Canada 2026 ICEBAT GLOBAL TRENDS IN AQUATIC THERAPY

BALANCING IN MOTION: A NOVEL APPROACH TO FALL PREVENTION THROUGH AQUATIC REACTIVE BALANCE TRAINING

Anna Ogonowska-Slodownik

Jozef Pilsudski University of Physical Education in Warsaw, Poland
KITE-Toronto Rehabilitation Institute, University Health Network, Canada

JÓZEF PIŁSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

UHN KITE Research Institute

NAWA POLISH NATIONAL AGENCY FOR ACADEMIC EXCHANGE

AquaTES Lab Aquatic Therapy, Exercise and Swimming Lab

2012

AQUAOUTCOME
Toledo, Spain

2012

Assistant, Faculty of Rehabilitation

JÓZEF PIŁSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

2016

Post-doctoral fellow, 4 months University of Maryland Rehabilitation & Orthopaedic Institute

UNIVERSITY of MARYLAND REHABILITATION & ORTHOPAEDIC INSTITUTE

2016

Assistant Professor, Faculty of Rehabilitation

JÓZEF PIŁSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

2024

Affiliate Scientist at KITE Research Institute

UHN KITE Research Institute

OUTLINE

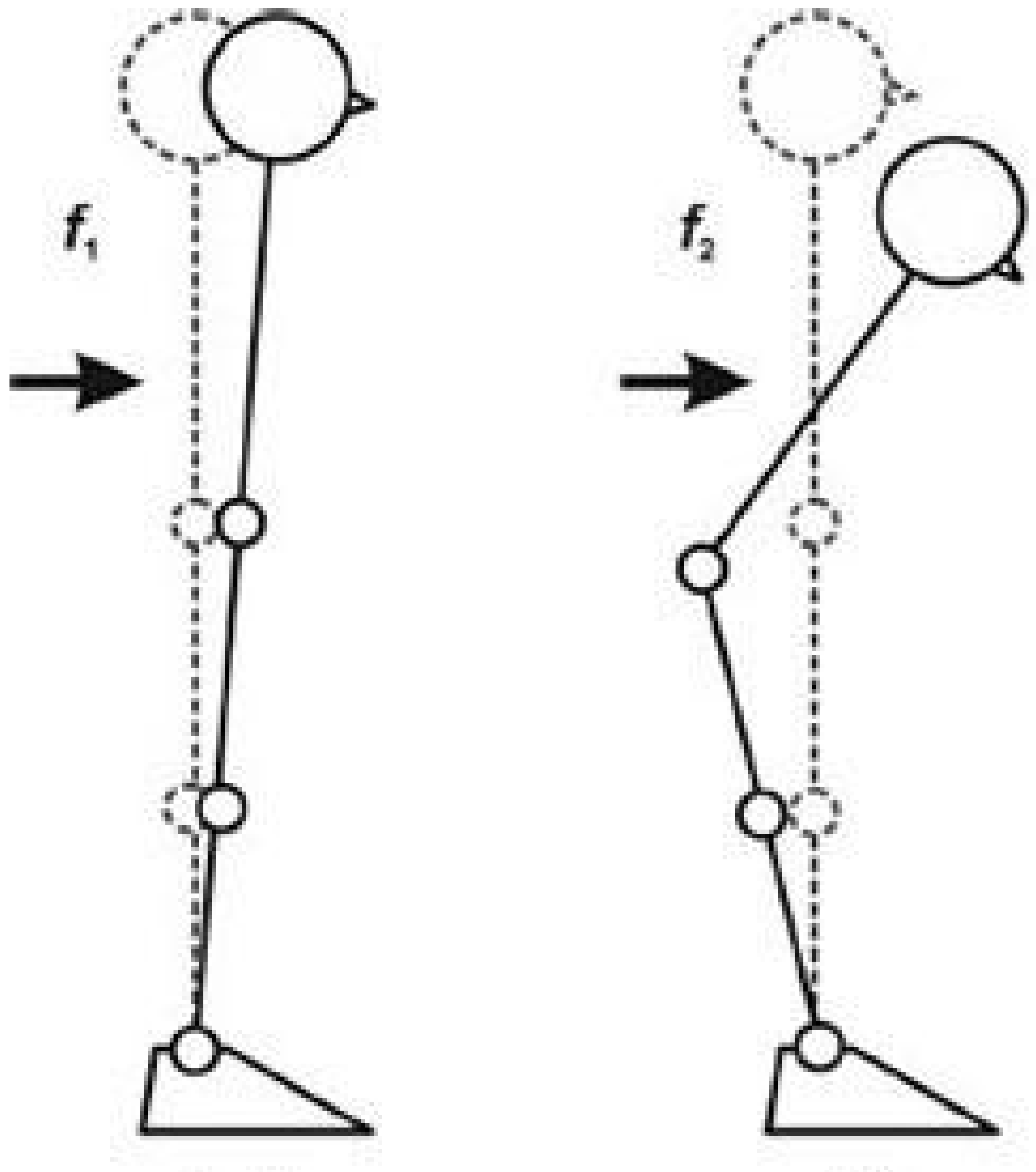
- REACTIVE BALANCE CONTROL
- REACTIVE BALANCE TRAINING
- AQUAREBAL
- CLINICAL IMPLICATIONS

- Falls happen in unexpected, high-challenge situations
- Many programs:
    - controlled
    - predictable
    - low challenge

GAP BETWEEN TRAINING AND REAL-LIFE DEMANDS

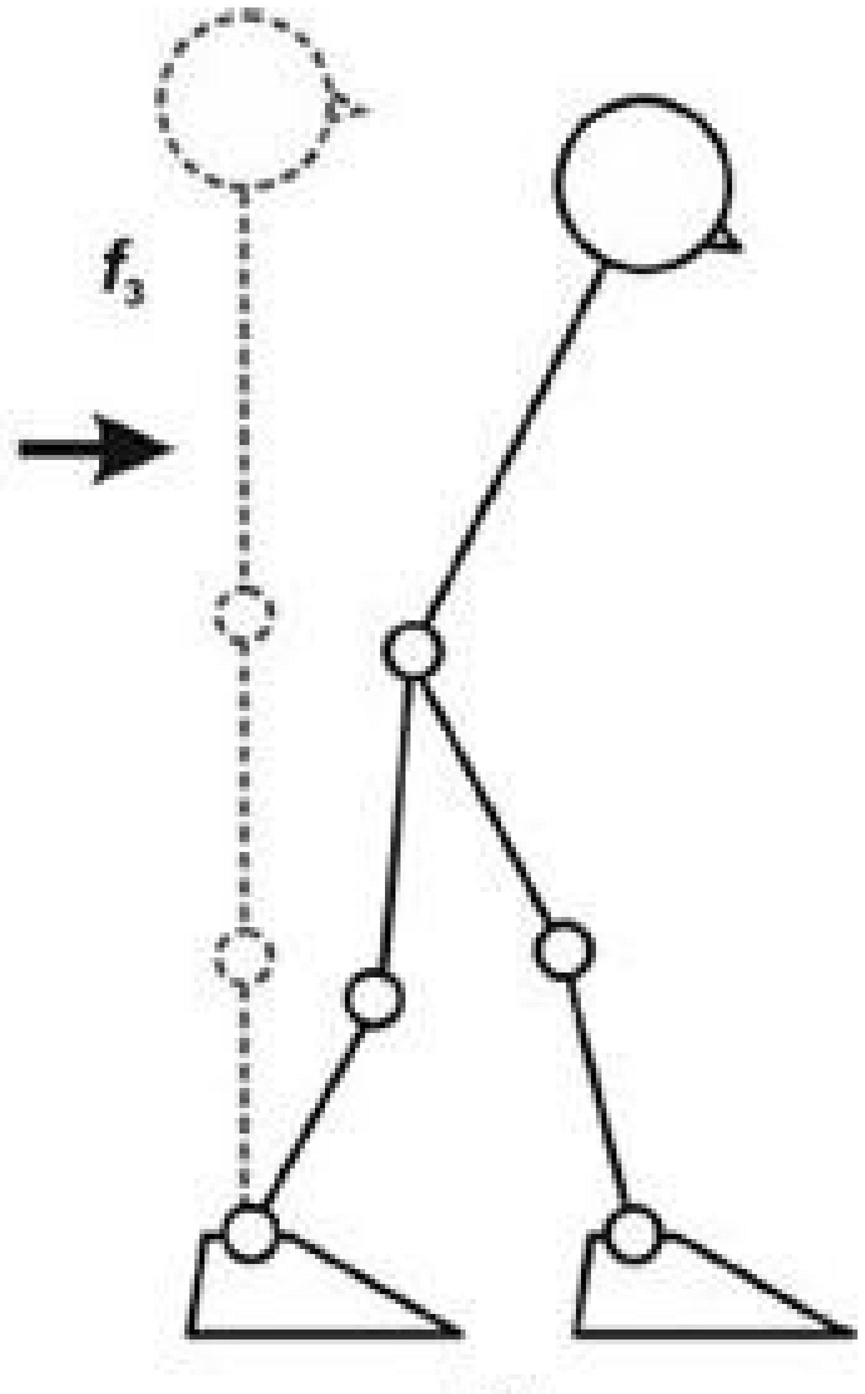
Brown et al. 2023
McCrum et al., 2022

Body's center of mass remains within the base of support



Runge et al. 1999
Hong et al., 2025

Robinovitch et al. 2013



REACTIVE BALANCE CONTROL

ability to respond to loss of balance and prevent fall

Sherrington et al., 2020

Reactive steps are most commonly used to respond to a loss of balance and are also the last resort to prevent a fall

Bahagwat et al. 2023

REACTIVE BALANCE TRAINING (RBT)

TASK-SPECIFIC

PERTURBATIONS

SAFE AND CONTROLLED ENVIRONMENT

Implementing reactive balance training in rehabilitation practice: a guide for healthcare professionals

UHN Toronto Rehabilitation Institute
The Kite Research Institute

Mansfield A, Inness EL, Danells CJ, Jagroop D, Musselman KE, Salbach NM, Kochanowski J. Implementing reactive balance training in rehabilitation practice: a guide for healthcare professionals; 2021

Toronto Perturbation-Based Balance Training

Program Manual

Program developed and manual written by: Avril Mansfield, Vincent DePaul, Cynthia Danells, Elizabeth Inness, Louis Biasin, Vivien Poon, and Svetlana Knorr

For further information, please contact: avril.mansfield@uhn.ca

Version date: 20 October 2017

Table 1.1: Summary of evidence for reactive balance training

Outcome	Evidence statements	Population studied
Reactive balance control	RBT is superior to other balance training methods for improving reactive balance control	Apparently healthy older adults[8-10] Sub-acute & chronic stroke[11-14] Parkinson's disease[15]
Falls in daily life	RBT is likely superior to other balance training methods for preventing falls in daily life	Apparently healthy older adults[16-18] Frail older adults[19] Chronic stroke[11,14] Parkinson's disease[20,21] Incomplete spinal cord injury[22]
Functional balance and mobility	RBT is similar to other balance training methods for improving functional balance and mobility	Apparently healthy older adults[23-26] Frail older adults[19] Sub-acute & chronic stroke[11,13,14] Parkinson's disease[15,20,21,27-31] Incomplete spinal cord injury[22]
Balance confidence/fear of falling	RBT is similar to other balance training methods for improving balance confidence/fear of falling	Apparently healthy older adults[8,25] Sub-acute & chronic stroke[11,13,14] Parkinson's disease[20,30,31] Incomplete spinal cord injury[22]
Reaction time	RBT is superior to other balance training methods for improving volitional reaction time	Apparently healthy older adults[10,24-26,32] Frail older adults[19] Chronic stroke[14] Parkinson disease[29]

AquaReBal

AQUATIC REACTIVE BALANCE TRAINING

WHY?

- increased risk of adverse events compared to other types of exercise
- joint pain
- fear and anxiety
- injury due to a ‘fall’ into the safety harness
- lack of safety equipment or equipment to provide balance perturbations

Devasahayam et al., 2023;
Jagroop et al., 2007;
Mansfield et al., 2021;
Margalit et al., 2023;
Ogonowska-Slodownik et al., 2025

"And even though I had the harness and there wasn't a danger of me actually hitting the floor, my brain seemed to just overlook that."

WATER-BASED PERTURBATION

Melzer I, Elbar O, Tsedek I, Oddsson L. A water-based training program that include perturbation exercises to improve stepping responses in older adults: study protocol for a randomized controlled cross-over trial. BMC Geriatr. **2008**;8:19.

Elbar O, Tzedek I, Vered E, Shvarth G, Friger M, Melzer I. A water-based training program that includes perturbation exercises improves speed of voluntary stepping in older adults: a randomized controlled cross-over trial. Arch Gerontol Geriatr. **2013**;56(1):134-40.

Muthukrishan R, Badr Ul Islam FM, Shanmugam S, et al. Perturbation-based Balance Training in Adults Aged Above 55 Years with Chronic Low Back Pain: A Comparison of Effects of Water versus Land Medium - A Preliminary Randomized Trial. Curr Aging Sci. **2024**;17(2):156-168.

medRxiv
THE PREPRINT SERVER FOR HEALTH SCIENCES

HOME

Follow this preprint

Using a co-design approach to develop aquatic reactive balance training for fall prevention

Anna Ogonowska-Slodownik, Júlia O. Faria, Shanuga Thavarajah, Karina Pacholczyk, Birgit Blain, Myra Wiener, Jane Walker, Avril Mansfield, Soo Chan Carusone

doi: https://doi.org/10.64898/2026.03.07.26347842

This article is a preprint and has not been peer-reviewed [what does this mean?]. It reports new medical research that has yet to be evaluated and so should *not* be used to guide clinical practice.

Karger OPEN ACCESS

Gerontology

Gerontology , DOI: 10.1159/000550917
Received: October 22, 2025
Accepted: February 4, 2026
Published online: March 4, 2026

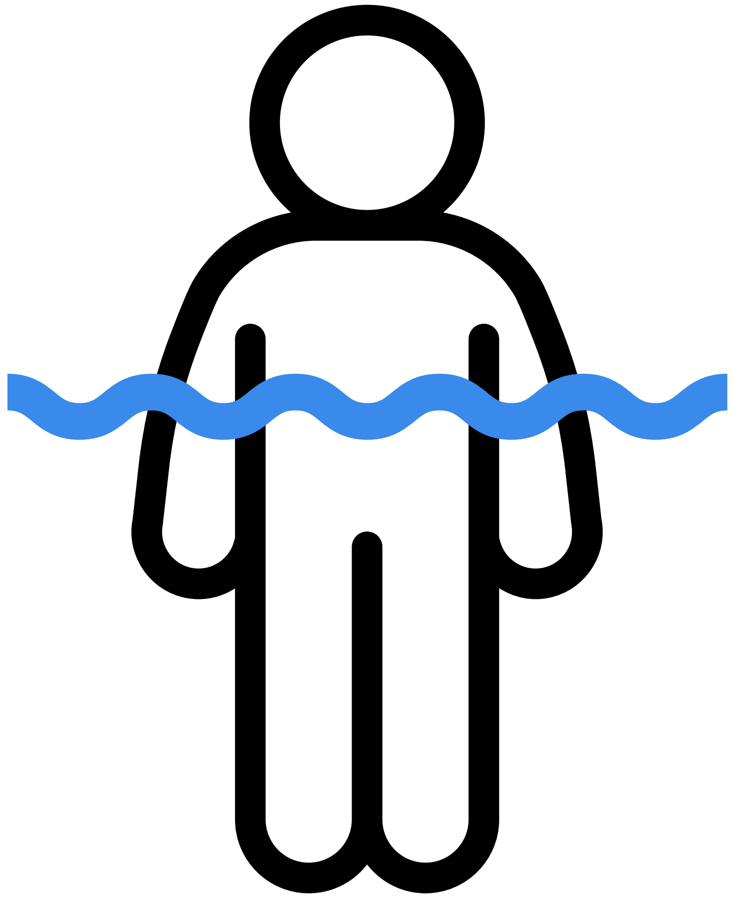
Feasibility of aquatic reactive balance training (AquaReBal) for older adults: protocol for a single-arm pre-post study

Ogonowska-Slodownik A, Marinho-Buzelli A, Danells C, Musselman KE, Bonnyman A, Alavinia M, Mansfield A

ISSN: 0304-324X (Print), eISSN: 1423-0003 (Online)
https://www.karger.com/GER
Gerontology

60 min
10 min warm-up
40 min perturbations
10 min cool-down

2 x week (6 weeks)



10 'voluntary' tasks

6 perturbation per task

=

60 perturbations

PERTURBATIONS

internal

water

physiotherapist

ADAPTATIONS TO REDUCE/INCREASE DIFFICULTY

wide base of support/feet together

low step/high step

walk slowly/walk fast

TYPES OF TASKS

stable (e.g. tandem stance)

quasi-mobile (e.g., stepping, tap ups, walking in place)

mobile (e.g. side stepping, turning)

unpredictably mobile (e.g. walking and pushing ball, cued walking)

ACCEPTABILITY

"I liked the fact that I was doing exercise in the water because **there was support and it wasn't painful for my joints... I was getting exercise without the pain of exercise on land.**"

"I really enjoyed the program. I liked being in the water. I liked doing the activities in the water. And I was working towards the goal"

OBSERVED CHANGES

"Turning around quickly or looking to one side... **I don't have as many wobbles as I did before.**"

"I tripped over my dog and it didn't throw me at all... I could just recover."

SAFETY

"In water, losing balance doesn't mean losing safety"

"Falling in water feels different— **you're challenged, but not threatened.**"

WHAT DO WE KNOW?

- Feasible to deliver in aquatic settings
- Safe for older adults
- High acceptability and engagement
- Participants can perform reactive balance tasks in water

WHAT WE STILL DON'T KNOW?

- Effectiveness for improving reactive balance control
- Impact on fall risk reduction
- Optimal training dose and progression

ACKNOWLEDGEMENTS

ALISON BONNYMAN
ANDRESA MARINHO BUZELLI
AVRIL MANSFIELD
BIRGIT BLAIN
CYNTHIA DANELLS
JANE WALKER
JULIA OLIVEIRA DE FARIA
KARINA PACHOLCZYK
MYRA WIENER
SHANUGA THAVARAJAH

JÓZEF PIŁSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

POLISH NATIONAL AGENCY FOR ACADEMIC EXCHANGE

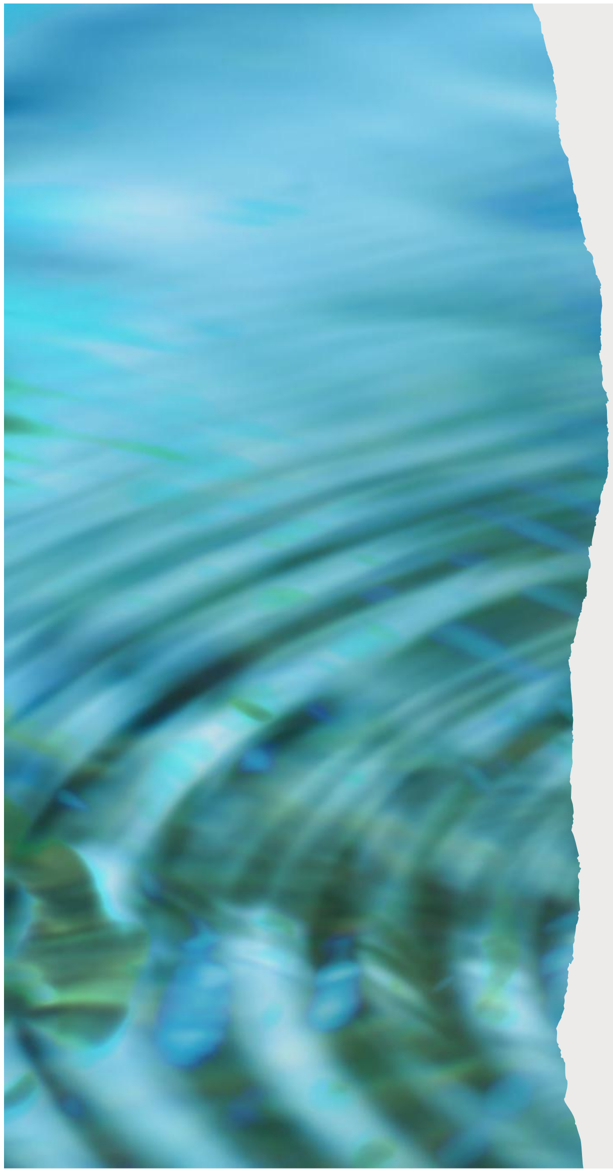
UHN KITE Research Institute

McMaster University

Collaborative for Health & Aging

PiPER | Pride in Patient Engagement in Research

anna.ogonowskaslodownik@awf.edu.pl



Beyond the Abstract: A Clinicians Guide to Critically Appraising Research in Aquatic Therapy

