i.e., detectors-sources) covering prefrontal regions (A), Frontal view; (B), Top view; (C), right sagittal view; (D), left sagittal view.



the computerized Stroop task.

- Condition : *F* (1, 54) =
- Cond x Fitness : *F* (1
- Cond x Fitness x Age : *F* (1, 54) = 0.3 ; *ns*

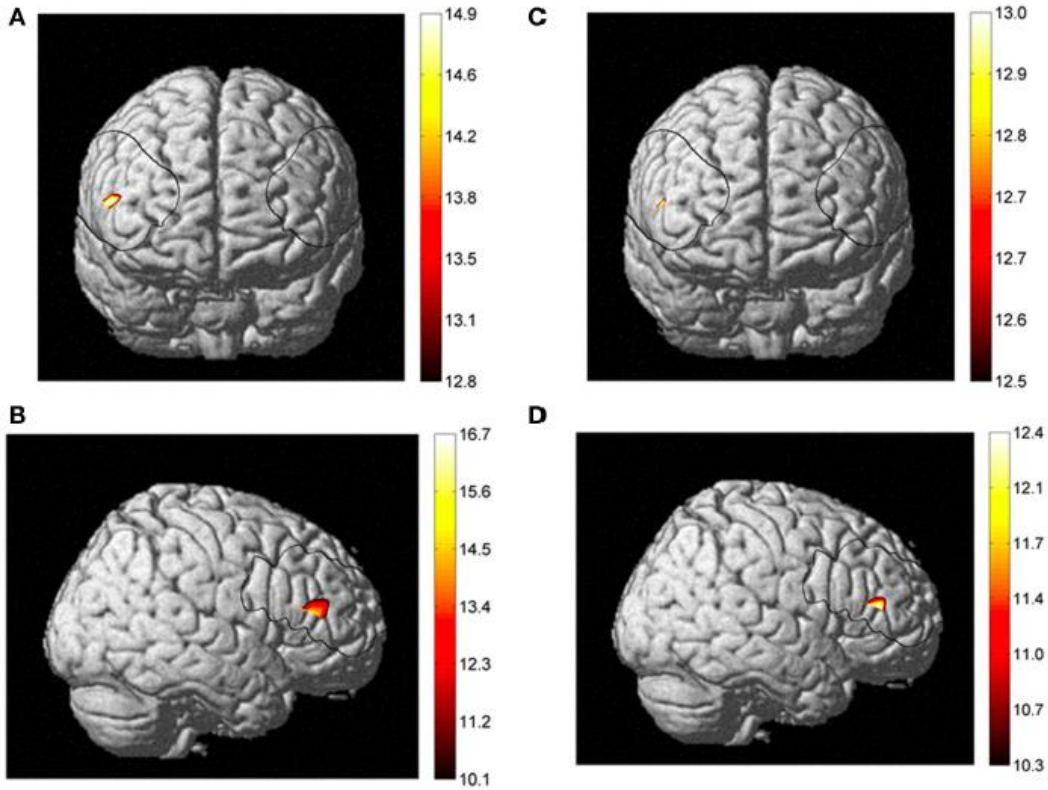


FIGURE 5 | Fitness effect between higher fit and lower fit women for HbO_2 in frontal (A) and right sagittal view (B), and for HbT in frontal (C) and right sagittal view (D).

Table 3 | Means and Standard deviations of cerebral changes (Δ) from baseline during both conditions of the Computerized Stroop task.

	Lower fit			Higher fit			Fitness ES (d)		
	ΔHbT (A.U)	ΔHbO_2 (A.U)	ΔHbr (A.U)	ΔHbT (A.U)	ΔHbO_2 (A.U)	ΔHbr (A.U)	ΔHbT	ΔHbO_2	ΔHbr
Naming condition	−0.93 ± 1.83	−1.29 ± 2.08	0.92 ±1.78	0.57 ± 1.63*	0.49 ± 1.81*	0.16 ± 1.32	0.9	0.9	0.5
Executive condition	−1.28 ± 1.86	−1.56 ± 2.25	0.93 ± 3.09	0.68 ± 2.10*	0.54 ± 2.33*	−0.15 ± 2.45	1.0	0.9	0.4

Results are presented mean ± SD; AU, arbitrary unit.

**Different from lower fit $p < 0.05$; ΔHbO_2, changes in oxyhemoglobin concentrations; ΔHbr, changes in deoxyhemoglobin concentrations; ΔHbT, changes in total hemoglobin. ES (d), Cohen's d (Effect Size).*

Exercise training increases size of hippocampus and improves memory

Kirk I. Erickson[a], Michelle W. Voss[b,c], Ruchika Shaurya Prakash[d], Chandramallika Basak[e], Amanda Szabo[f], Laura Chaddock[b,c], Jennifer S. Kim[b], Susie Heo[b,c], Heloisa Alves[b,c], Siobhan M. White[f], Thomas R. Wojcicki[f], Emily Mailey[f], Victoria J. Vieira[f], Stephen A. Martin[f], Brandt D. Pence[f], Jeffrey A. Woods[f], Edward McAuley[b,f], and Arthur F. Kramer[b,c,1]