Emily Dunlap, PT, PhD

ICEBAT – Toronto, Canada

April 25, 2026

Dive into an Upcoming Journal Club Meeting

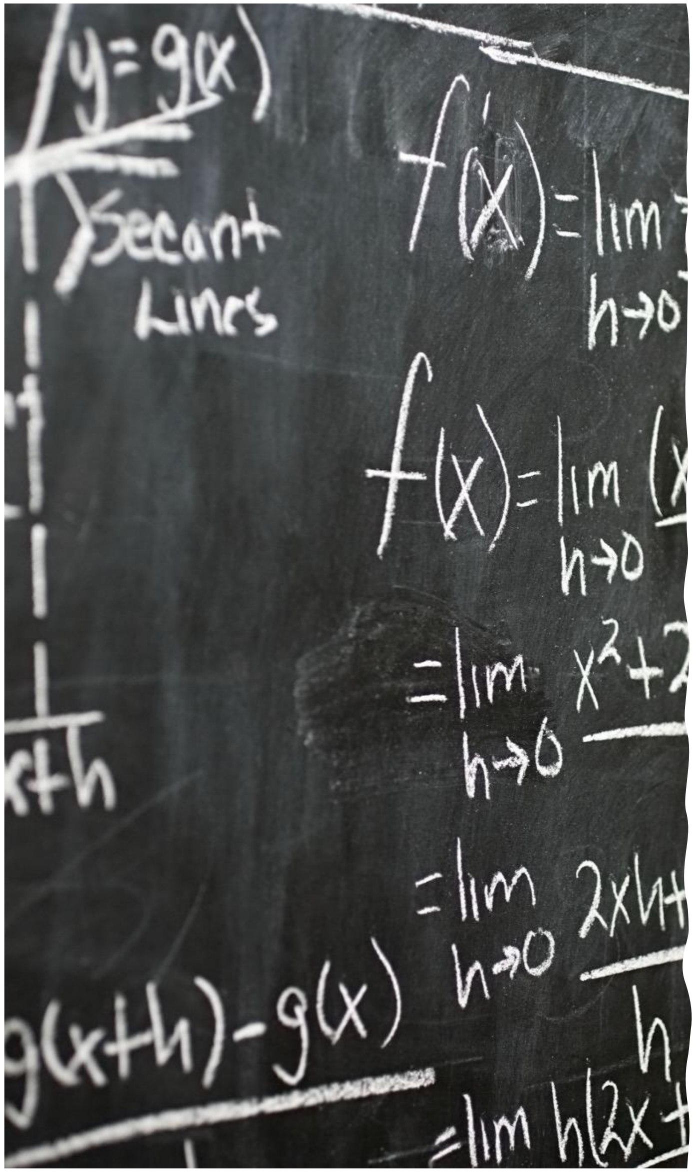
AQUATIC REHABILITATION
JOURNAL CLUB

<u>Bi-monthly (even months)</u>

1st Wed. at 8:00am (Pacific Time)

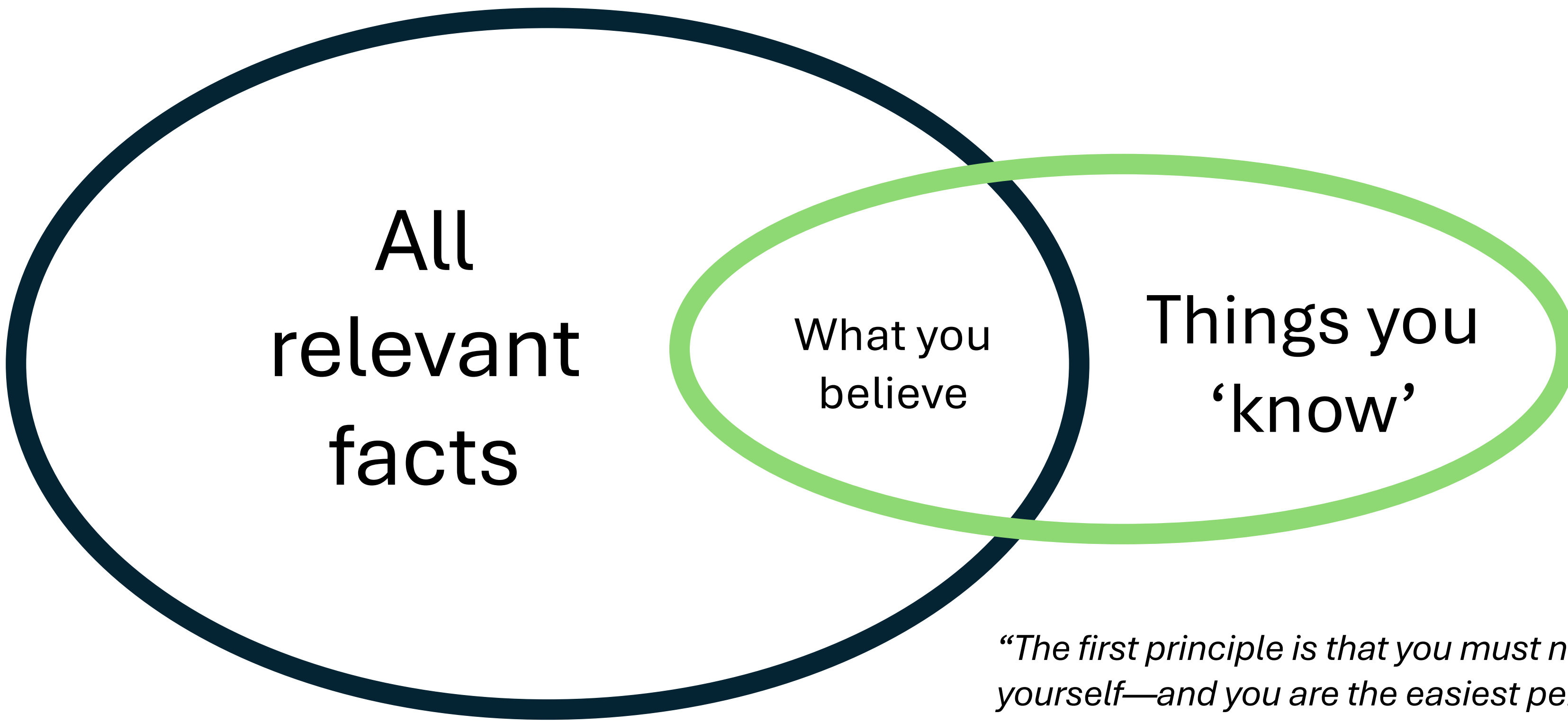
4th Mon. at 9:00pm (Pacific Time)

aquaticrehabjournalclub.com



Abstracts ≠ Clinical Truth

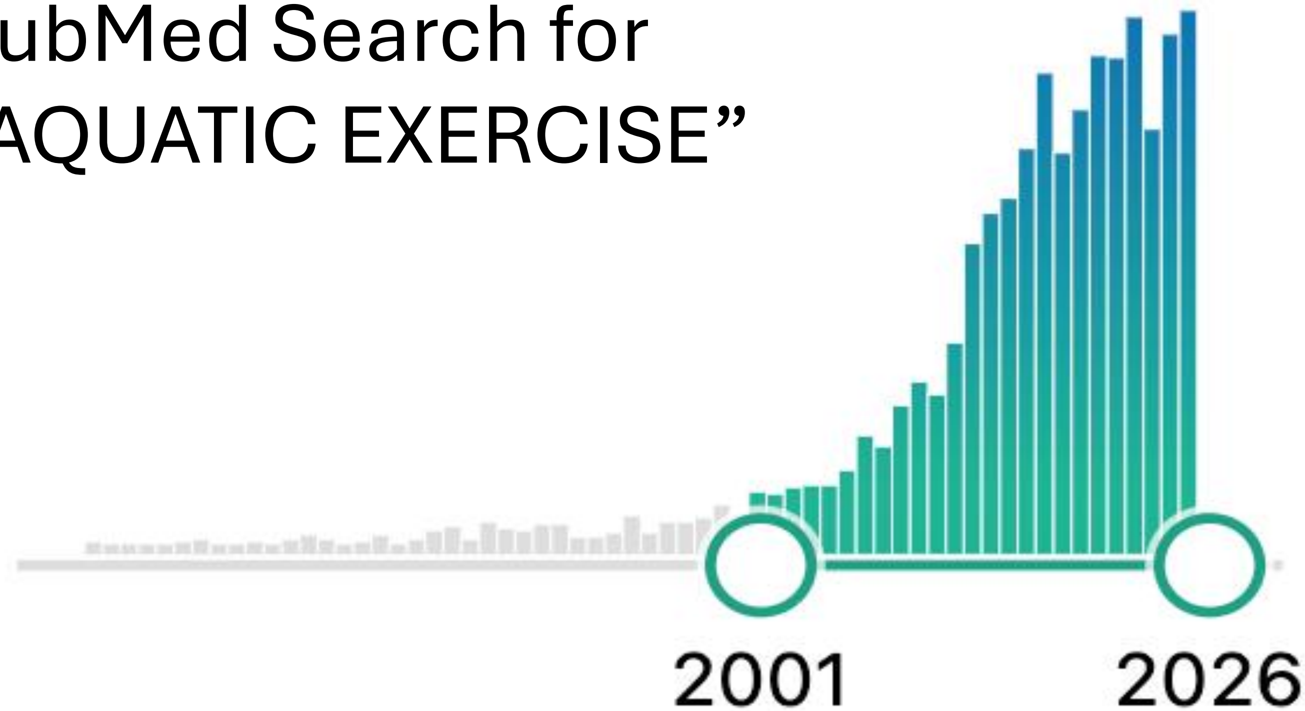
Watch Out for Confirmation Bias!!!



"The first principle is that you must not fool yourself—and you are the easiest person to fool."

- Richard Feynman (Nobel Prize in Physics)

PubMed Search for
"AQUATIC EXERCISE"

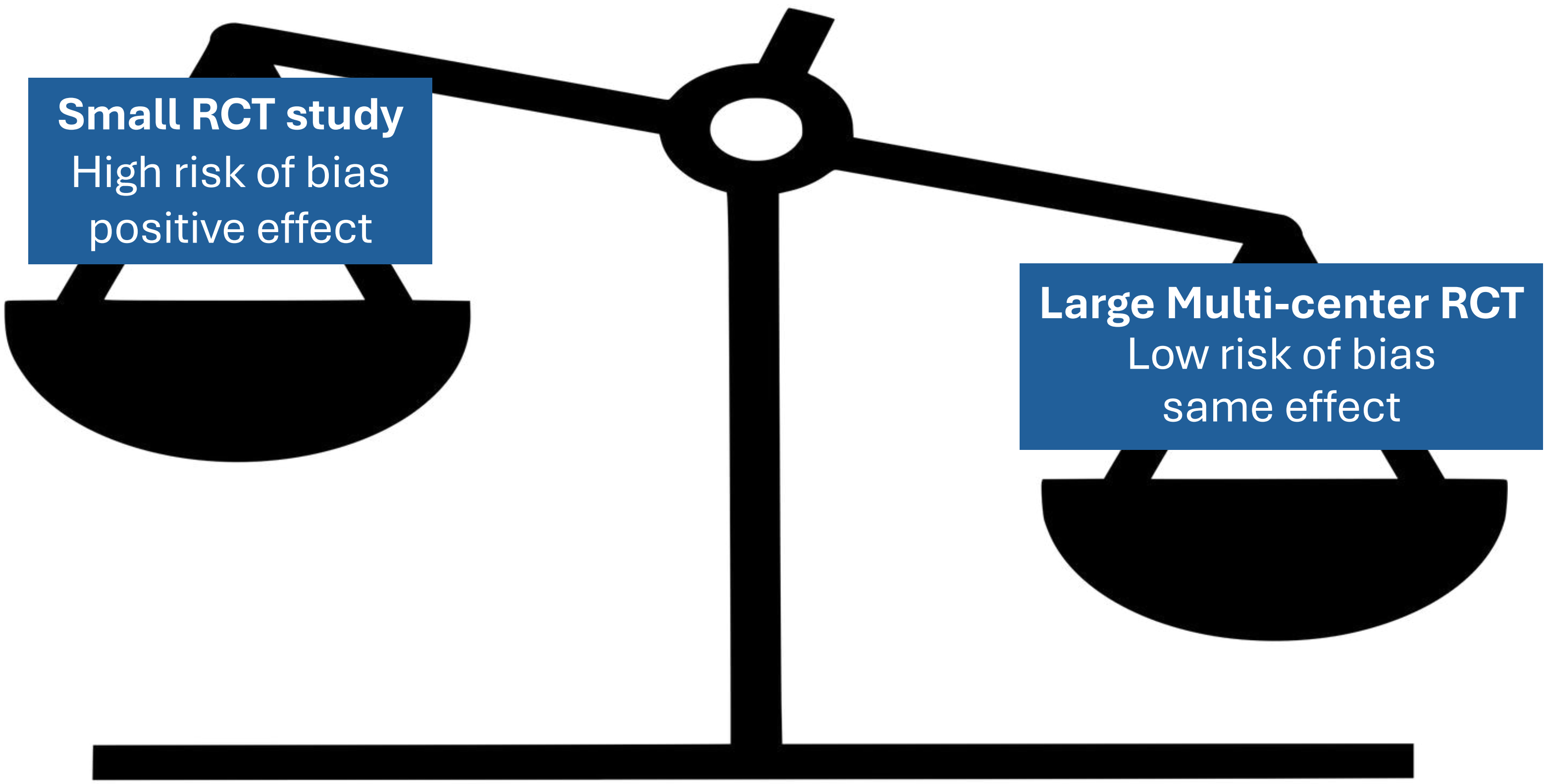


Study Designs

Quality includes:

- Study design
- Internal validity
- Sample size/ power
- Outcome measure
- Intervention description
- Statistical analysis
- External validity

Not All Evidence Has Equal 'Weight'



Individual Studies vs. the Big Picture

Individual study → **risk of bias**
Body of evidence → **certainty of evidence**

Tools used:

Risk of bias → **PEDro scale**

Certainty of evidence → **GRADE**

Physiotherapy Evidence Database (PEDro)

1. subjects were randomly allocated to groups
2. allocation was concealed
3. groups were similar at baseline
4. blinding of subjects
5. blinding of therapists
6. blinding of assessors
7. ≥1 key outcome obtained from >85% of the subjects initially allocated to groups
8. ≥1 key outcome was analyzed by “intention to treat”
9. between-group statistical comparisons for ≥1 key outcome
10. point measures and measures of variability for ≥1 key outcome

Rating interpretation

Excellent: ≥ 9

Good : 6-8

Fair: 4-5

Poor : ≤ 3

Note: Subject source + eligibility criteria is not counted in the total score

https://pedro.org.au/

Grading of Recommendations, Assessments, Development, and Evaluation (GRADE)

The certainty of the evidence may be downgraded for:

- **Risk of bias**
- **Inconsistency**
- **Indirectness**
- **Imprecision**
- **Publication bias**

Certainty Levels

- High
- Moderate
- Low
- Very Low

Questions Every Clinician Should Ask

Does this apply to my patient?

- Is the population, setting, and intervention feasible in my clinical environment.

What exactly was done?

- Were the dosing, type of intervention/s including aquatic variables clearly defined and appropriate?

Is this study valid?

- Are the methods sound and risk of bias acceptable?

Are the findings clinically relevant?

- Did the changes in outcomes lead to a minimal clinically important difference (MCID), not just a statistically significant one?

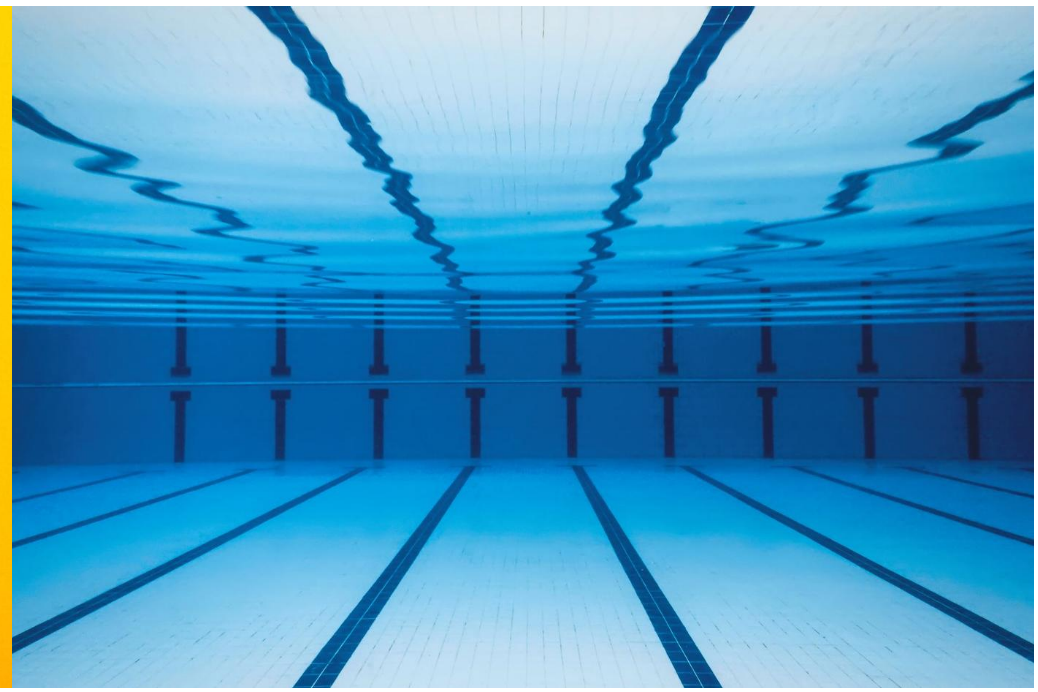
Most Important – Look at Figures and Charts

If time is limited – this is the best bang for you buck!

- Consort diagram: study flow
- Table: baseline characteristics – sample size
- Figure: protocol (sometimes)
- Figure or tables: outcomes !!!

Don't forget supplemental material!!!

Intervention Details: The Driver of Results

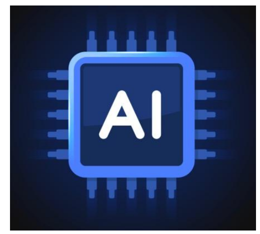


Understand the Outcome Measure!

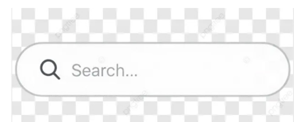
Is the outcome measured valid and reliable for the population?

MDC vs MCID vs statistical change

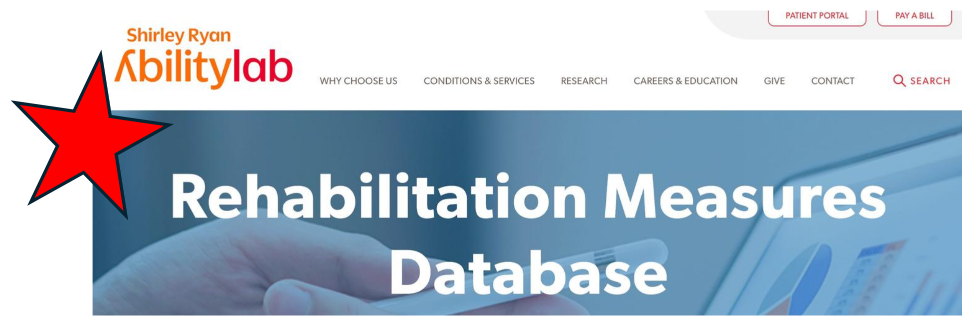
- Minimal detectable change (MDC) = smallest change that exceeds measurement error
- Minimal Clinically Important Difference (MCID) = smallest change that the patient will perceive as beneficial



Be VERY CAREFUL with AI - ask for specific studies and verify everything



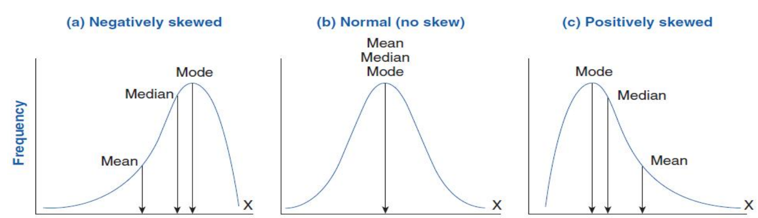
Search engine works but it may take a while



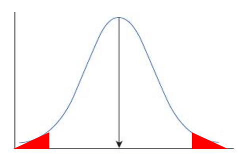
https://www.sralab.org/rehabilitation-measures

Basic Statistics You Need to Know

Not all data follow a **bell curve**
(not all statistics require one)

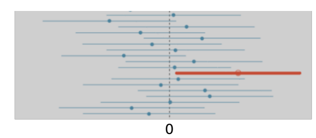


P-value vs confidence intervals
(Is the result likely real - not by chance?)



P value ≤ 0.05

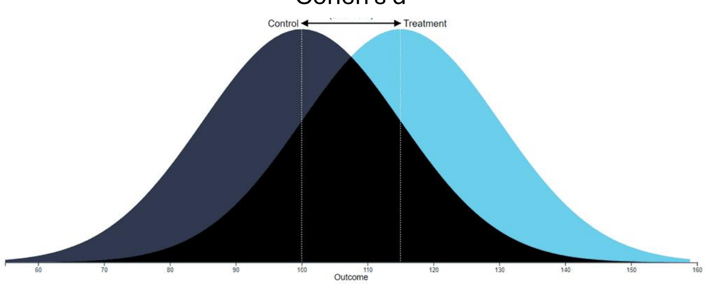
(95% CI: 0.4 to 3.8)



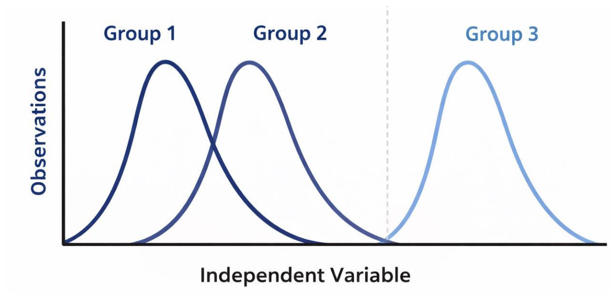
95% CI doesn't cross 0

Effect sizes (how big is the difference)

Cohen's d

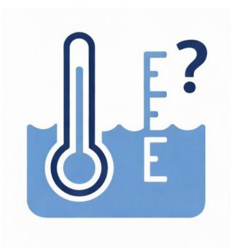


ANOVA
(Are any of these groups different from each other?)



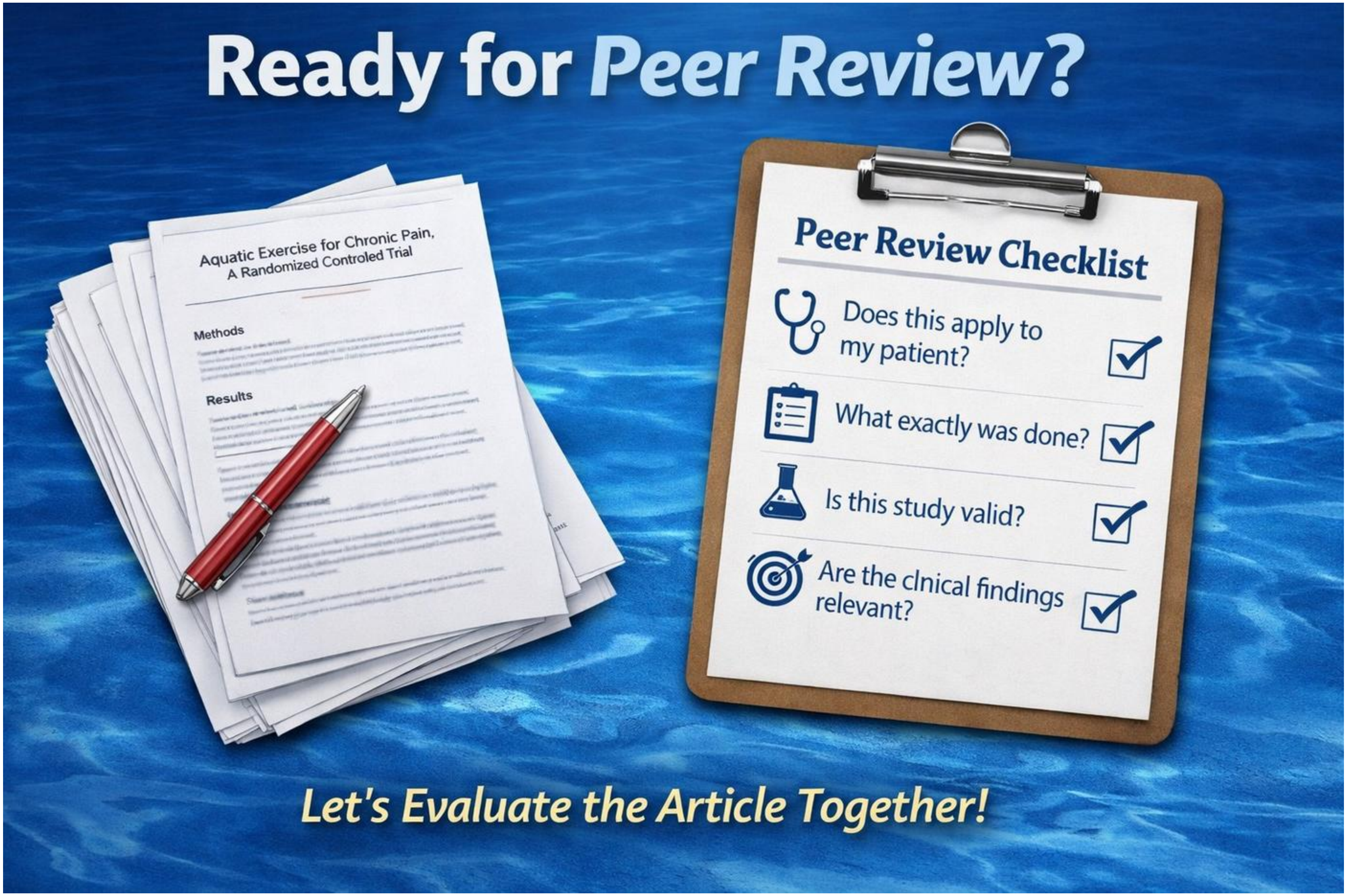
Considerations with Aquatic Therapy Evidence

- Heart rate comparison in water vs on land is challenging



- Don’t tell us pool temperature or depth

- Don’t report adverse effects



Ready for Peer Review?
Aquatic Exercise for Chronic Pain,
A Randomized Controled Trial
Methods
Results
Peer Review Checklist
Does this apply to my patient?
What exactly was done?
Is this study valid?
Are the clnical findings relevant?
Let's Evaluate the Article Together!

Does this apply to my patient?

www.nature.com/scientificreports

scientific reports

Check for updates

OPEN

Effects of early aquatic exercise intervention on trunk strength and functional recovery of patients with lumbar fusion: a randomized controlled trial

An-Hua Huang[1,2,4], Wen-Hsiang Chou[3,4], Wendy Tzyy-Jiuan Wang[1], Wen-Yin Chen[1,5] & Yi-Fen Shih[1,5]

Effects of early aquatic exercise intervention on trunk strength and functional recovery of patients with lumbar fusion: a randomized controlled trial

Huang AH, Chou WH, Wang WT, Chen WY, Shih YF

Scientific Reports 2023 Jul 3;13(10716):Epub

clinical trial

PEDro
Physiotherapy Evidence Database

7/10 = good

7/10 [Eligibility criteria: Yes; Random allocation: Yes; Concealed allocation: No; Baseline comparability: Yes; Blind subjects: No; Blind therapists: No; Blind assessors: Yes; Adequate follow-up: Yes; Intention-to-treat analysis: Yes; Between-group comparisons: Yes; Point estimates and variability: Yes. Note: Eligibility criteria item does not contribute to total score] *This score has been confirmed*

Abstract Highlights

Methods

- Aquatic vs active control
- N=28
- Aq Group
  - Aq ex 60 min, 2x/wk + HEP 60 min, 3x/wk
- Control Group
  - HEP 60 min 5x/wk.

Results

- Aquatic group better pain and ODI improvement than control
- Both aquatic and control groups had similar improvements with TUG test
- + more (read the full article to find out)

Is this study valid?

Consort Diagram (also need to read methods section)

PEDro: 7 (or 8)

1. Randomization – YES
2. Concealment – NO (I think YES)
4. Blind Subjects – NO
5. Blind Therapist – NO
6. Blind Assessors – YES
7. > 85% outcomes measured – YES
8. Intent to treat - YES

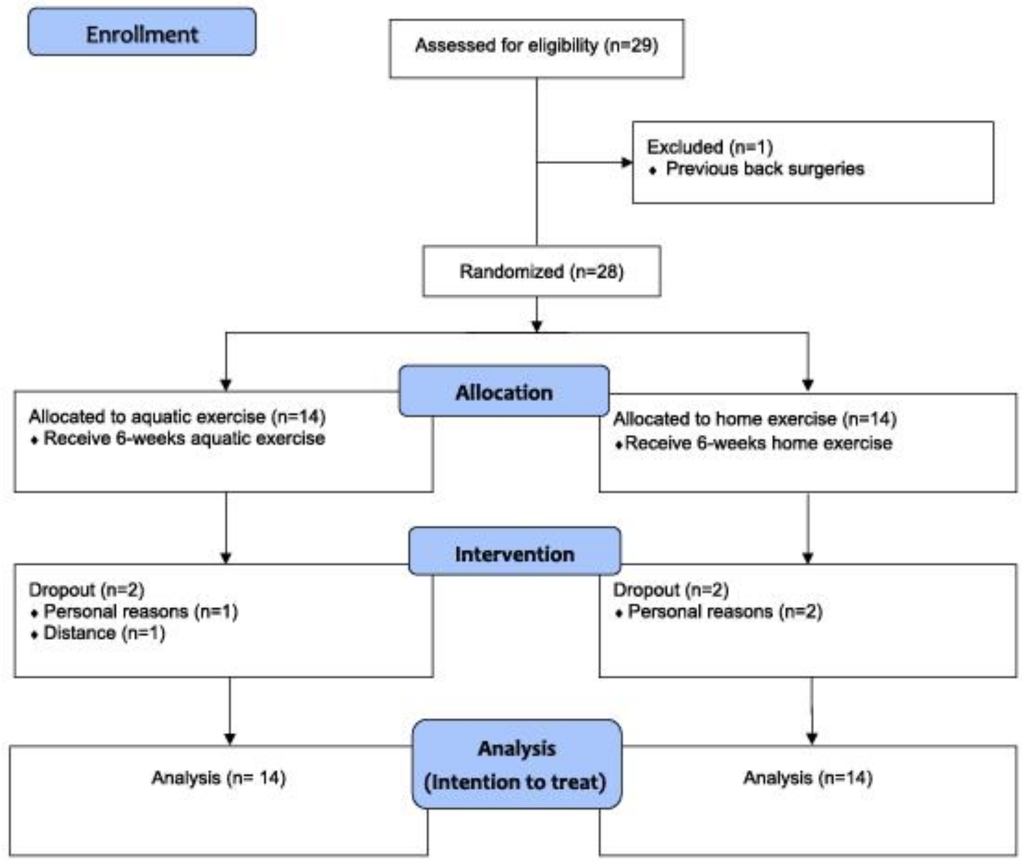


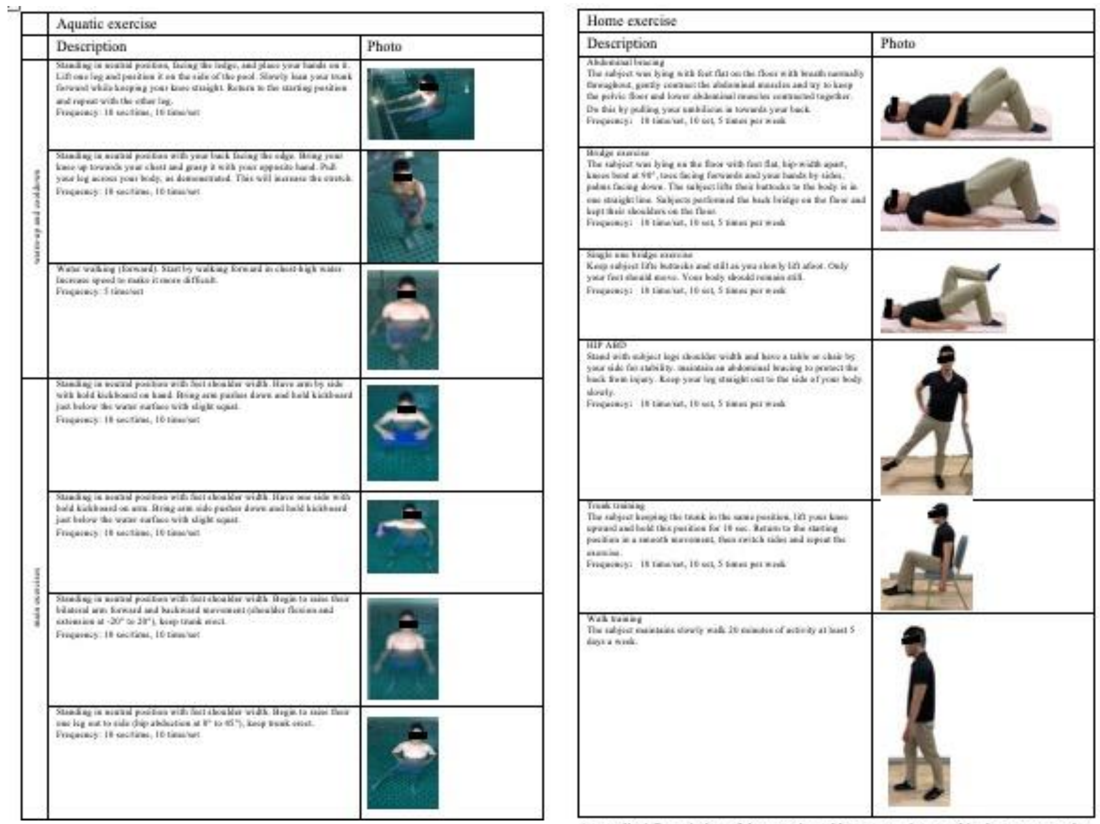
Figure 1. Flow chart of the study.

What exactly was done?

Methods/ Intervention

- 4 weeks post surgery
- Aq Group
  - 2x/wk +HEP 3x/wk
- Control Group
  - HEP 5x/wk
- Pool
  - 7mx10m, depth 0.9-1.3m, temp 34-36C
- Other
  - 1:2 PT to participant ratio
  - PT with 8 yrs aquatic therapy exp
  - Appendix with exercise details

Sample of the appendix/ supplemental material



Appendix 1 Description of the aquatic and home exercises used in the present study.

Is this study valid?

Baseline Characteristics

	Experimental group (n = 14)	Control group (n = 14)	P value
	Mean (SD)	Mean (SD)	
Age (years)	49.64 (10.18)	54.36 (8.32)	0.19
Gender (male/female)	8/6	7/7	0.37
Height (cm)	167.64 (7.19)	162.86 (7.54)	0.09
Weight (kg)	70.75 (12.55)	68 (15.65)	0.61
BMI (kg/m²)	24.43 (3.15)	25.95 (3.98)	0.27

Table 1. Comparisons of the demographic data of the experimental and control group, using the independent *t* test for continuous data (age, height, weight and BMI) and chi-square tests for categorical data (gender). *SD* standard deviation.

PEDro:

3. Baseline similar – YES (Also can confirm baseline similar with outcomes in the next table)

Is this study valid?

Baseline Characteristics

PEDro:

3. Baseline similar – YES!!!

Outcome	Experimental group (n = 14)	Control group (n = 14)	Mean difference between groups (95% CI)	p value	Group by time effect
NPRS					
Baseline	3.21 ± 2.72	2.14 ± 1.1	1 (– 0.66 to 2.66)	0.221	0.003*
Post test	1.29 ± 0.99†	2.78 ± 2.15	– 1.5 (0.2 to – 2.8)	0.02	
ODI					
Baseline	42.24 ± 13.41	34.25 ± 14.89	7.99 (– 3.02 to 19)	0.148	0.01*
Post test	20.43 ± 18.15†	26.16 ± 11.45†	– 5.73 (– 0.56 to 17.52)	0.327	
TUGT					
Baseline	10.79 ± 1.96	10.42 ± 2.61	0.34 (– 1.45 to 2.13)	0.7	0.53
Post test	8.96 ± 2.03†	9.37 ± 1.92†	– 0.41 (– 1.13 to 1.95)	0.747	
Trunk flexor					
Baseline	20.6 ± 11.04	14.75 ± 9.06	5.85 (– 2 to 13.7)	0.14	0.183
Post test	25.9 ± 14.52†	19.35 ± 9.17†	9.41 (– 0.11 to 18.93)	0.53	
Trunk extensor					
Baseline	22.73 ± 11.82	19.49 ± 11.46	3.24 (– 5.8 to 12.29)	0.468	0.013*
Post test	32.51 ± 20.9†	22.56 ± 10.07	12.8 (0.6 to 25)	0.04	
Lumbopelvic stability					
Baseline	8.49 ± 7.99	8.83 ± 6.63	– 0.34 (– 6.04 to 5.36)	0.904	0.018*
Post test	25.24 ± 19.5†	12.94 ± 14.37	13.02 (– 0.05 to 26.08)	0.051	
LM thickness rest					
Baseline	28.68 ± 4.62	29 ± 7.0	0.6 (– 0.43 to 0.55)	0.805	0.001*
Post test	32.95 ± 6.60†	28.61 ± 5.57	4.55 (– 0.24 to 9.33)	0.062	
Relative change in the LM thickness %					
Baseline	6.33 ± 5.49	7.00 ± 5.83	– 0.68 (– 5.08 to 3.71)	0.752	0.044*
Post test	8.59 ± 3.49†	6.05 ± 3.98	0.98 (– 2.78 to 4.75)	0.096	

Table 2. Comparisons between the experimental and control groups before and after the intervention, using

Are the findings clinically relevant?

Results

PEDro:

9. Between group analysis- YES
10. Point and variability - YES

Shirley Ryan Ability Lab Rehabilitation Measures

NPRS (Pain)

- MCID = 1.0 point

(Salaffi et al., 2004; chronic MSK pain)

ODI (LBP functional impairment)

- MCID = 12.8 points

(Johnsen et al., 2012; Lowe back pain)

TUG test (Elderly - Mobility, balance, fall risk)

- MDC = 2.9 sec or 23%

(Flansbjer et al., 2005; Stroke)

Outcome	Experimental group (n = 14)		Control group (n = 14)		Mean difference between groups (95% CI)	p value	Group by time effect
NPRS							
Baseline	3.21 ± 2.72	Δ= -1.9†	2.14 ± 1.1	Δ= +0.6	1 (– 0.66 to 2.66)	0.221	0.003*
Post test	1.29 ± 0.99†		2.78 ± 2.15		– 1.5 (0.2 to – 2.8)	0.02	
ODI							
Baseline	42.24 ± 13.41	Δ= -21.8 †	34.25 ± 14.89	Δ= -8.1 †	7.99 (– 3.02 to 19)	0.148	0.01*
Post test	20.43 ± 18.15†		26.16 ± 11.45†		– 5.73 (– 0.56 to 17.52)	0.327	
TUGT							
Baseline	10.79 ± 1.96	Δ= -1.8 † or -17%	10.42 ± 2.61	Δ= -1.1 † or -10%	0.34 (– 1.45 to 2.13)	0.7	0.53
Post test	8.96 ± 2.03†		9.37 ± 1.92†		– 0.41 (– 1.13 to 1.95)	0.747	
Trunk flexor							
Baseline	20.6 ± 11.04		14.75 ± 9.06		5.85 (– 2 to 13.7)	0.14	0.183
Post test	25.9 ± 14.52†		19.35 ± 9.17†		9.41 (– 0.11 to 18.93)	0.53	
Trunk extensor							
Baseline	22.73 ± 11.82		19.49 ± 11.46		3.24 (– 5.8 to 12.29)	0.468	0.013*
Post test	32.51 ± 20.9†		22.56 ± 10.07		12.8 (0.6 to 25)	0.04	
Lumbopelvic stability							
Baseline	8.49 ± 7.99		8.83 ± 6.63		– 0.34 (– 6.04 to 5.36)	0.904	0.018*
Post test	25.24 ± 19.5†		12.94 ± 14.37		13.02 (– 0.05 to 26.08)	0.051	
LM thickness rest							
Baseline	28.68 ± 4.62		29 ± 7.0		0.6 (– 0.43 to 0.55)	0.805	0.001*
Post test	32.95 ± 6.60†		28.61 ± 5.57		4.55 (– 0.24 to 9.33)	0.062	
Relative change in the LM thickness %							
Baseline	6.33 ± 5.49		7.00 ± 5.83		– 0.68 (– 5.08 to 3.71)	0.752	0.044*
Post test	8.59 ± 3.49†		6.05 ± 3.98		0.98 (– 2.78 to 4.75)	0.096	

Table 2. Comparisons between the experimental and control groups before and after the intervention, using

Do You Agree with the Authors Conclusions?

- “Our data supported most of the hypotheses, with the 6-week aquatic rehabilitation program significantly improving trunk muscle strength, lumbopelvic stability, and LM muscle thickness, and reducing pain and disability in patients after lumbar fusion compared with the home exercise program.”

Evidence is Evolving

- stay curious,
- stay critical,
- stay in the water.