www.pnas.org/cgi/doi/10.1073/pnas.1015950108

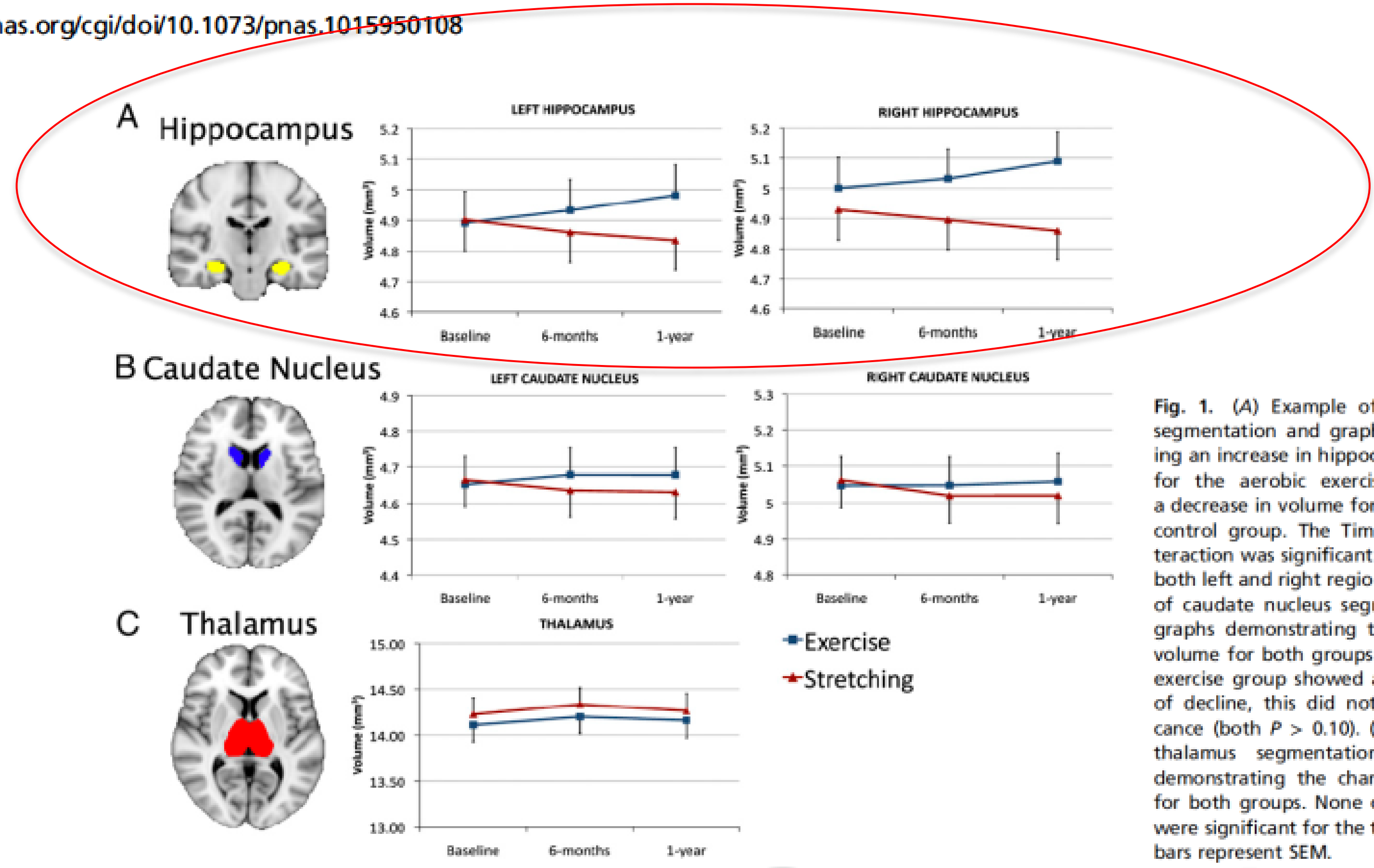


Fig. 1. (*A*) Example of hippocampus segmentation and graphs demonstrating an increase in hippocampus volume for the aerobic exercise group and a decrease in volume for the stretching control group. The Time × Group interaction was significant ($P < 0.001$) for both left and right regions. (*B*) Example of caudate nucleus segmentation and graphs demonstrating the changes in volume for both groups. Although the exercise group showed an attenuation of decline, this did not reach significance (both $P > 0.10$). (*C*) Example of thalamus segmentation and graph demonstrating the change in volume for both groups. None of the changes were significant for the thalamus. Error bars represent SEM.

Neurobiology of Aging 36 (2015) 304–314

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Hearts and minds: linking vascular rigidity and aerobic fitness with cognitive aging

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Preservation of vessel elasticity (cerebrovascular reactivity) may be one of the key mechanism by which physical exercise helps to alleviate age-related cognitive decline in executive

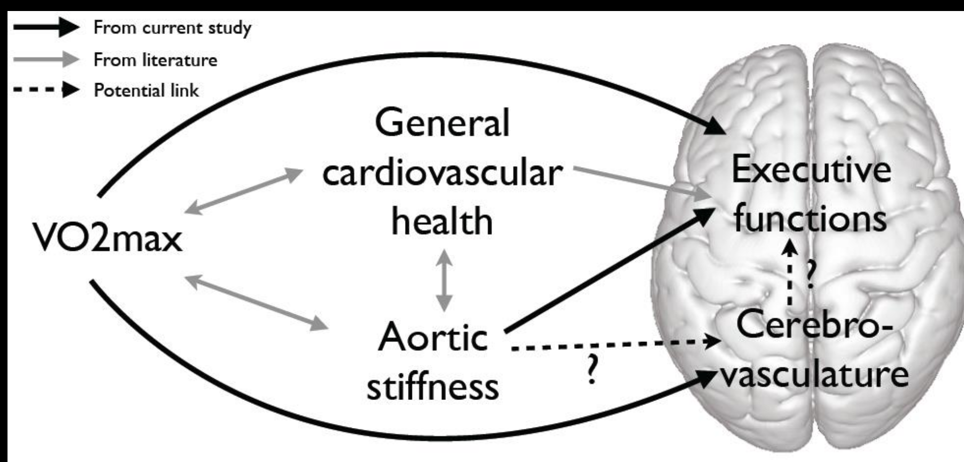

Figure 6. Conceptual framework for links between vascular health, cardiorespiratory fitness and executive functions

Dose-response ?