Dive into an Upcoming Journal Club Meeting

AQUATIC REHABILITATION
JOURNAL CLUB

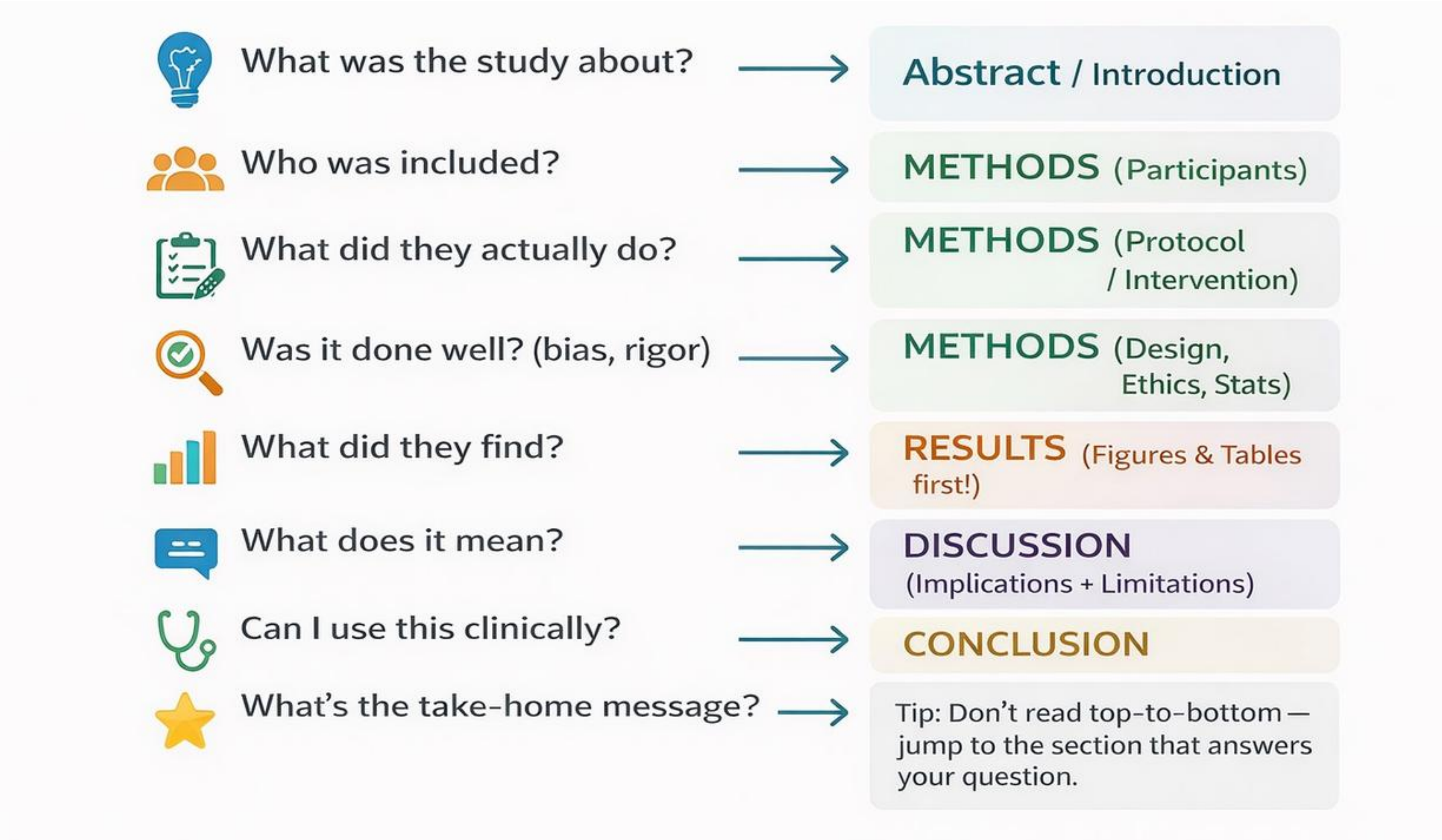
Next meetings
June 3rd 8:00am (Pacific Time)
June 22nd 9:00pm (Pacific Time)

aquaticrehabjournalclub.com
Emily.dunlap.pt@gmail.com

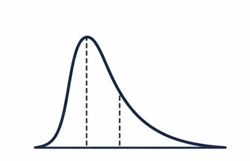
Not All Designs Answer the Same Questions

- **Case series** → Is it feasibility? What happens? (hypothesis generation)
- **Cohort & case control**→ What is the association between exposure and outcomes?
- **Randomized controlled trials** → Does it work? (effectiveness and safety)
- **Systematic reviews & meta-analysis** → *What does all the evidence say?*

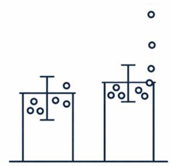
Where to Find What in a Research Paper



Statistics - Common Issues



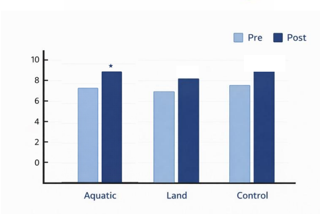
- Non-normality of data and using parametric tests



- Outliers – not reported or considered

- P-hacking

- Over-interpreting non-significant results



- Doing within group stats when between group is not significant

Makin et al. *Elife*, 2019

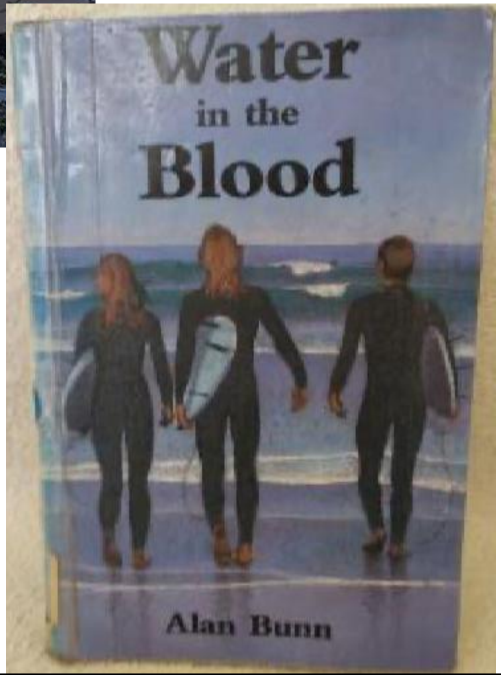
Treading Water

Aquatic Treadmill Exercise as an Optimal Therapeutic Exercise Strategy for Improving Brain Vascular Health.

Professor Sam Lucas, FECSS

Professor of Cerebrovascular, Exercise and Environmental Physiology
Fellow of the European College of Sport Science
School of Sport, Exercise and Rehabilitation Sciences
Centre for Movement and Wellbeing & Centre for Human Brain Health
University of Birmingham
Email: s.j.e.lucas@bham.ac.uk

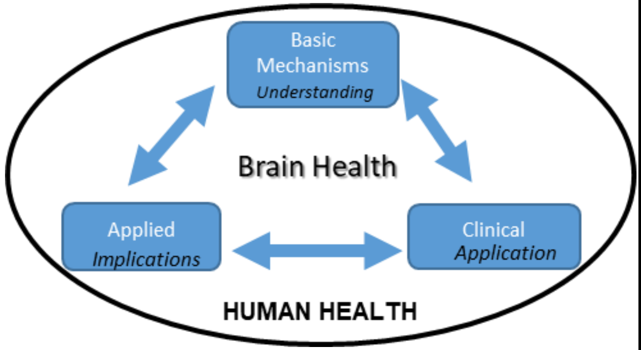
My background.. Water in my blood!

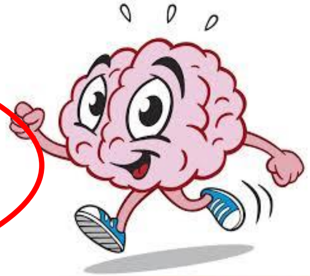


UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

UNIVERSITY OF
BIRMINGHAM

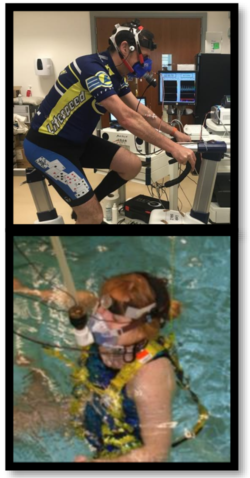
Research Overview: Translational Perspective



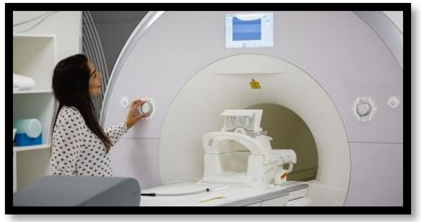


- ☐ Understanding and Maintaining a Healthy Brain
  - What makes a healthy brain?
  - How do we optimise brain health (optimising exercise, etc)

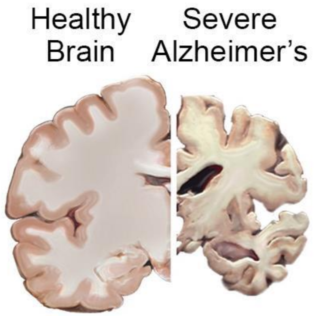
- ☐ Assessing Brain (vascular) Health
  - A multimodal approach



Structural & functional measures



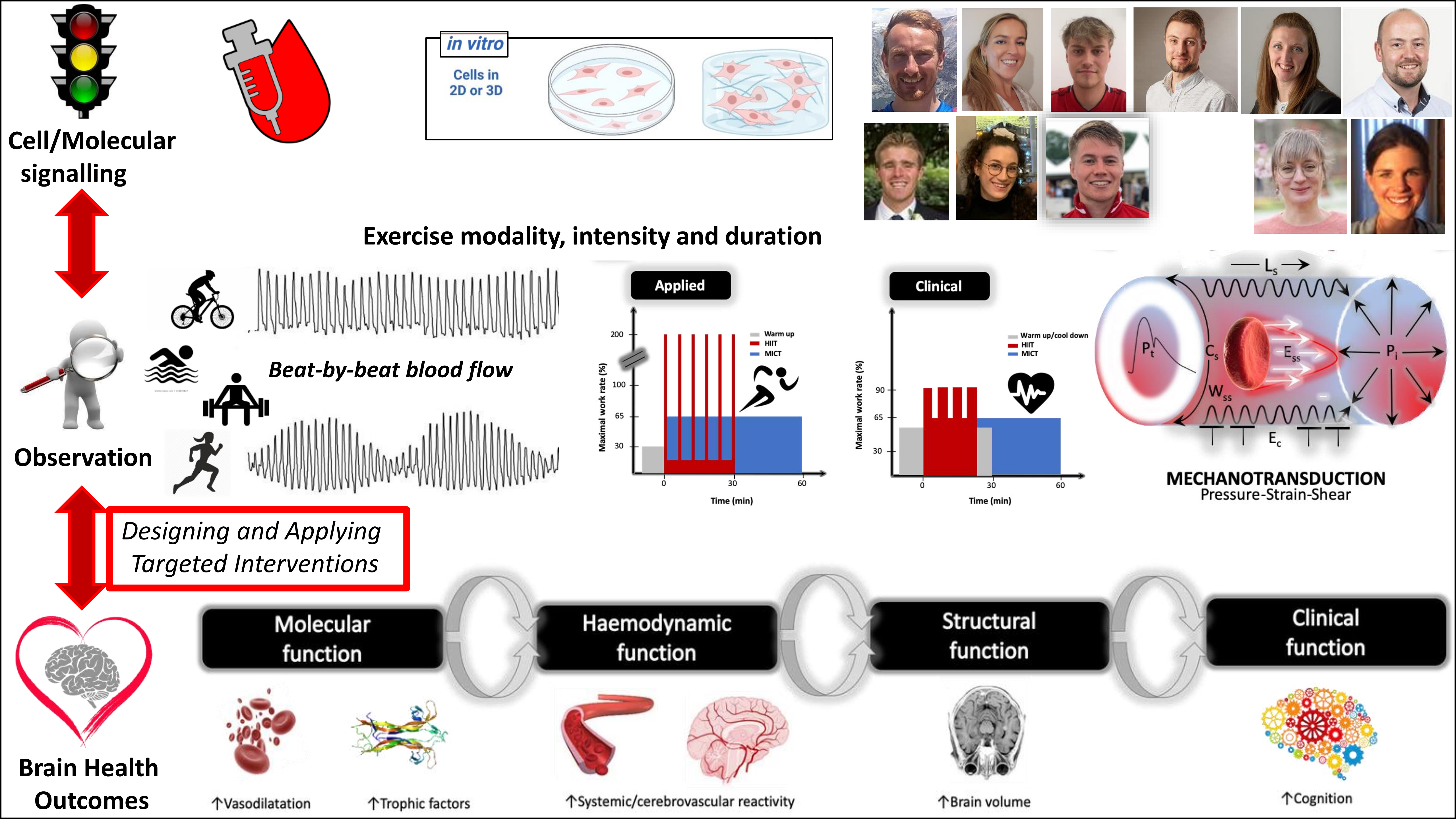
- ☐ Identifying and Treating the Injured /Diseased Brain



mTBI Predict

UNIVERSITY OF BIRMINGHAM | Concussion and Sports Injury Clinics at MoveWell

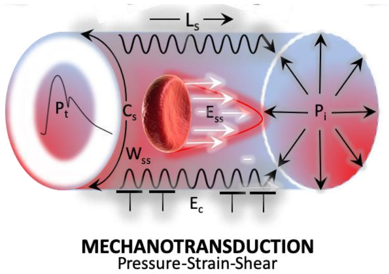
Brain Health Outcomes



Cell/Molecular signalling
in vitro
Cells in 2D or 3D
Exercise modality, intensity and duration
Beat-by-beat blood flow
Observation
Applied
Maximal work rate (%)
200
100
65
30
Warm up
HIIT
MICT
0
30
60
Time (min)
Clinical
Maximal work rate (%)
90
65
30
Warm up/cool down
HIIT
MICT
0
30
60
Time (min)
MECHANOTRANSDUCTION
Pressure-Strain-Shear
Designing and Applying Targeted Interventions
Brain Health Outcomes
Molecular function
Haemodynamic function
Structural function
Clinical function
↑Vasodilatation
↑Trophic factors
↑Systemic/cerebrovascular reactivity
↑Brain volume
↑Cognition

Outline

- Exercise and the brain
  - Background
  - Links between brain vascular health, brain function, ageing, and exercise
- Rethinking exercise to improve its effectiveness
  - Targeted conditioning for brain vascular health
    - Optimising a key mechanistic pathway - Shear stress
    - Exercise modality/intensity matters



- The power of water!
  - Water-based strategies that enhance vascular health
  - Aquatic treadmill exercise as an optimal therapeutic exercise strategy

Blood flow to and within the brain is vital…

– Vital for survival
  - ✓ Oxygen and substrate supply
    - – Brain only 2-3% of body mass, yet demands 20% of total cardiac output
  - ✓ Stroke caused by over or under perfusion

– Functional Consequences
  - ✓ Performance
  - ✓ Cognitive function
  - ✓ Impairment linked with disease/conditions (e.g. dementia, stroke, TBI)
  - ✓ Prognostic value (predictor of cardiovascular mortality)

– Continuum of challenged/impaired CBF regulation

Faint

Stroke

Hypertension

Dementia

Concussion / TBI

- Can we improve it?

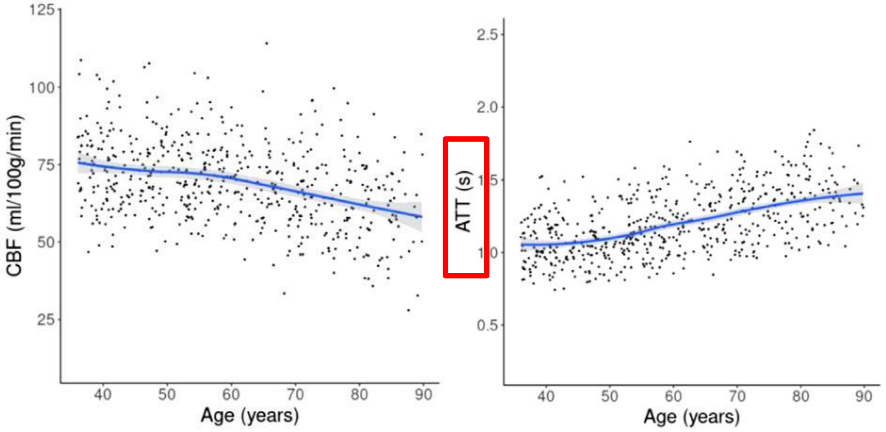
Role for physical activity, component stressors of exercise

Ageing and Brain Vascular Health

vs.

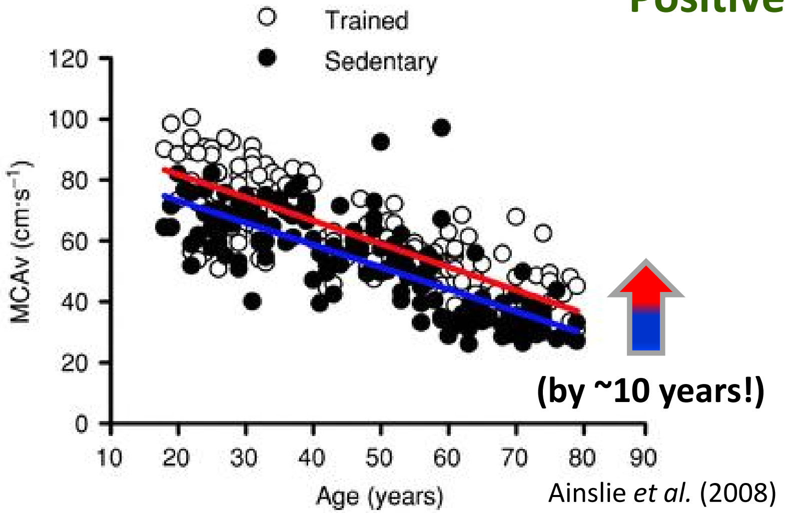
Cerebrovascular health declines with age

MRI-based (ASL)



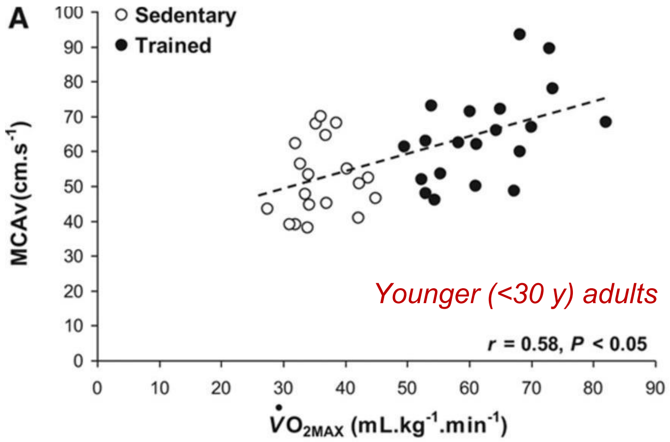
Damestani et al. (2023)

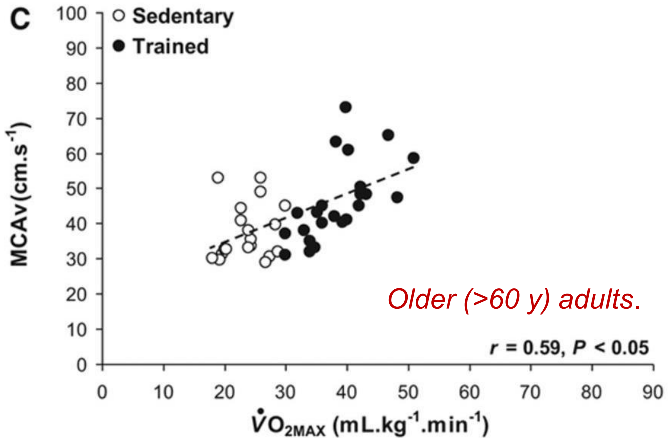
Doppler-based (TCD)



Ainslie *et al.* (2008)

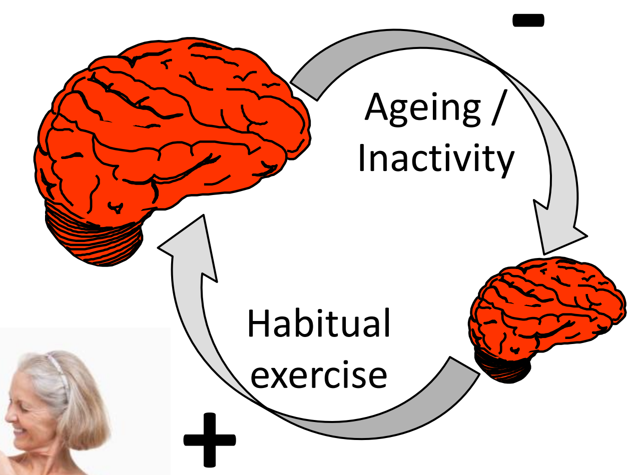
Positive effect of fitness…



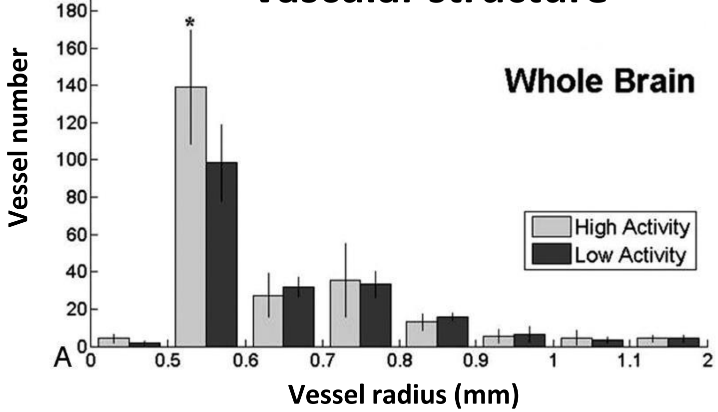


Resting brain blood flow associated with age and fitness.