Aerobic training ?

Other type of exercise training ?

Multiple roads lead to Rome: combined high-intensity aerobic and strength training vs. gross motor activities leads to equivalent improvement in executive functions in a cohort of healthy older adults

Nicolas Berryman • Louis Bherer • Sylvie Nadeau • Séléna Lauzière • Lora Lehr • Florian Bobeuf • Maxime Lussier • Marie Jeanne Kergoat • Thien Tuong Minh Vu • Laurent Bosquet

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- Large improvement in walking physiological parameters (potential energy) in LBS-A and UBS-A
- Equivalent improvement in cognitive function in all groups, with inhibition being more sensitive to the intervention.
- Different physical exercise programs (aerobic, gross motor, strength, etc) may help improve cognition in older adults.

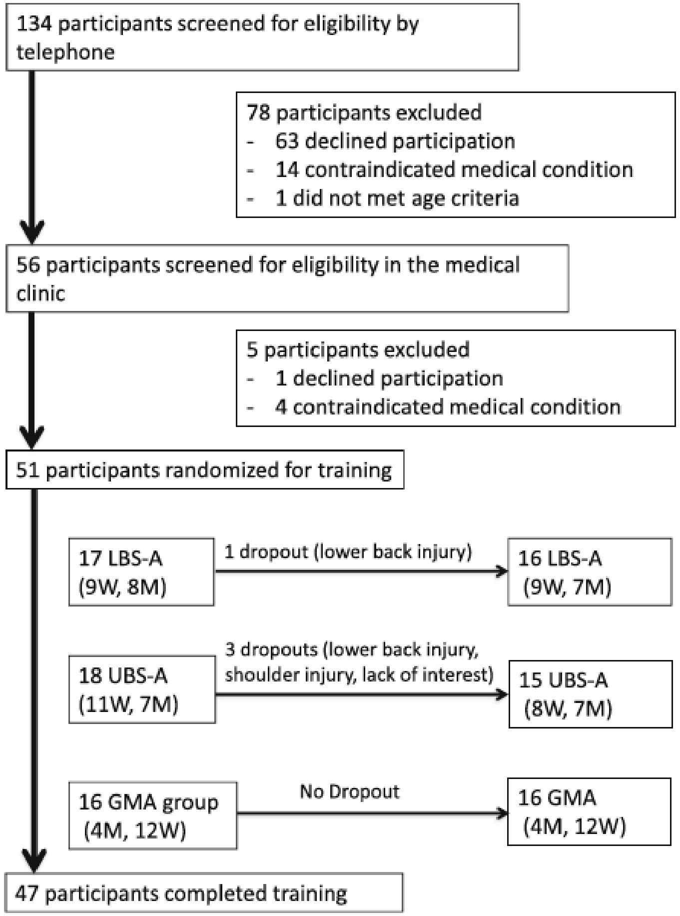


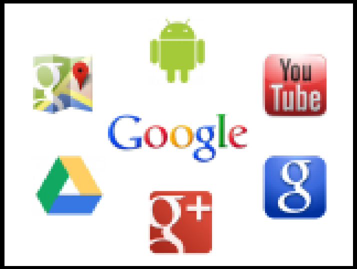
Fig. 1 Flow chart

Combined intervention ?

A 4-arm intervention ?

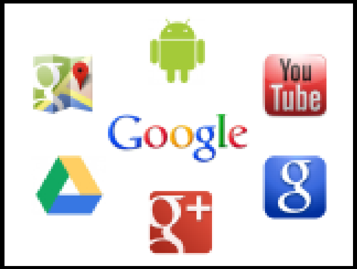
Aerobic + DT-training


Aerobic + Lessons

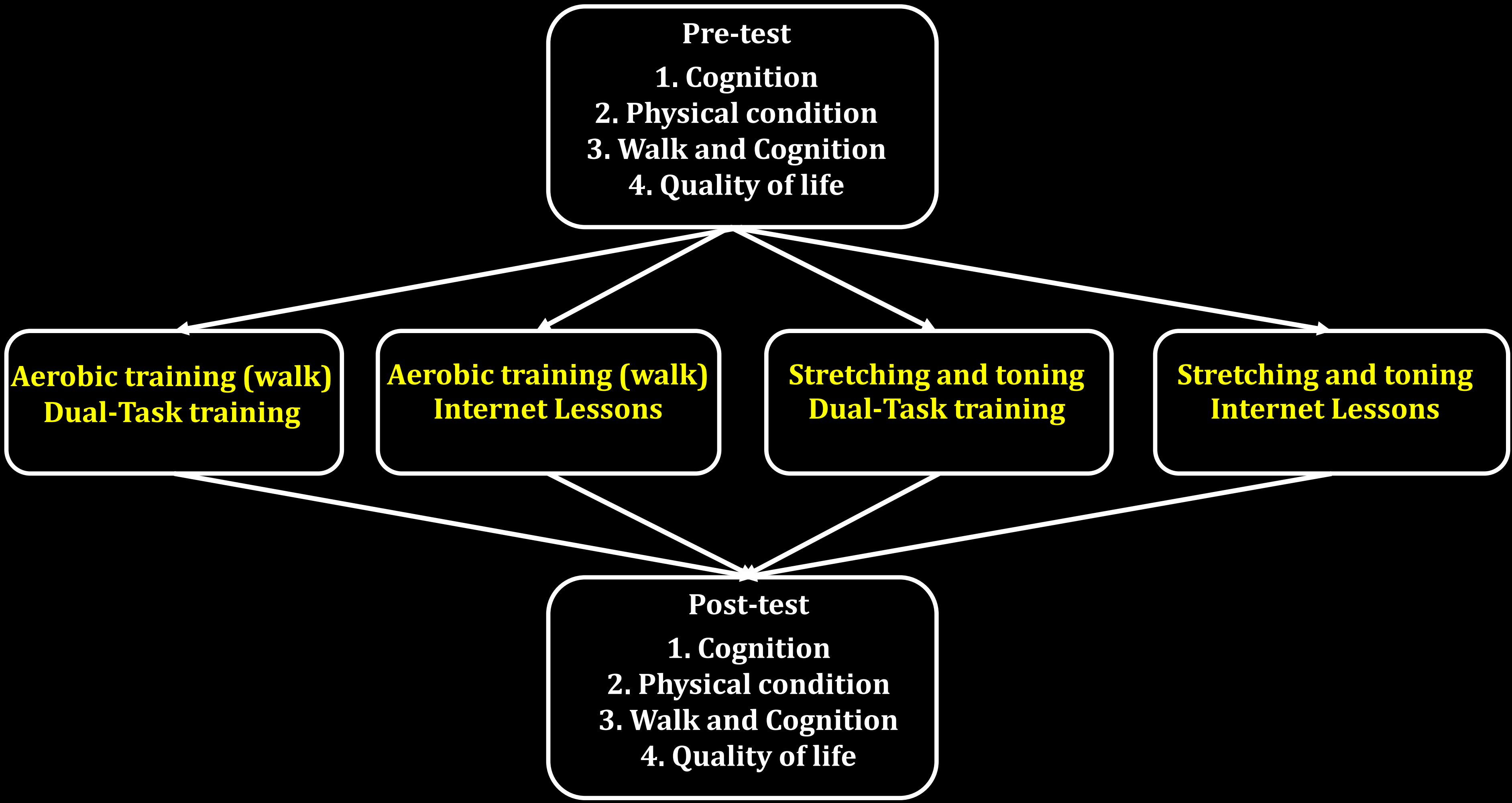
Stretching + DT-training


Stretching + Lessons

Study design

- All participants completed 12 weeks of training
- 3 times per week (2 exercise, 1 computer session)



The search for the best lifestyle intervention

Dance Movement Therapy

LES GRANDS BALLETS | NATIONAL CENTRE FOR DANCE THERAPY

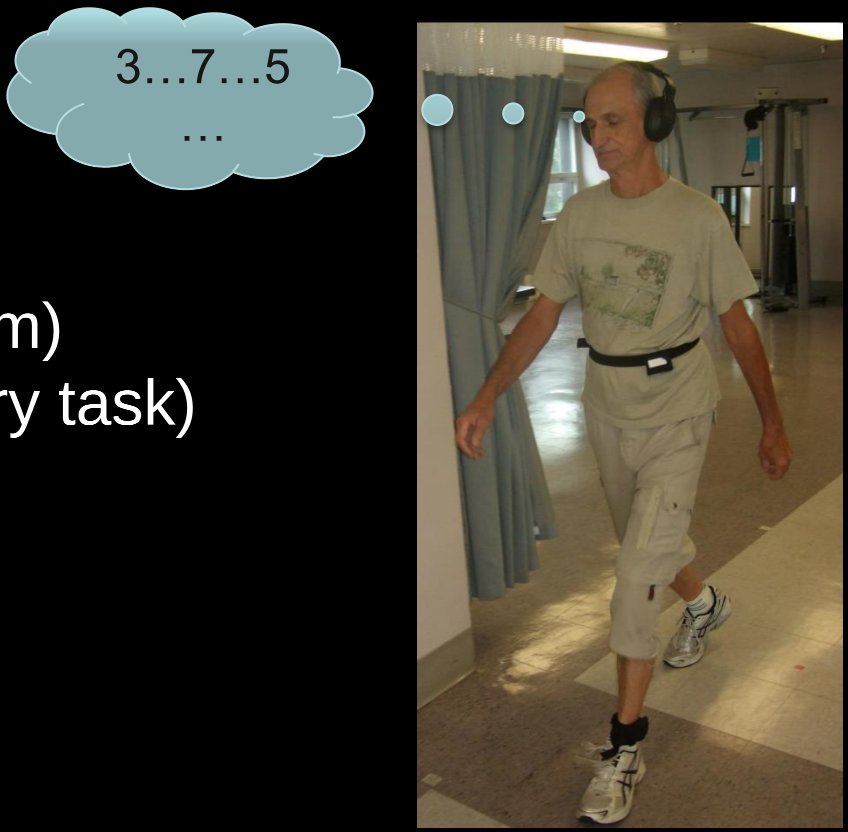
Aerobic training

Santé et Services sociaux Québec

fNIRS studies suggest frontal compensation in physical function tasks such as walking with a cognitive load (dual-task walking)

Portable fNIRS is an ideal tool to study the interaction between decline in executive control and mobility

Dual-task walking paradigm (walking + thinking) can help detect cognitive declines that are not apparent in clinical tests (subclinic).



Dual-task walk paradigm:
1-Walking alone (distance in m)
2-Cognitive task (% in memory task)
3-Both tasks combined

Ongoing study

1-Identify preclinical (silent) cognitive decline in at risk population of older adults with coronary heart disease).