Bailey et al., 2013. Stroke; 44:3235-3238



Vascular structure

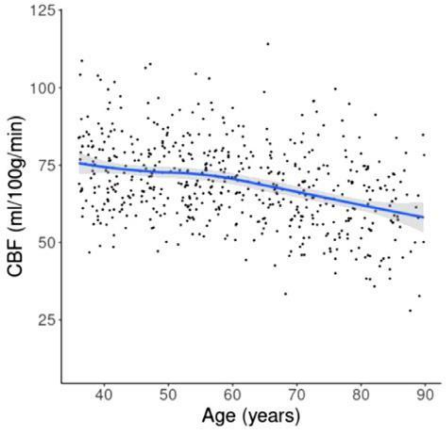


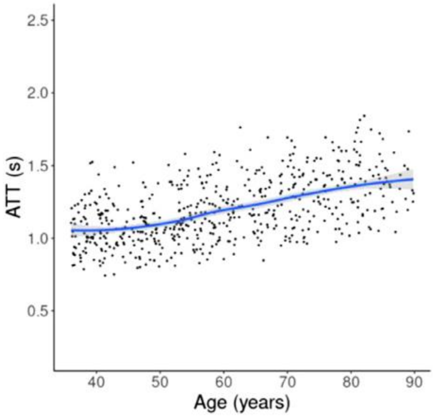
Bullitt et al. (2009)

Brain vascular health and brain function…

Cerebrovascular health declines with age

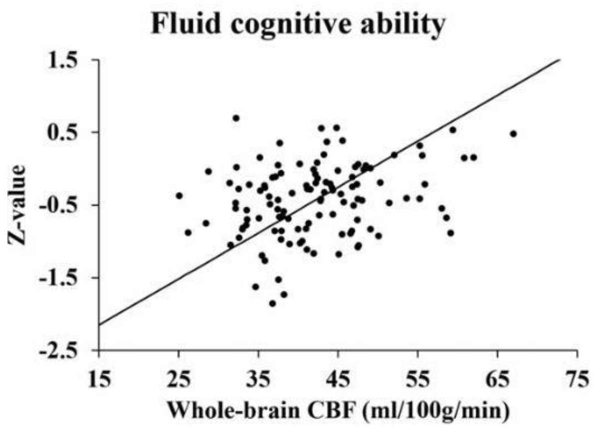
MRI-based measures





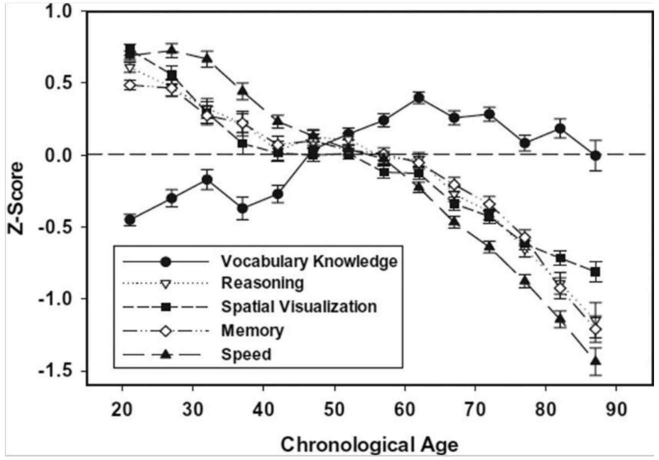
Damestani et al. (2023)

Low CBF predicts cognitive decline



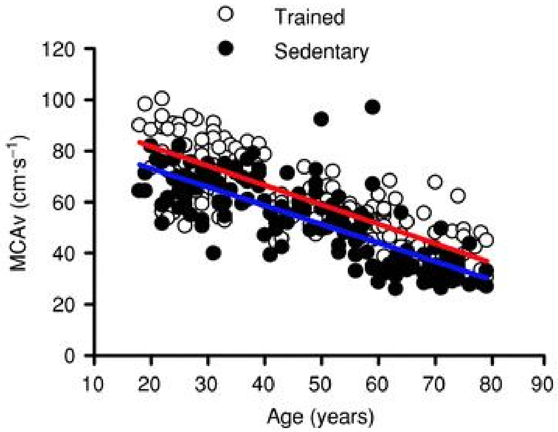
van Dinther et al. (2023); De Vis et al. (2018); Ebenau et al. (2023)

Cognitive function declines with age

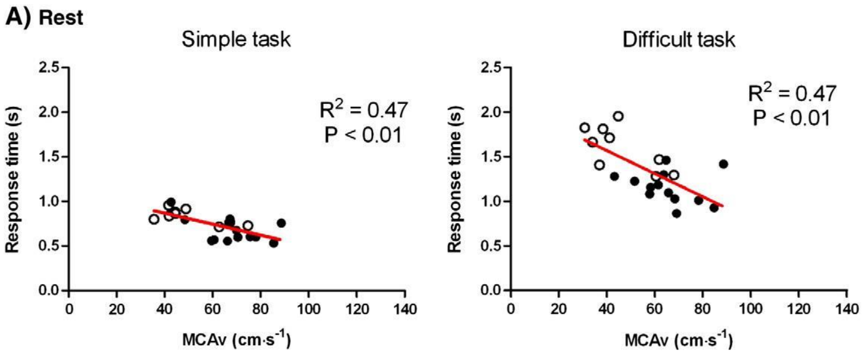


Salthouse et al. (2010)

Doppler-based measures



Ainslie *et al.* (2008)



(Lucas *et al.* 2012)

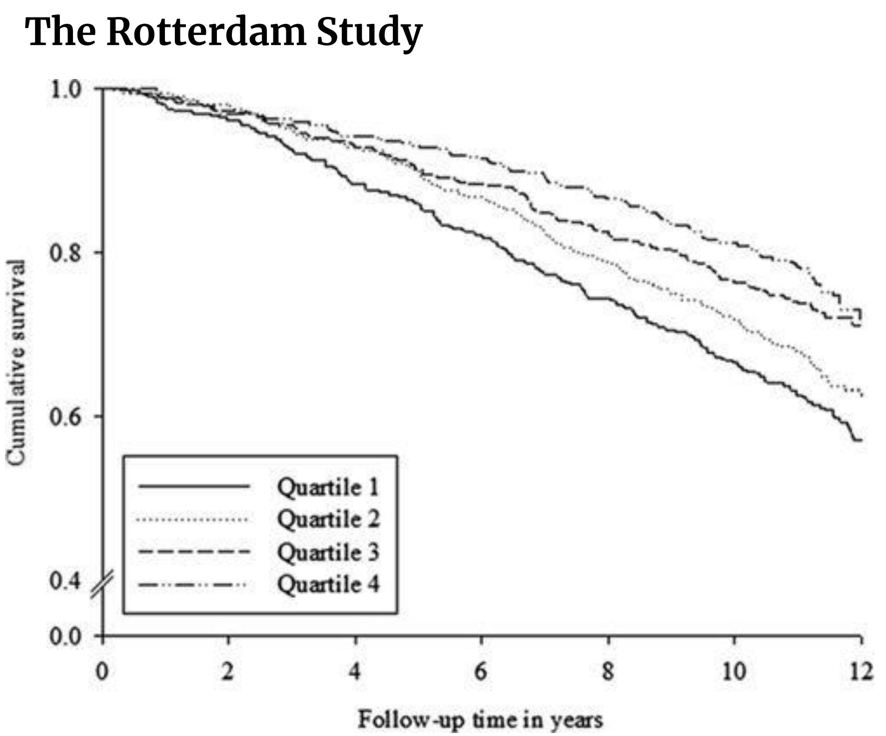
Prolonged ATT in Alzheimer's disease

ATT (s)	NC	AD
Olfactory L	1.28 ± 0.16	1.38 ± 0.25*†
Olfactory R	1.30 ± 0.19	1.42 ± 0.24*†
Posterior Cingulate L	1.60 ± 0.19	1.71 ± 0.19*†
Posterior Cingulate R	1.52 ± 0.17	1.64 ± 0.20*†
Hippocampus L	1.34 ± 0.14	1.49 ± 0.20*†
Hippocampus R	1.40 ± 0.16	1.49 ± 0.20*†
Cuneus L	1.73 ± 0.20	1.86 ± 0.20*†
Cuneus R	1.77 ± 0.18	1.87 ± 0.20*†
Precuneus L	1.70 ± 0.18	1.80 ± 0.19*†
Precuneus R	1.66 ± 0.18	1.78 ± 0.20*†

Sun et al. (2022)

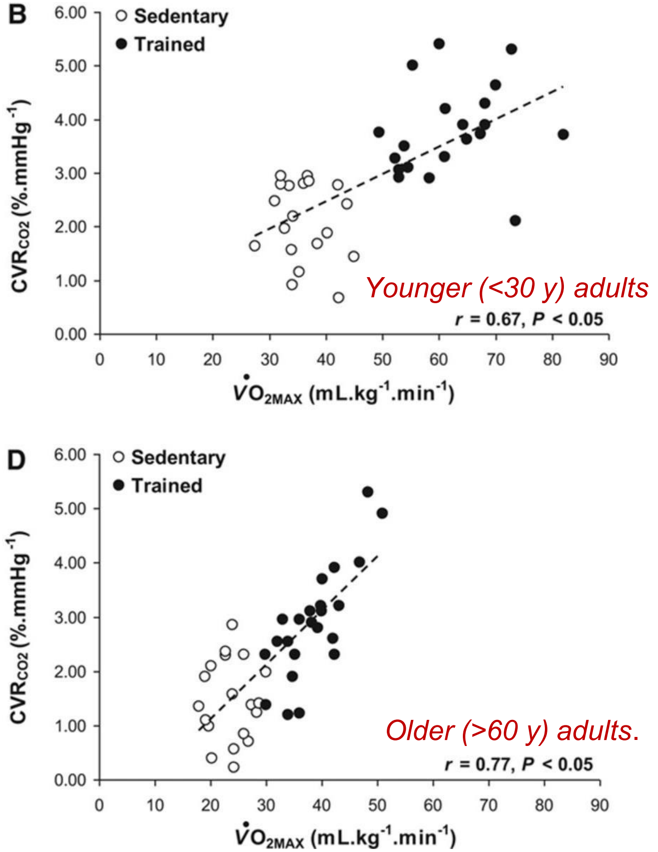
Brain health and cerebral flow blood regulation

Is cerebrovascular CO_2 reactivity/responsiveness (CVR_{CO_2}) a useful ***functional*** brain vascular health biomarker?



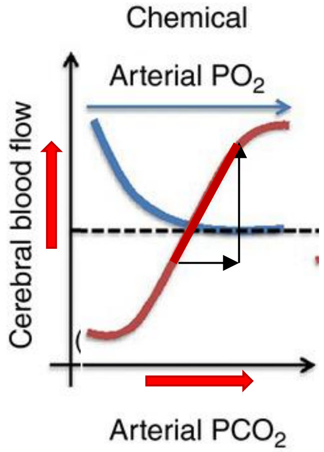
Lower cerebral vasomotor reactivity associated with increased risk of mortality

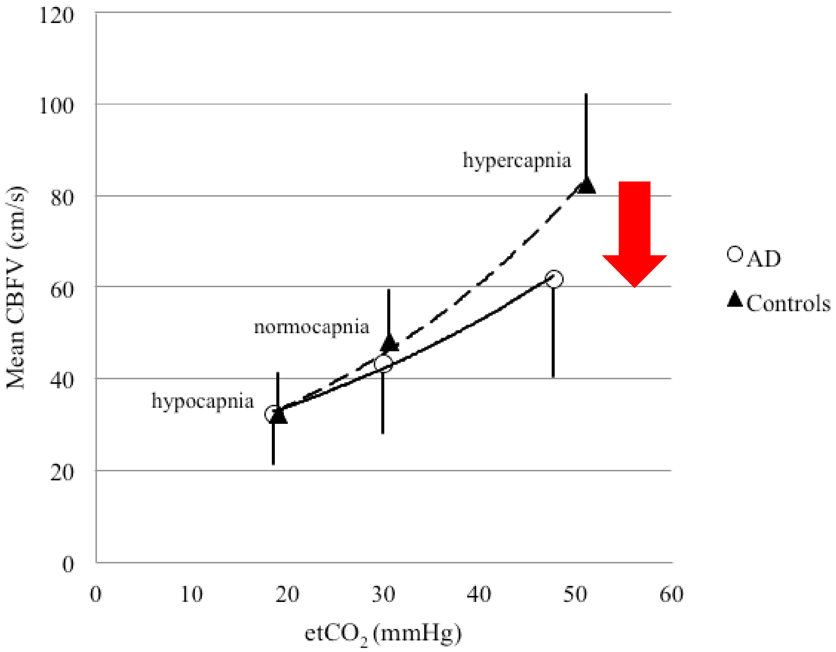
Portegies et al., 2014. *Stoke,* 45(1):42-7.



Cerebral vasomotor reactivity associated with age and fitness.

Bailey et al., 2013. *Stroke*; 44:3235-3238





Impaired hypercapnic responsiveness in Alzheimer's Disease

Meel-van den Abeelen *et al. Current Alzheimer Research*, 2014

american physiological society
AMERICAN JOURNAL OF PHYSIOLOGY
HEART AND CIRCULATORY PHYSIOLOGY

Am J Physiol Heart Circ Physiol 321: H59–H76, 2021.
First published May 21, 2021; doi:10.1152/ajpheart.00880.2020

SYSTEMATIC REVIEW

Exercise and Cardiac Remodeling in Normal and Athletic States

Effects of cardiorespiratory fitness and exercise training on cerebrovascular blood flow and reactivity: a systematic review with meta-analyses

Emily C. Smith,[1,4] Faith K. Pizzey,[1,4] Christopher D. Askew,[2,3] Gregore I. Mielke,[4] Philip N. Ainslie,[5] Jeff S. Coombes,[1,4] and Tom G. Bailey[1,4,6]

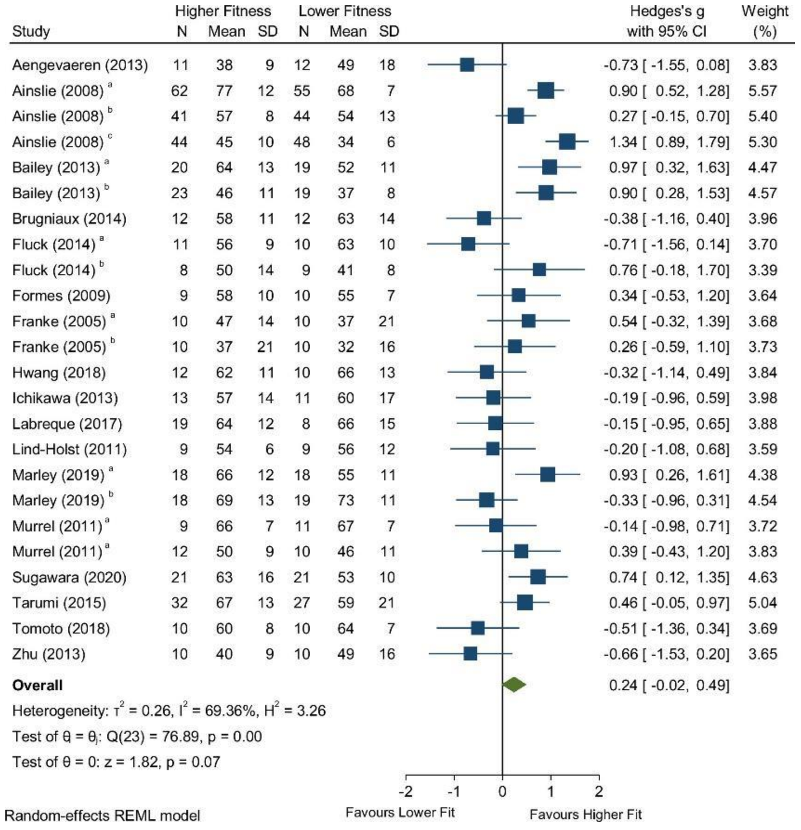


Fig 2: Forrest plot of the mean difference of middle cerebral artery blood velocity **(at rest)**, as measured by transcranial Doppler (TCD), between higher fit and lower fit participants (total *n* = 866).

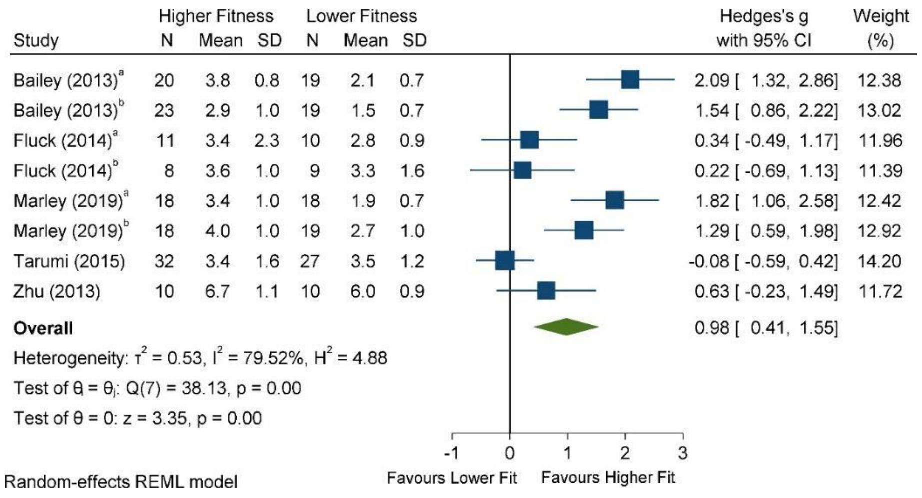


Fig 5: Forrest plot of the mean difference of **cerebrovascular reactivity**, as measured by transcranial Doppler (TCD), between higher fit and lower fit participants (total *n*= 271).

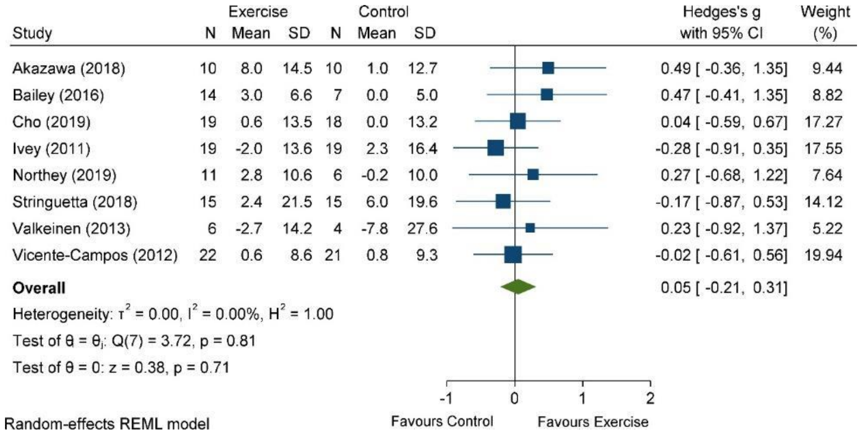


Fig 6: Forrest plot of the mean effect of exercise training on middle cerebral artery blood flow velocity **(at rest)**, as measured by transcranial Doppler (TCD) (total *n* = 216).

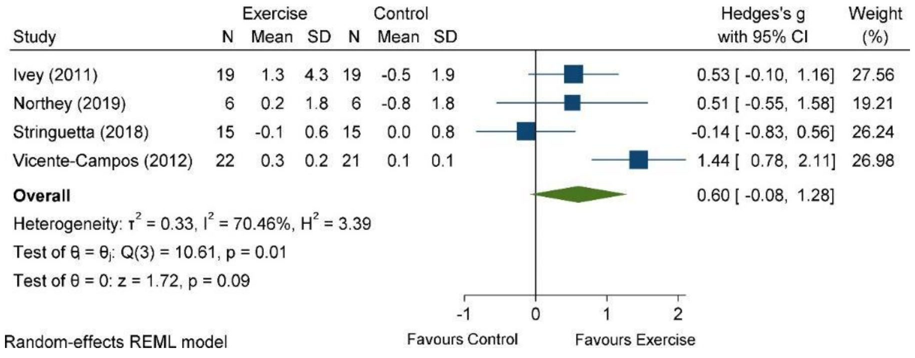
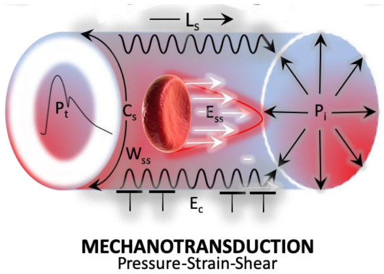


Fig 7: Forrest plot of the mean effect of exercise training compared with control on **cerebrovascular reactivity**, as measured by transcranial Doppler (TCD) (total *n* = 123).

Outline

- Exercise and the brain
  - Background
  - Links between brain vascular health, brain function, ageing, and exercise

- Rethinking exercise to improve its effectiveness
  - Targeted conditioning for brain vascular health
    - Optimising a key mechanistic pathway - Shear stress
    - Exercise modality/intensity matters



- The power of water!
  - Water-based strategies that enhance vascular health
  - Aquatic treadmill exercise as an optimal therapeutic exercise strategy

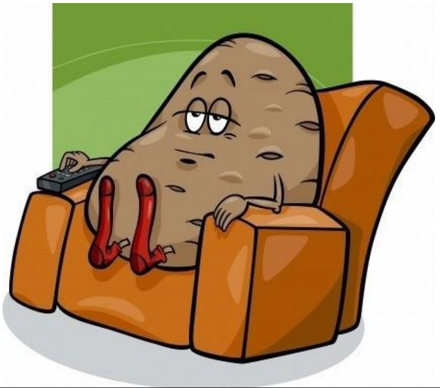
The Problem…

- Strenuous physical activity (e.g. exercise) is the most accessible, effective, multi-potent and safe intervention to improve and maintain health, and treat most modern chronic diseases.