2-Use fNIRS in dual-task walking condition to track changes (or absence of) in cognition over 6-12 months in participants engaged in an exercise training program (preventive cardiology clinic)

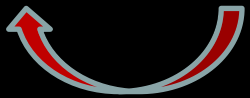
ÉPIC Centre de médecine préventive et d'activité physique de l'Institut de Cardiologie de Montréal

IRSC CIHR

Cognitive Task: Auditory N-Back

- Hear a series of numbers (digits: 0-9)
- Say aloud the number you heard 2-back

9 – 1 – 7 – 2 – 0 – 3 – 5 – 8 – 6 -



- **Dual-task paradigm**
  - Walk alone
  - Cognition alone
  - Dual-task: 2 tasks at the same time

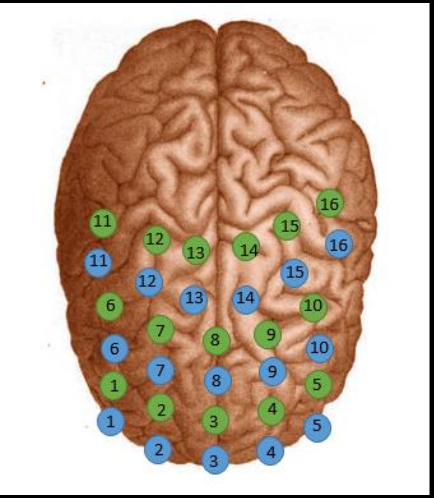
POLYTECHNIQUE MONTRÉAL

LE GÉNIE EN PREMIÈRE CLASSE

Imaginc System

- ✓ High channel count: 32 emittors, 32 detectors, 32 EEG electrodes

  → *128 NIRS channels, 32 EEG channels*
- ✓ Lightweight: 440 grams / 1 lb
- ✓ Small size: 11.6 x 9 x 5 cm^3 / 4.6 x 3.5 x 2 in^3
- ✓ Low power consumption
- ✓ Wireless: Battery powered and Bluetooth communication

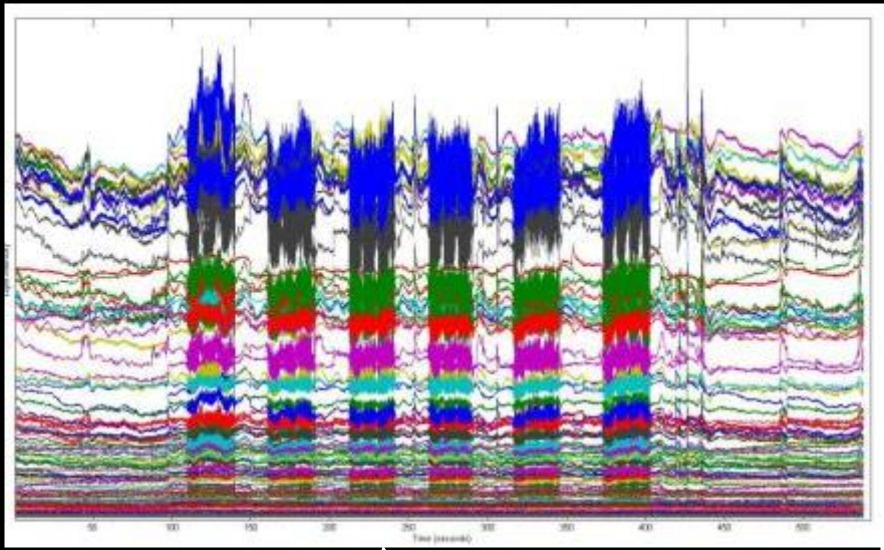


Emittor

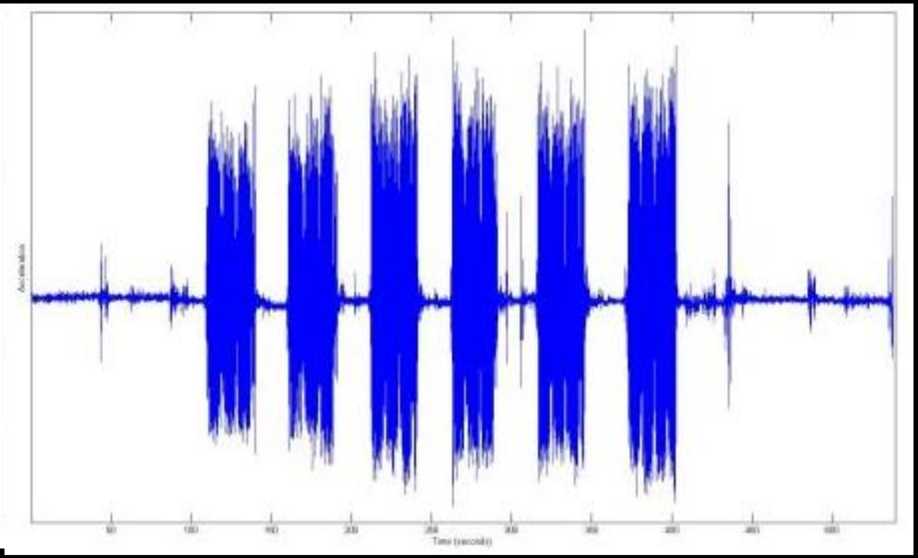
Detector

Challenges: worse case scenario !

Motion Artifacts during walk periods



Raw fNIRS data



Accelerometer signal

Accelerometers and Independent Component Analysis (ICA) were used to develop a walk related motion artefacts removal algorithm.

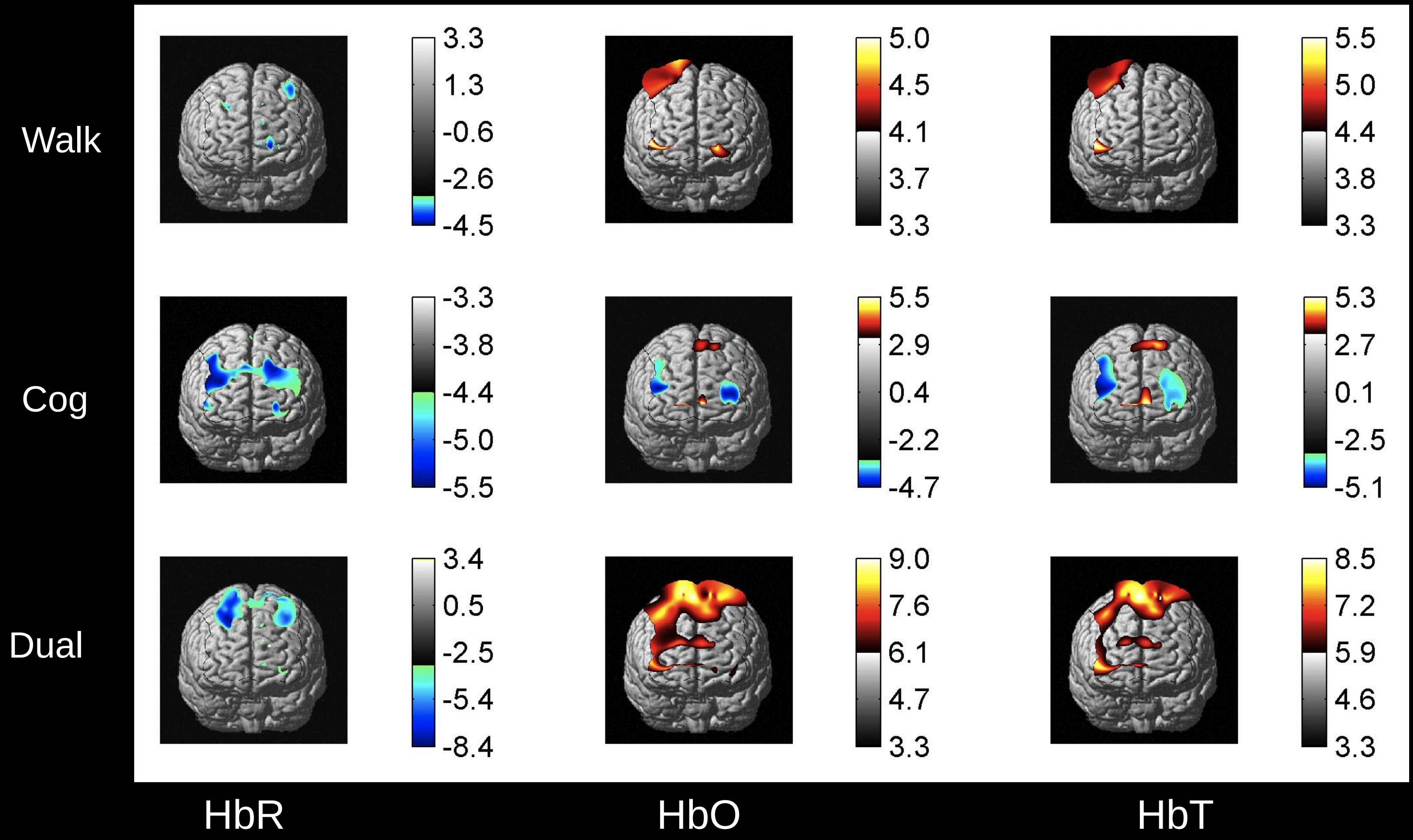
Solutions

- Fixed optodes (Collodion)
  - → Increases installation time
  - → Acquisition less pleasant for participants
- Motion Artifacts Removal Algorithms
  - → Principal components analysis
  - → **Independent components analysis**
  - → Wavelet
  - → Kalman filtering
  - → …

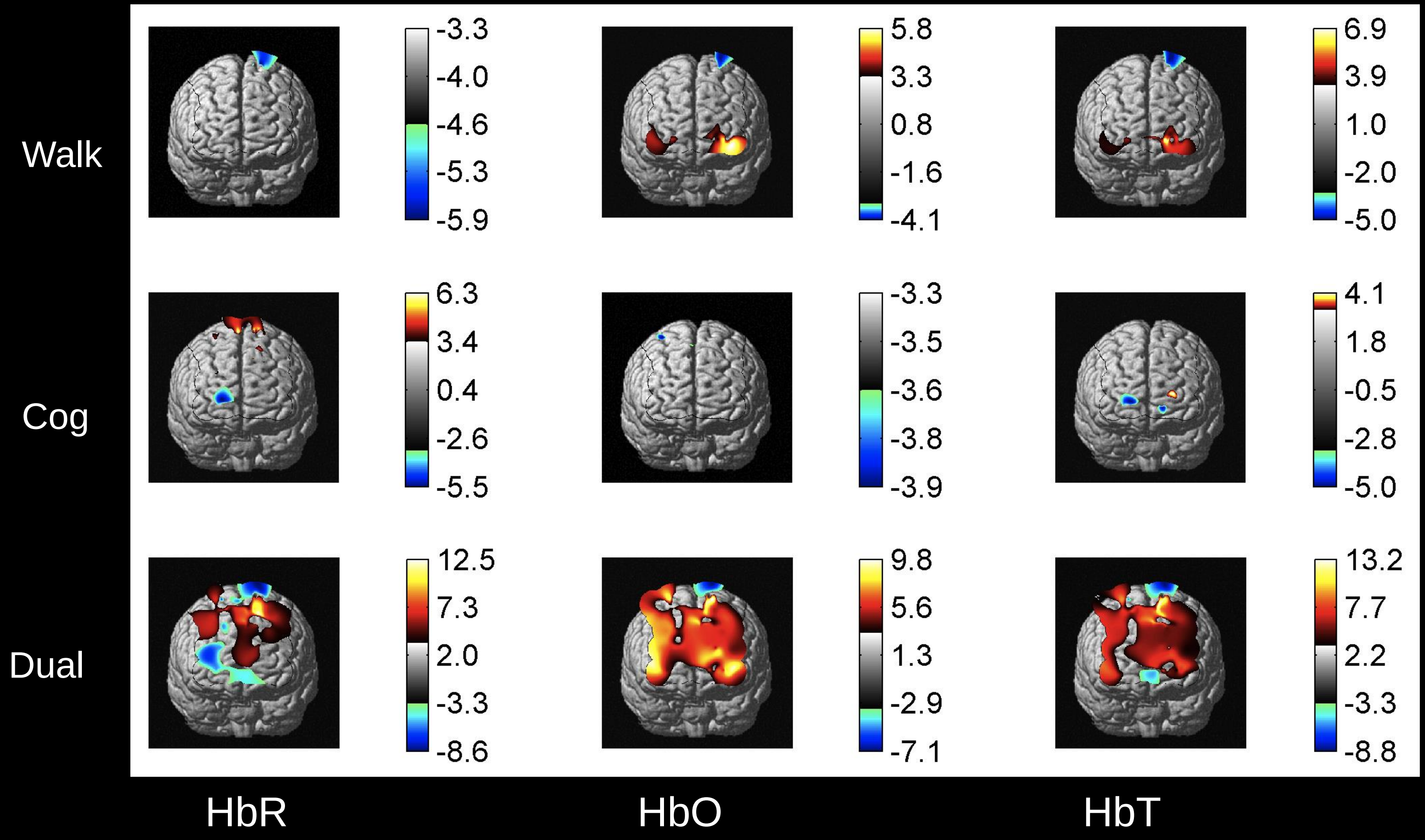
PARTICIPANTS (pilot data)