Yet,

- Health recommendations of 30 min/d not being meet.
  - Depending on demographic, proportion not meeting these guidelines is very high – 80-90%!
  - Inactivity now a top 10 risk factor for poor health, and is associated with increased overall cardiovascular mortality

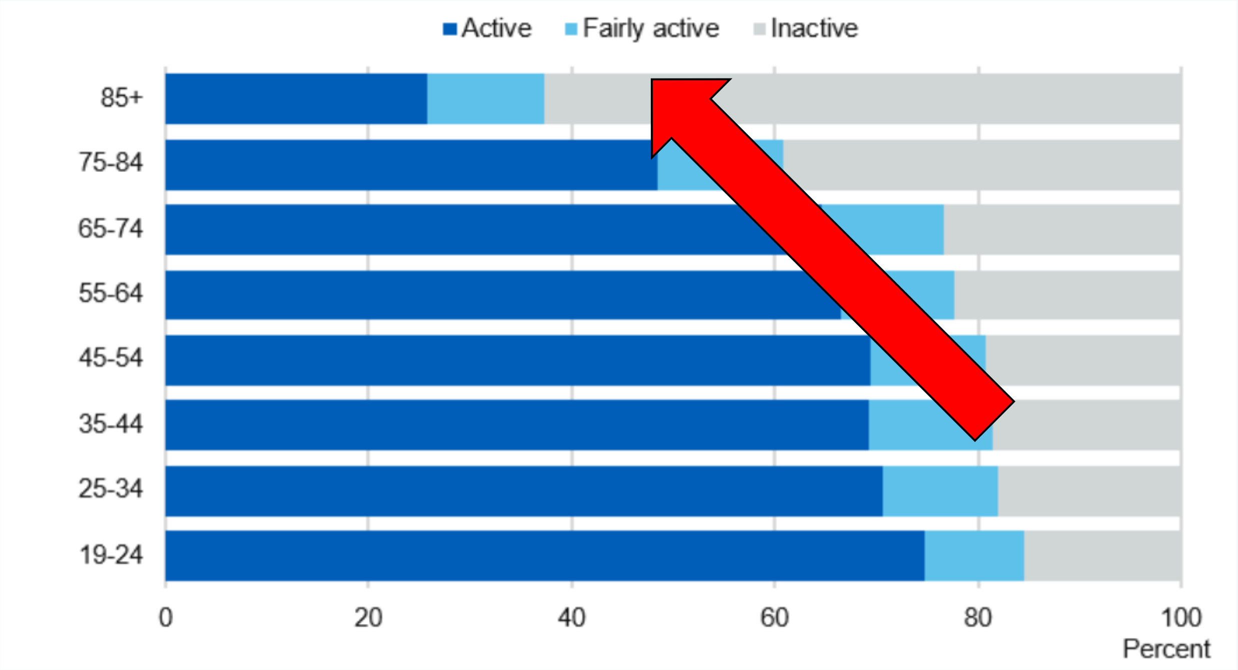
(Lee et al., *The Lancet*, 2012)



Statistics on Obesity, Physical Activity and Diet, England, 2019; National Statistics

Adult physical activity by age group

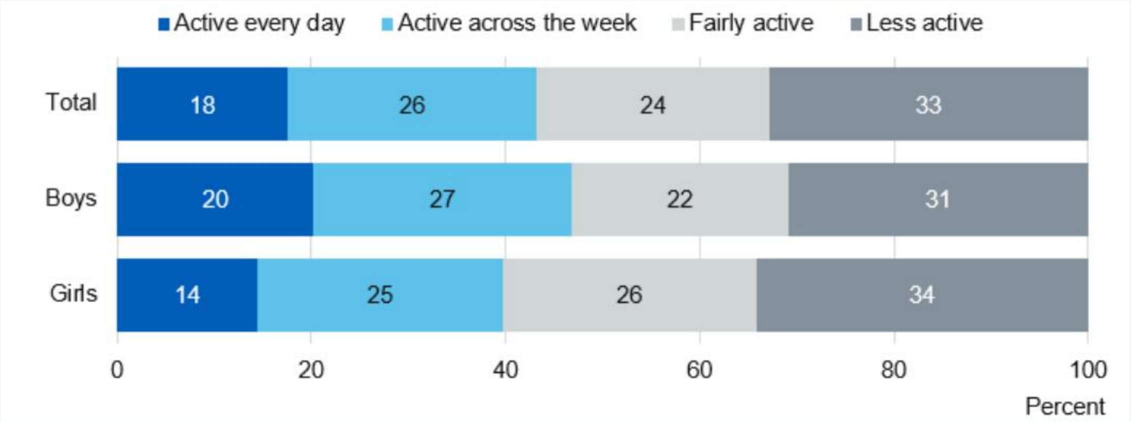
Activity levels generally fall with age, but the sharpest decline comes at ages 75-84 (48% active) and age 85+ (26% active).



Childhood physical activity by gender

18% of children and young people are meeting the current Chief Medical Officer guidelines of taking part in sport and physical activity for at least 60 minutes every day. A further 26% sit just below this threshold, taking part on average for 60+ minutes a day across the week, whilst 33% do less than an average of 30 minutes a day.

Boys (20%) are more likely to be active every day than girls (14%).



‘Exercise’ needs rethinking…

Image by VoxUkraine: www.VoxUkraine.org

- ***How*** does exercise work?
  - Need to better understand the mechanism by which adaptation occurs
- ***What types*** of exercise best facilitate improved function?
  - **For example, high intensity interval training (HIT) vs. moderate intensity aerobic-based**

- Such knowledge will inform exercise prescription guidelines as well as allow for **exploration of alternative approaches** to access the health benefits of exercise for both healthy and disease populations.

What is it about exercise that drives the beneficial adaptation?

- Exercise is a ‘dirty’ stressor, inducing a complex physiological strain response.
- By understanding this better, can we:
  - Improve its potency?
  - Increase its application?
    - Especially for populations that don’t/can’t access traditionally promoted physical activity guidelines
      - (e.g. 150-300 min/week of moderate intensity exercise + strength training at least x2/week)

What is it about exercise that drives the beneficial adaptation?

Stress → **Strain** → **Adaptation**

<u>Physical Activity</u>
Intensity,
Frequency, timing
Duration, Mode

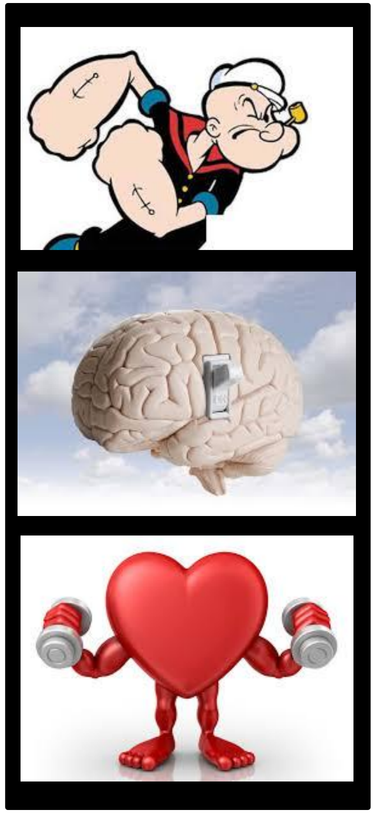
→

<u>Strain</u>
e.g., Mechanical T
Tissue temperatu
[energy substrate
Hypohydration

→

<u>Resting status</u>
e.g., receptor sensitivities, tissue mass or substrate mass

<u>Functional status</u>
e.g., effector sensitivities or capacities



Stress → **Strain** → **Adaptation**

Environment
Oxygen pressure
Thermal energy
Water pressure

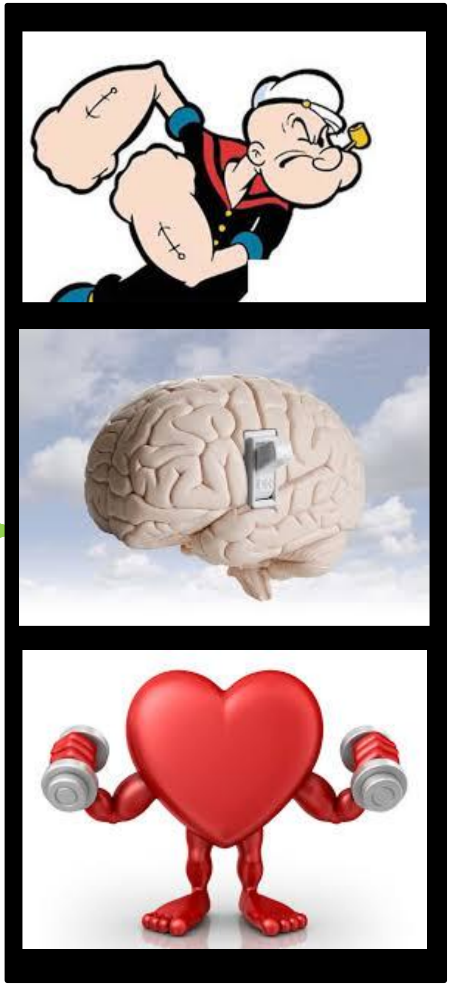
Physical Activity
Intensity,
Frequency, timing
Duration, Mode

Modulators
Genetics (incl. sex)
Age, Training status,
Clinical status, etc

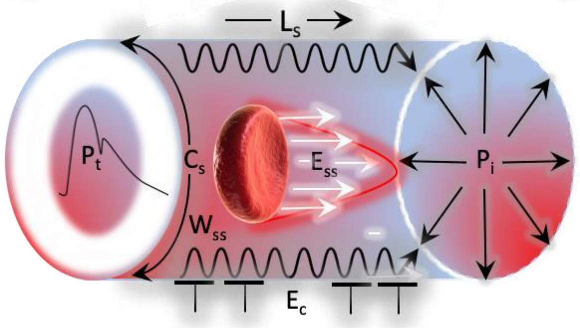
Strain
Mechanical Tension
Tissue temperature
Hypoxia
Oxidative stress
[energy substrates]
Hypohydration

Responses

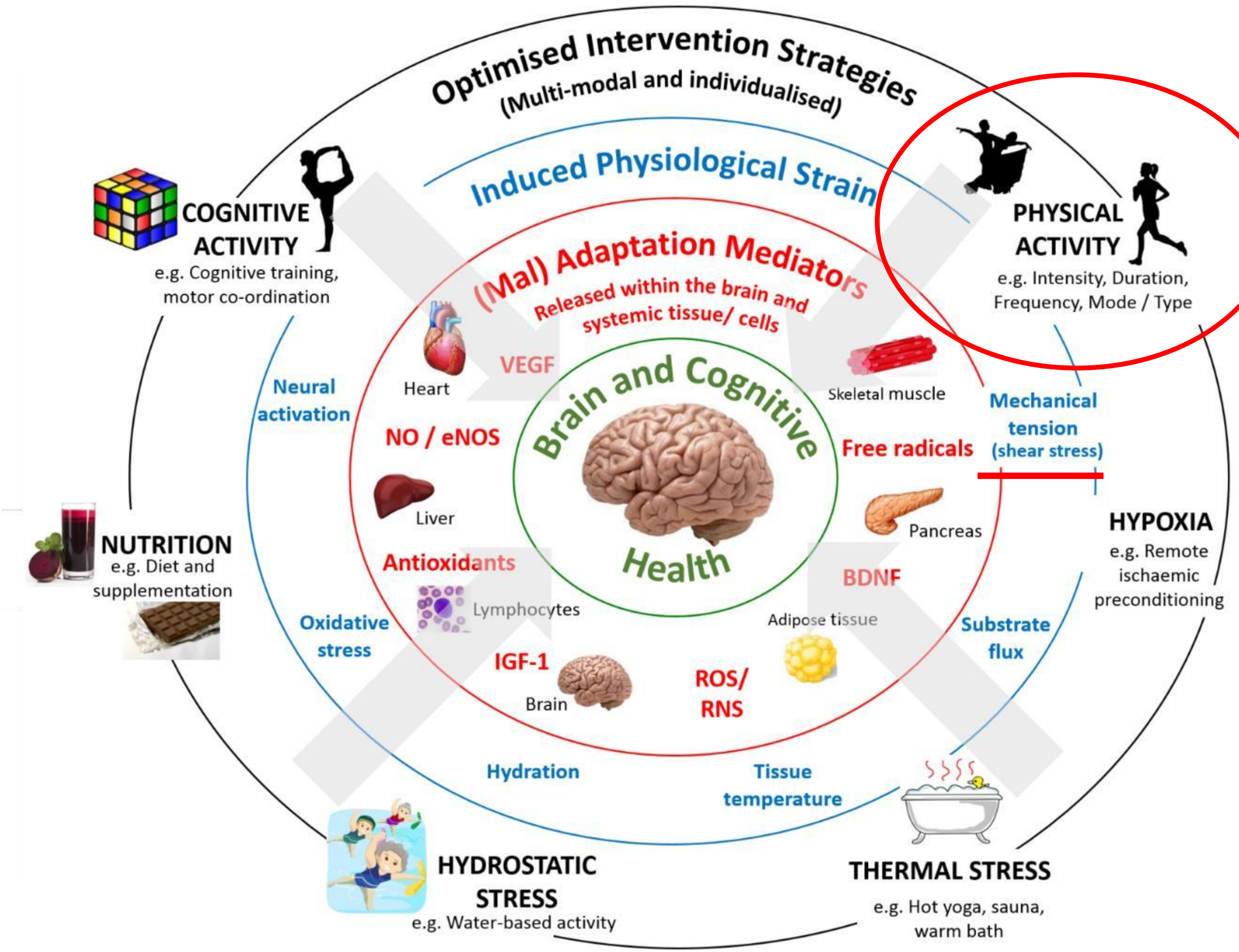
Nutrition & Medications
Substrates (e.g., CHO, a.a.s)
Water, vitamins, minerals



Key 'mechanism of action' for changes in vascular function

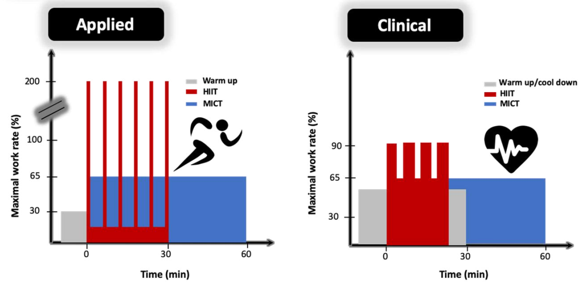


Exercise and brain health: Brain train to combat brain drain



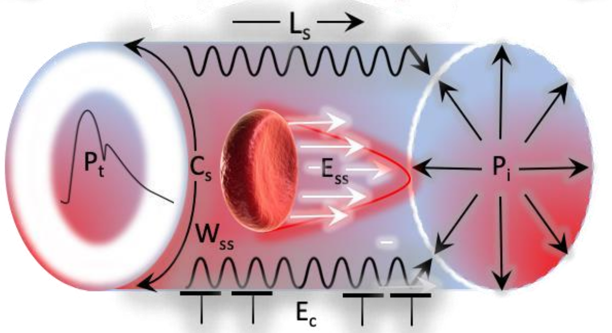
Exercise modality

Exercise Intensity and duration



High-intensity interval vs. traditional moderate intensity continuous training paradigms

Key 'mechanism of action' for changes in vascular function



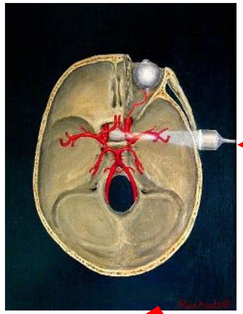
MECHANOTRANSDUCTION
Pressure-Strain-Shear

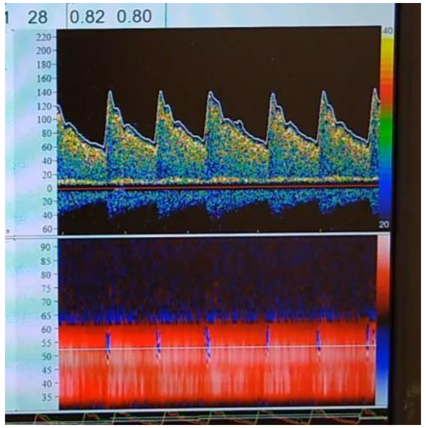
Burley et al. (2016) Exp Physiol

Exercise and brain health: Brain train to combat brain drain

Transcranial Doppler

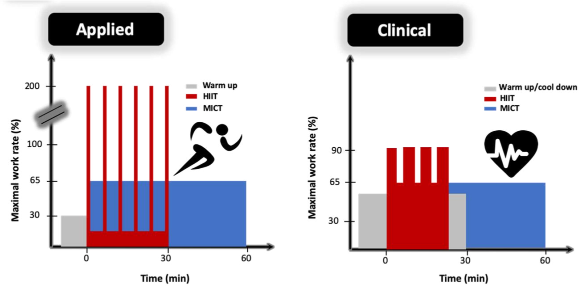
Measures blood velocity in main blood supply vessels





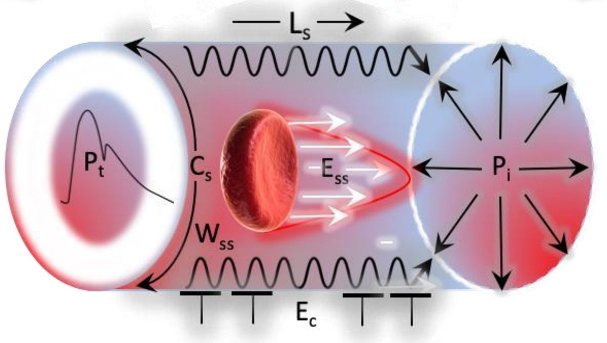
Exercise modality

Exercise Intensity and duration



High-intensity interval vs. traditional moderate intensity continuous training paradigms

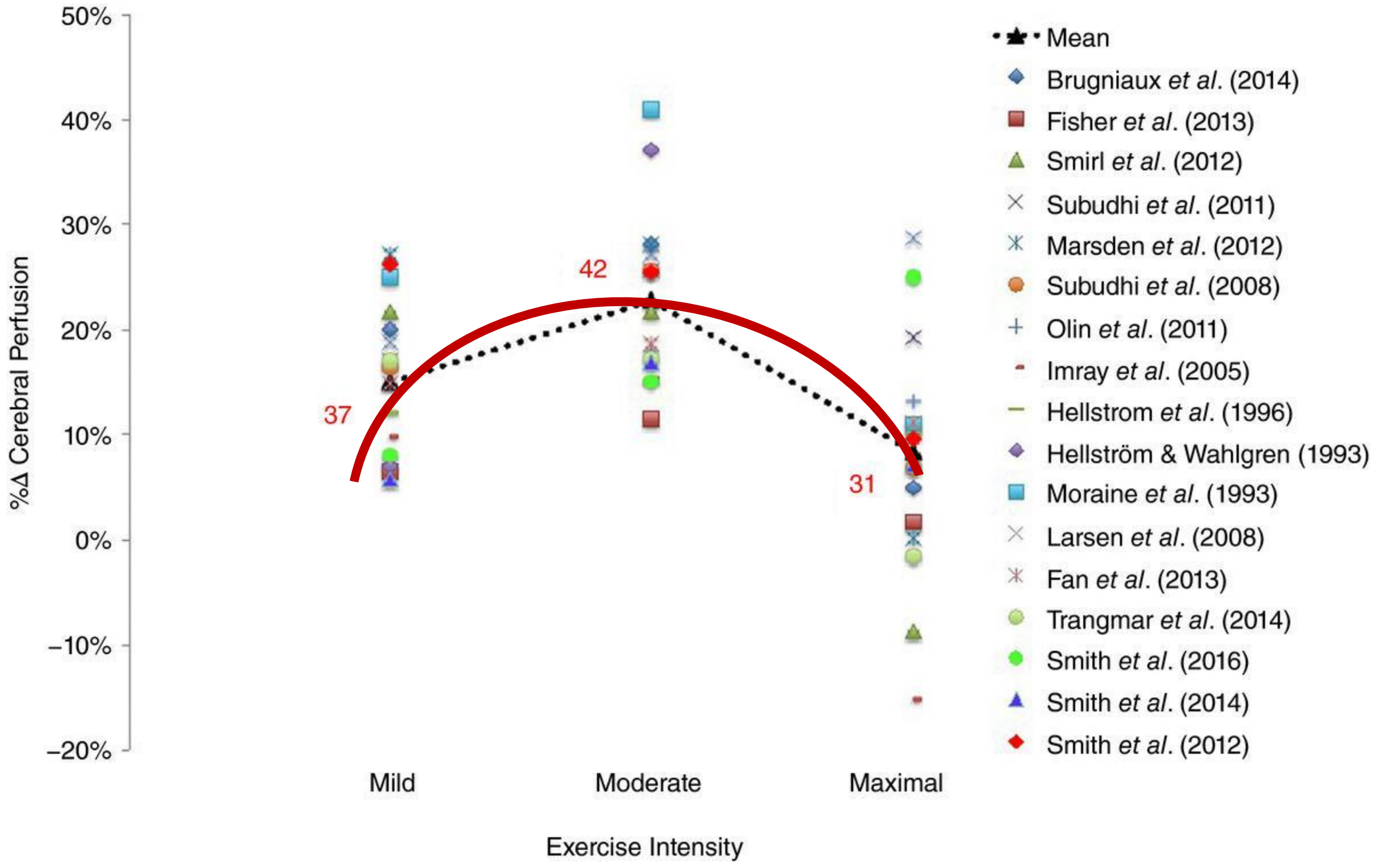
Key 'mechanism of action' for changes in vascular function



MECHANOTRANSDUCTION
Pressure-Strain-Shear

Exercise-induced changes in brain blood flow

– one index for the pattern of exercise-induce shear (esp. for the cerebrovascular)



Data from 17 studies that examined changes in cerebral blood velocity (using transcranial Doppler) during exercise to exhaustion (from Smith and Ainslie, Exp Physiol, 2017)

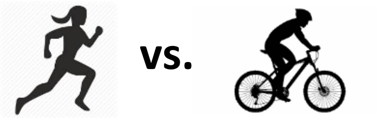
Commonly reported pattern of CBF across the full range of exercise intensity.
- Inverted U shape

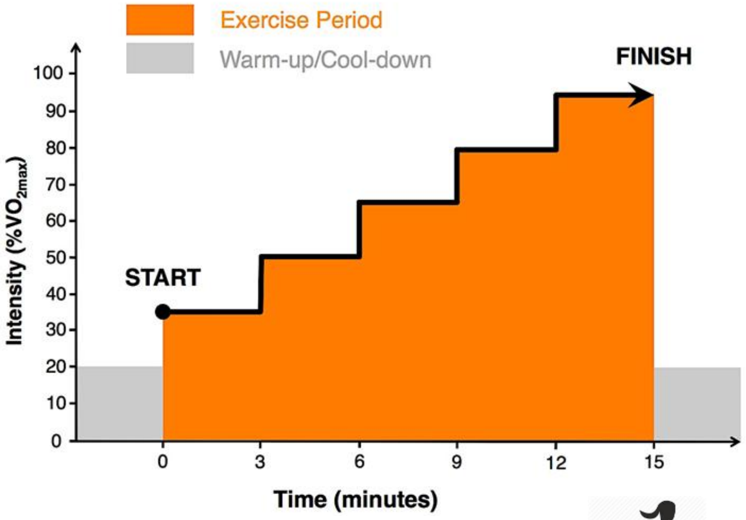
Figure: Percentage changes in cerebral perfusion from rest, during incremental exercise from mild [20–40% maximal workload (W_{max})] moderate (50–80% W_{max}) and maximal (90–100% W_{max}) intensities.

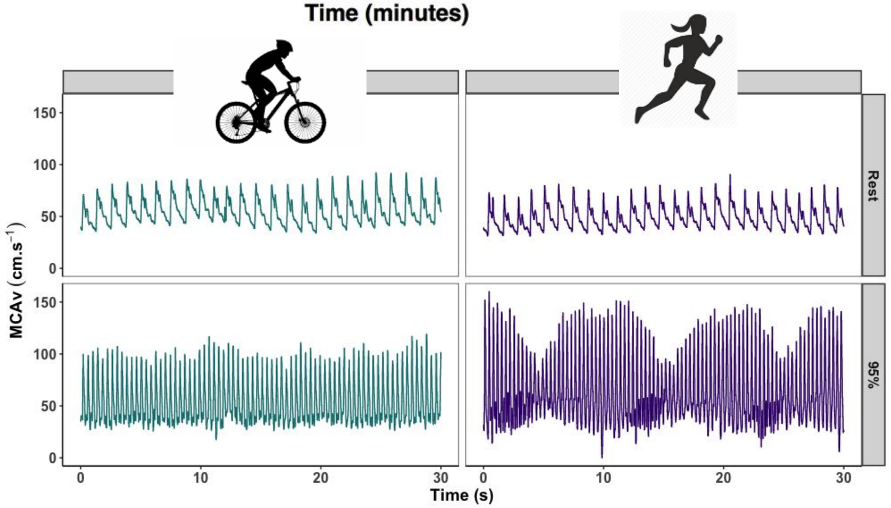
Red numbers indicate average PaCO2 values

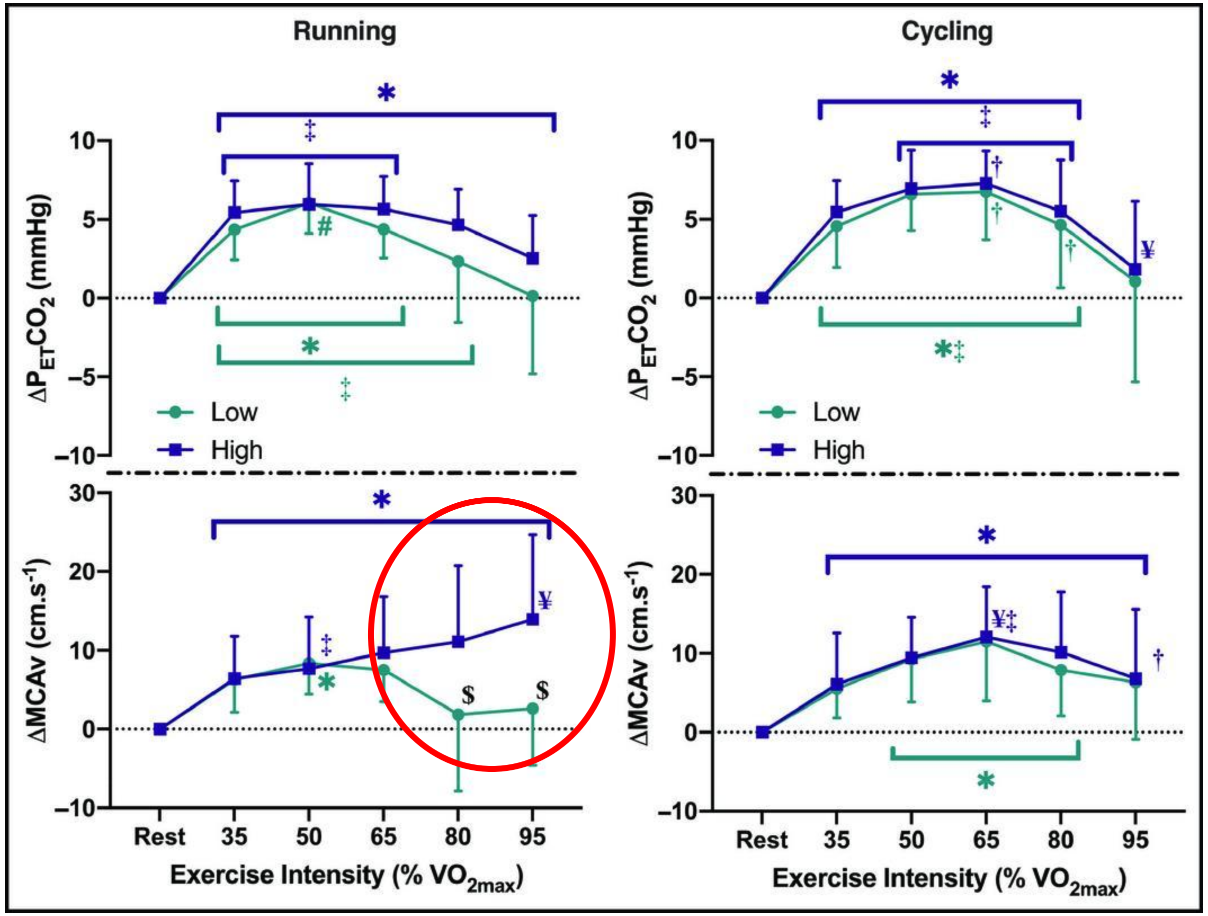
How do different exercise modalities and protocols affect brain health outcomes? (e.g. brain blood flow)

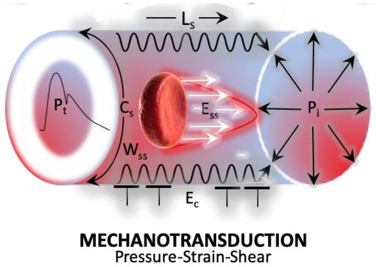
Comparing brain blood flow (velocity) responses between cycling and running exercise









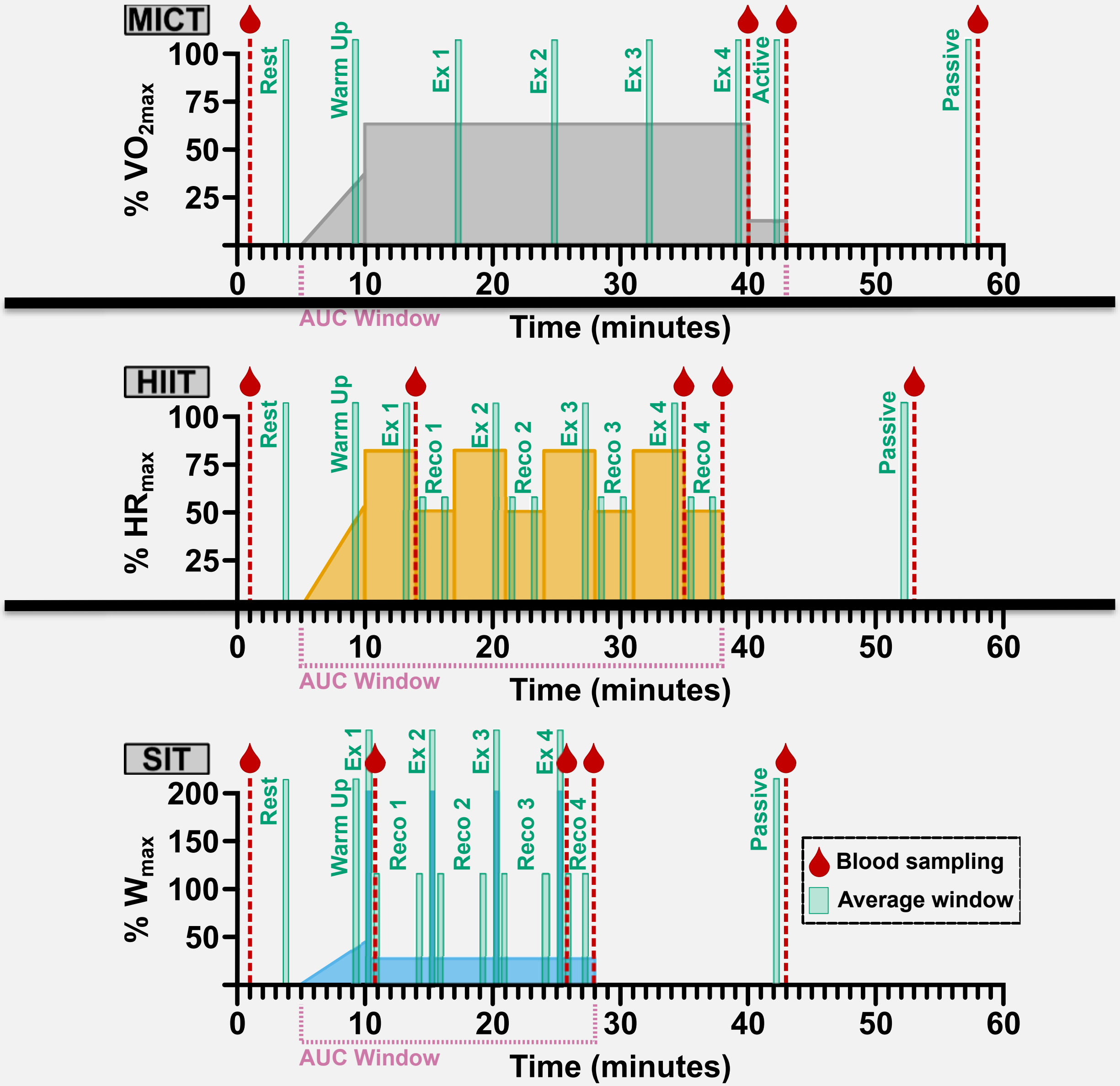


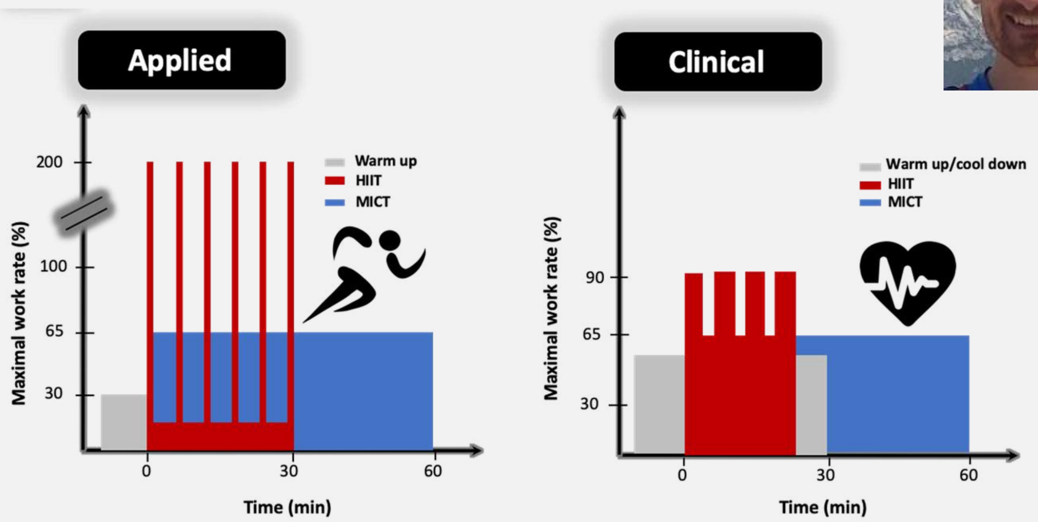
- ☐ **Findings demonstrate that modality- and fitness-specific profiles for mean MCAv at exercise intensities exceeding 65% VO_{2max}.**

Furlong et al., *Physiol Rep.* 2020. doi: 10.14814/phy2.14539

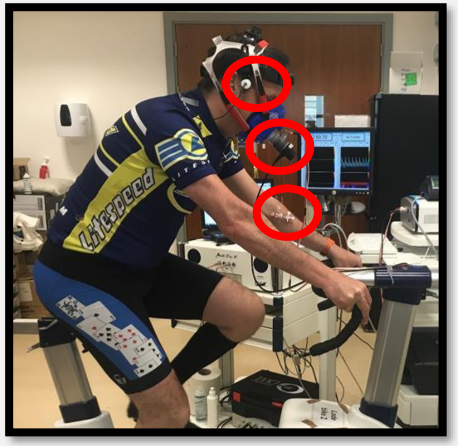
So, pattern of physiological strain (shear) between exercise modalities can be different…

Brain blood flow (velocity) responses to different exercise protocols





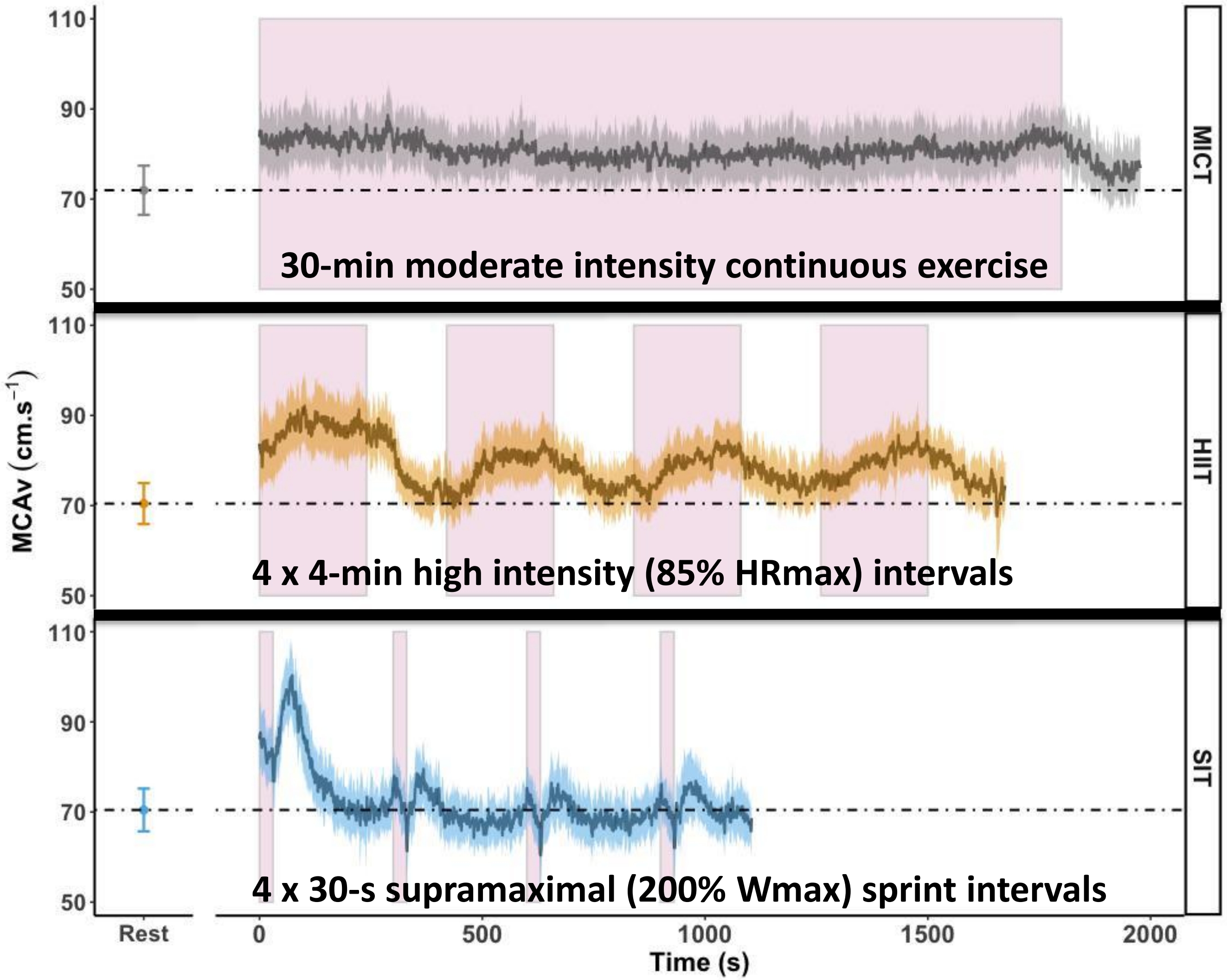
High-intensity interval vs. traditional moderate intensity continuous training paradigms

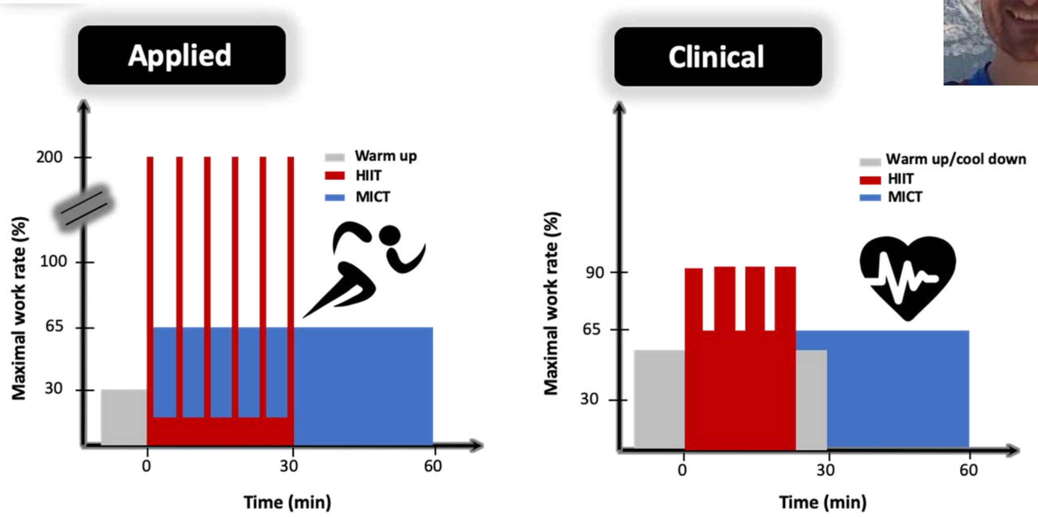


Aim: To examine the acute cerebral haemodynamic and circulating neurotrophic factor responses to three distinct and widely utilised exercise protocols.

Weaver et al., *Front Physiol.* 2021;11:609935. doi: 10.3389/fphys.2020.609935.

Brain blood flow (velocity) responses to different exercise protocols





High-intensity interval vs. traditional moderate intensity continuous training paradigms

Aim: To examine the acute cerebral haemodynamic and circulating neurotrophic factor responses to three distinct and widely utilised exercise protocols.