- Healthy participants (no cardiovascular disease or hypertension)
- Patients with either cardiovascular risk factors (i.e., hypertension) or who had heart surgery (coronary bypass)

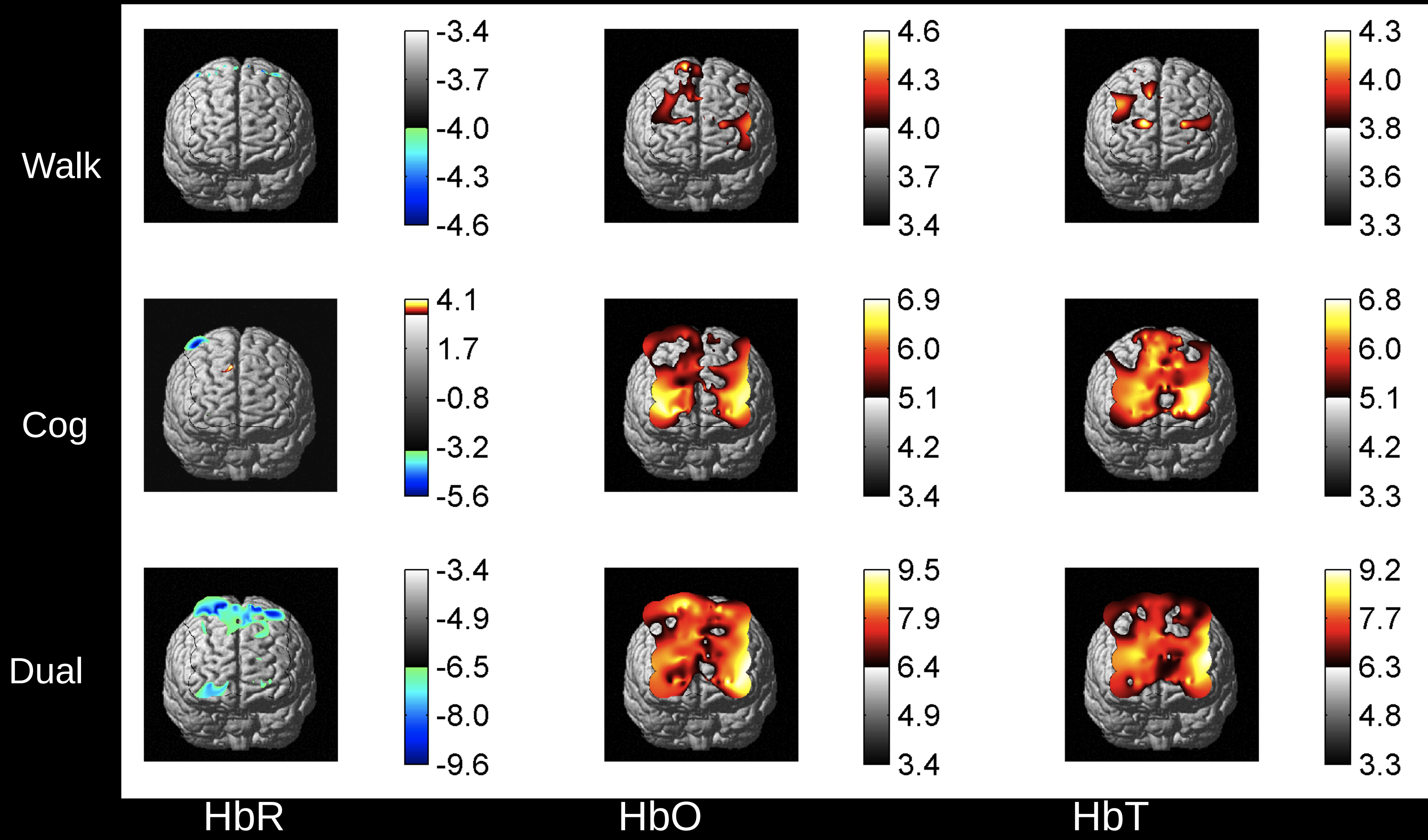
Healthy adult (MOCA = 29)



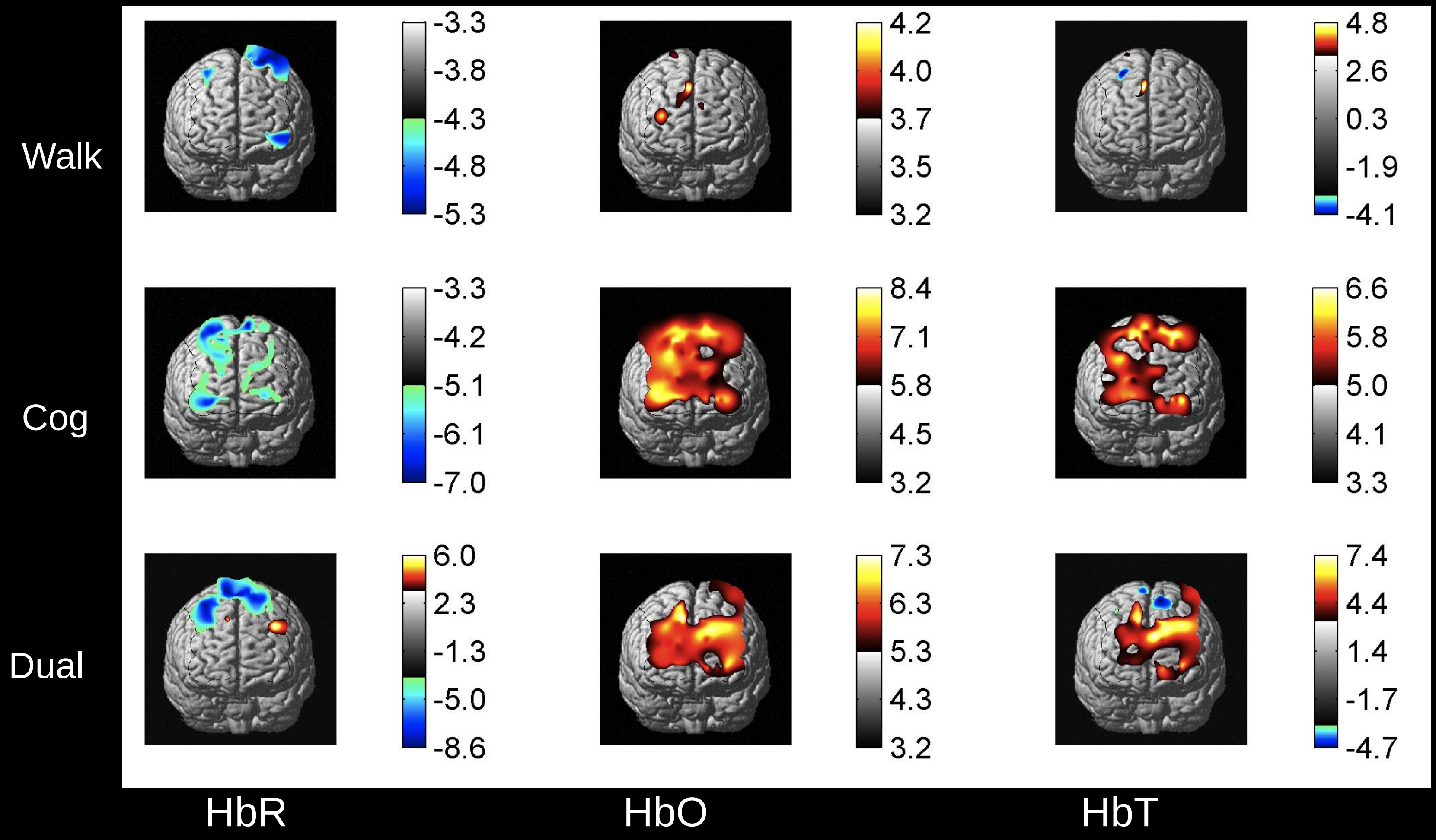
Healthy adult (MOCA = 28)



Coronary patient (MOCA = 26)



Coronary patient (MOCA = 26)



Best outcomes measure to assess cog-gait changes induced by exercise intervention

- ❖Portable fNIRS device might help to track associated brain mechanisms of impaired cognitive control on gait
- ❖Psychomotor executive functions: Response preparation
  - ❖Closely involved in motor control
  - ❖Age-sensitive and enhanced with fitness training
- ❖Inhibition (flanker task/ Stroop)
- ❖Switching
  - ❖Modified Stroop (DKEF)
  - ❖Involved in dual-task control
- ❖Dual-task performance

Best outcomes measure to assess cog-gait changes induced by exercise intervention

- Compound scores of executive control and speed (distinctively)

Journal of Gerontoloy: Psych Sicences, 2014

Physical Functioning Is Associated With Processing Speed and Executive Functions in Community-Dwelling Older Adults

Laurence Desjardins-Crépeau,[1,2] Nicolas Berryman,[2,3] Thien Tuong Minh Vu,[2] Juan Manuel Villalpando,[2] Marie-Jeanne Kergoat,[2,4] Karen Z. Li,[5] Laurent Bosquet,[3,6] and Louis Bherer[2,5]

- Physical functioning associated with processing speed and executive functions but not memory performance.
- Independent of age, sex, and level of education.
- Cardiovascular burden not associated with cognition.

Table 1. Summary of Regression Analyses Predicting Cognitive Composite Scores

	R^2	ΔR^2	ΔF
Memory			
Model 1	.270	.270	10.996*
Model 2	.295	.025	3.085
Model 3	.295	.000	.008
Speed			
Model 1	.229	.229	8.806*
Model 2	.379	.150	21.311*
Model 3	.381	.002	.293
Executive			
Model 1	.191	.191	6.984*
Model 2	.334	.143	18.932*
Model 3	.356	.022	3.015

Note. Model 1 = Age, education, and sex; Model 2 = Age, education, sex, and functional score; Model 3 = Age, education, sex, functional score, and cardiovascular risk score.

*$p < .05$.

Centre de recherche iugm Institut universitaire de gériatrie de Montréal

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