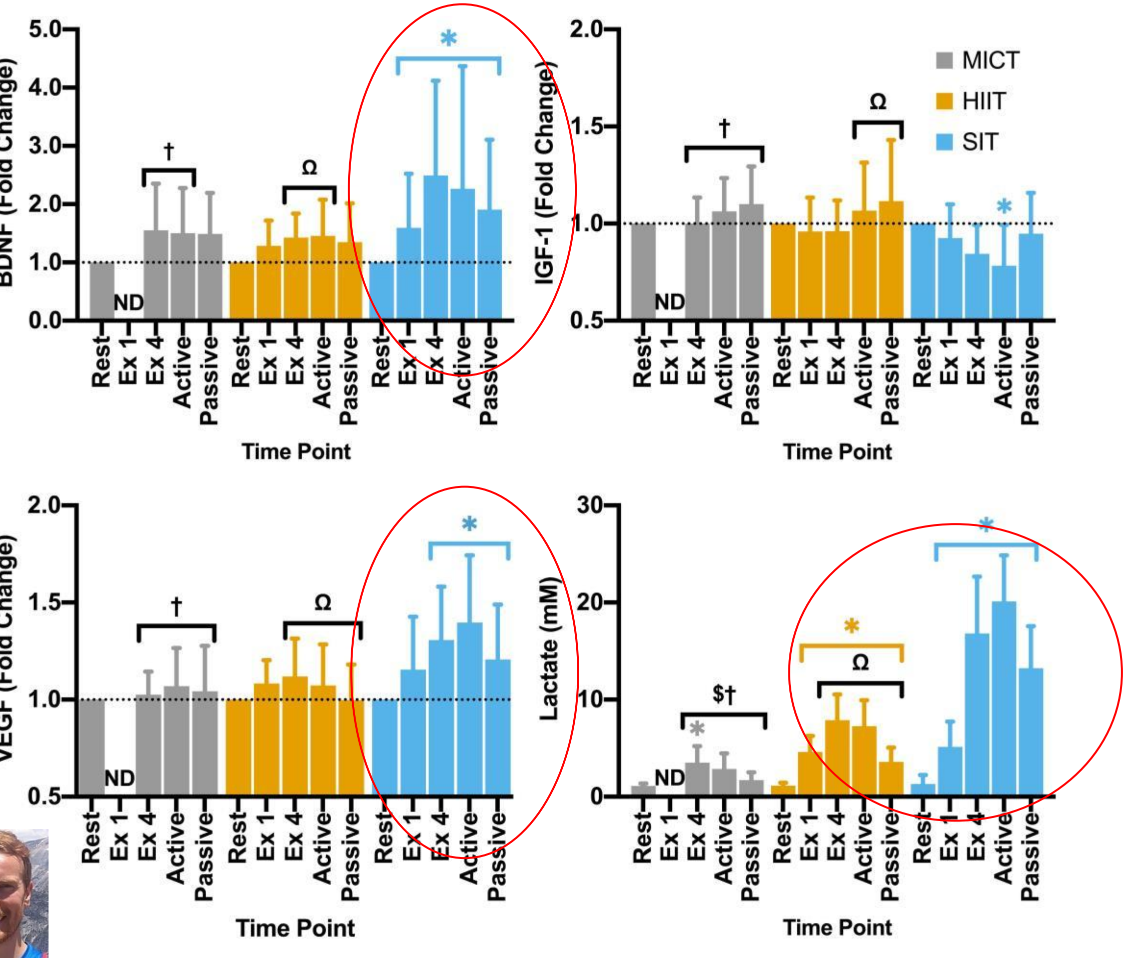
- MCAv decreases during 30-s sprint, but rebounds immediately following each sprint. What do these different CBF profiles mean for adaptation?

Weaver et al., *Front Physiol.* 2021;11:609935. doi: 10.3389/fphys.2020.609935.

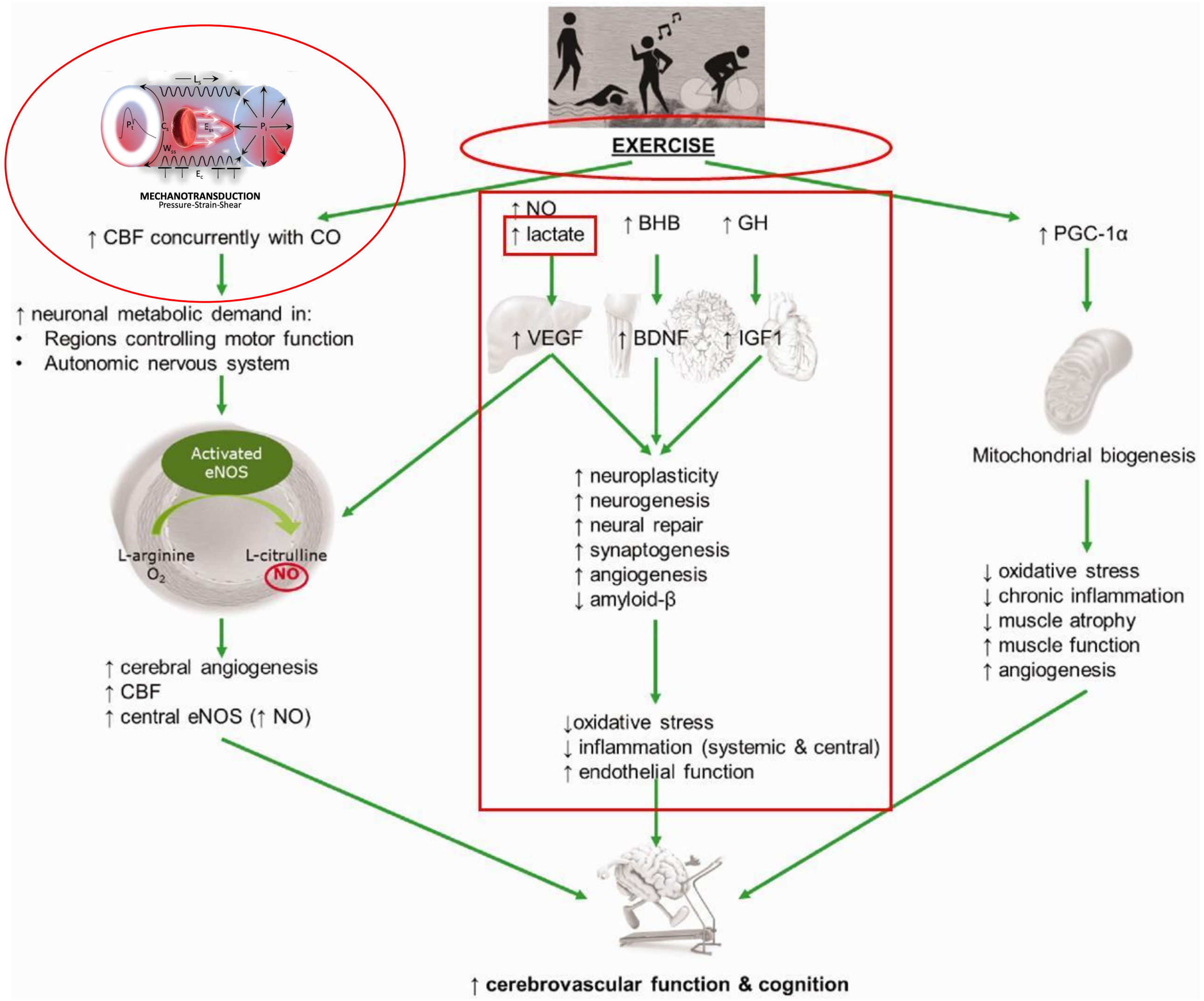
Note: The positive effect of exercise on cerebrovascular function and cognition likely to occur via numerous pathways….


Cell/Molecular signalling

Neurotrophic responses to the three different exercise protocols



Weaver et al., *Front Physiol.* 2021;11:609935. doi: 10.3389/fphys.2020.609935.



A summary of the potential mechanisms that may be elicited by exercise in improving cerebrovascular function and cognition (Bliss et al. *JCBFM*, 2021)

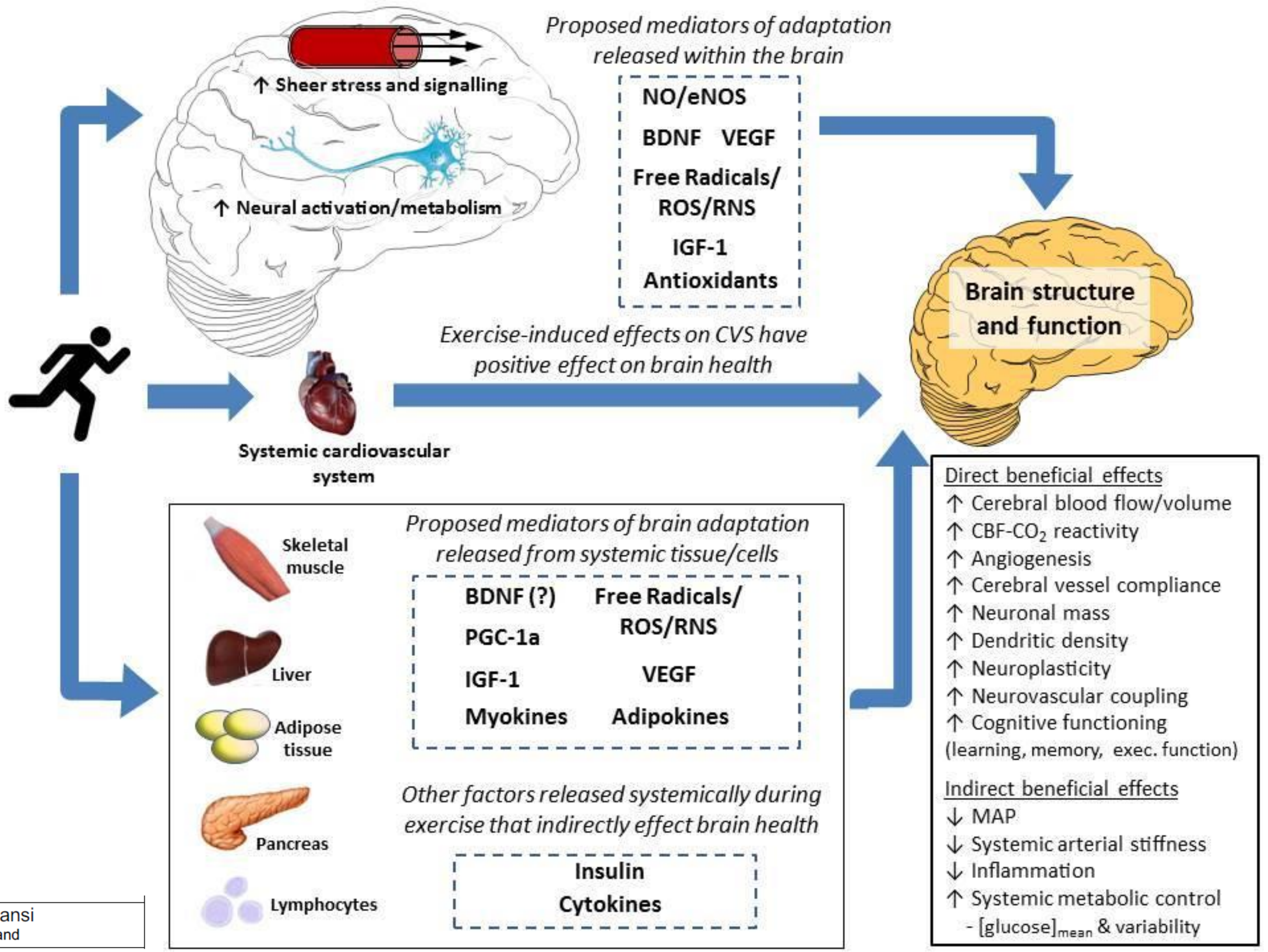
Lucas *et al.* *JCBFM*, 2015

Overview: Exercise and the Brain

Direct and indirect processes resulting in beneficial effects on Brain Structure and Function

Ongoing work exploring how to optimise HIIT-based protocols for brain health in older adults

Working hypothesis:
HIIT-based protocols = Greater increases in neurotrophic factors linked to positive adaptations in brain structure and function.
(Targeting the lactate – BDNF relation)



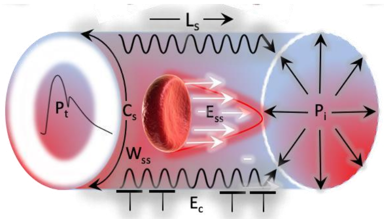
BBSRC bioscience for the future

13:10-14:00 K2	Making Waves – The power of high-intensive (aquatic) exercise	Jens Bansi Switzerland

Outline

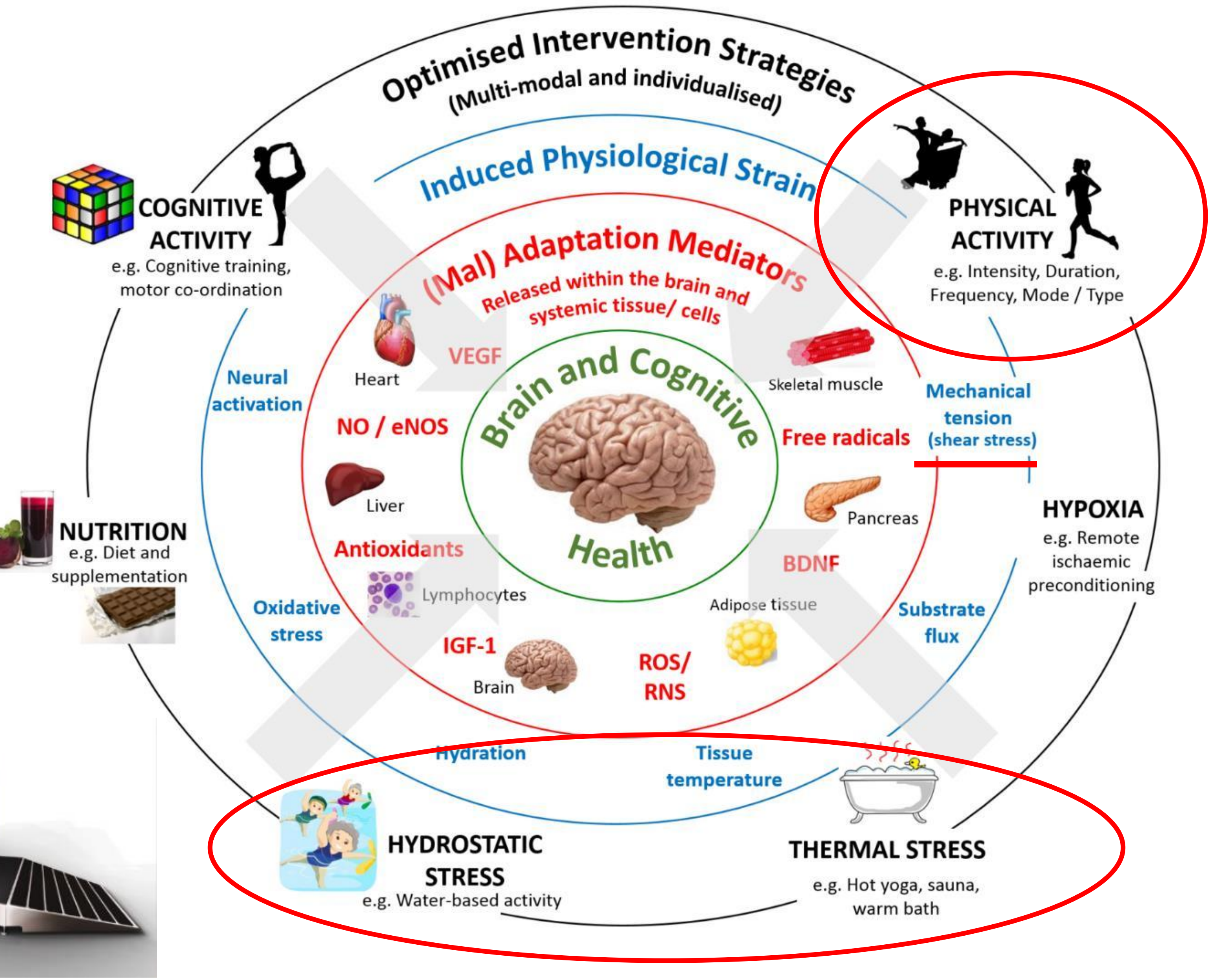
- Exercise and the brain
  - Background
  - Links between brain vascular health, brain function, ageing, and exercise

- Rethinking exercise to improve its effectiveness
  - Targeted conditioning for brain vascular health
    - Optimising a key mechanistic pathway - Shear stress
    - Exercise modality/intensity matters



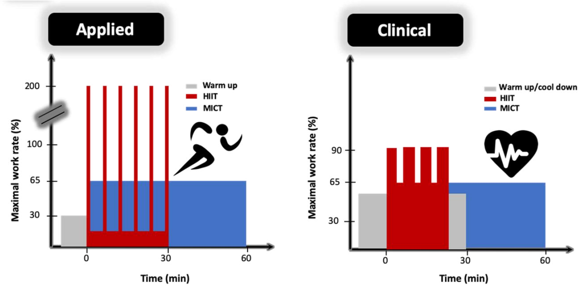
- The power of water!
  - Water-based strategies that enhance vascular health
  - Aquatic treadmill exercise as an optimal therapeutic exercise strategy

Exercise and brain health: Brain train to combat brain drain



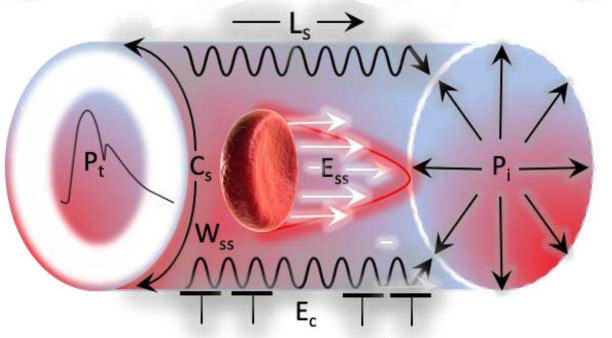
Exercise modality

Exercise Intensity and duration



High-intensity interval vs. traditional moderate intensity continuous training paradigms

Key 'mechanism of action' for changes in vascular function

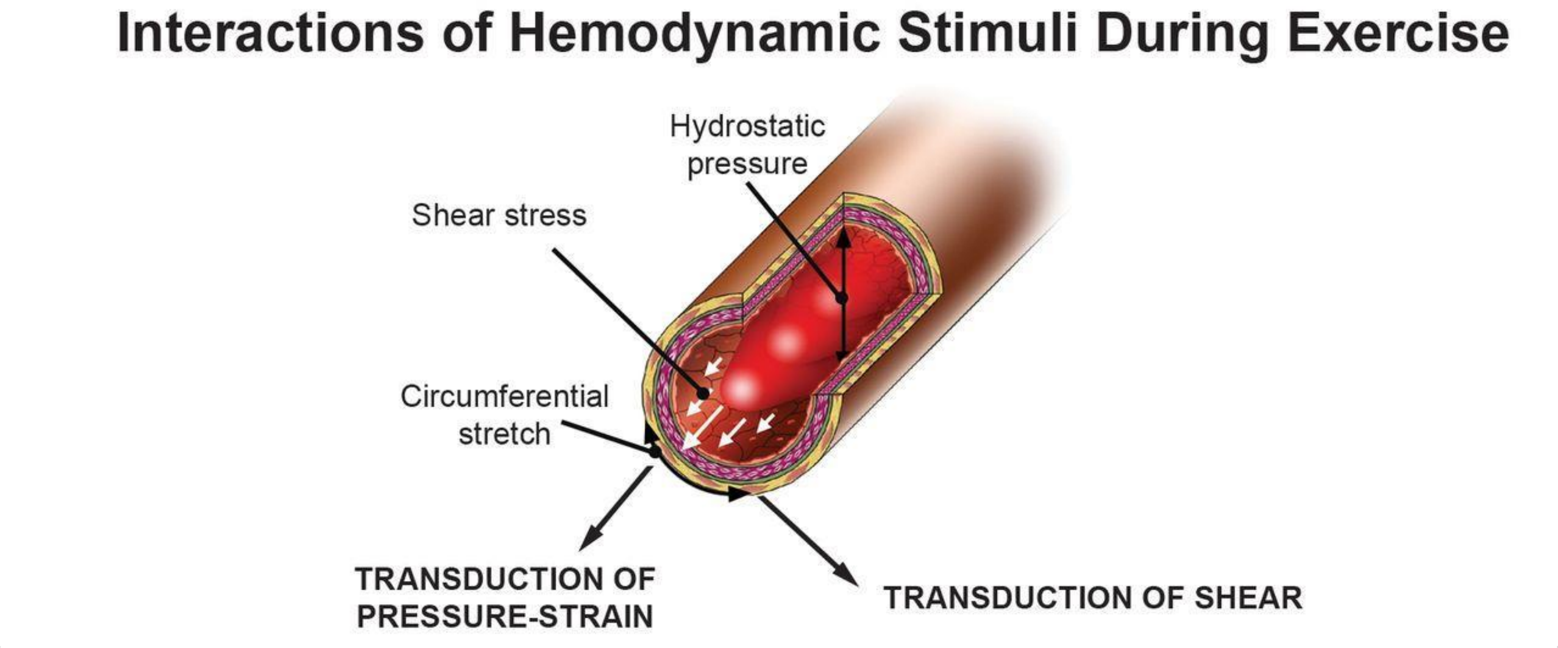


MECHANOTRANSDUCTION
Pressure-Strain-Shear

The Power of Water

HYDROSTATIC STRESS

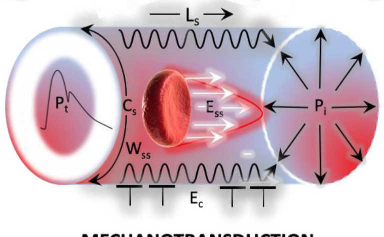
- Water immersion elicits a hydrostatic stress that increases blood flow through vessels.
- Consequently, water-based activities have great potential to enhance shear stress-mediated adaptation within the vasculature



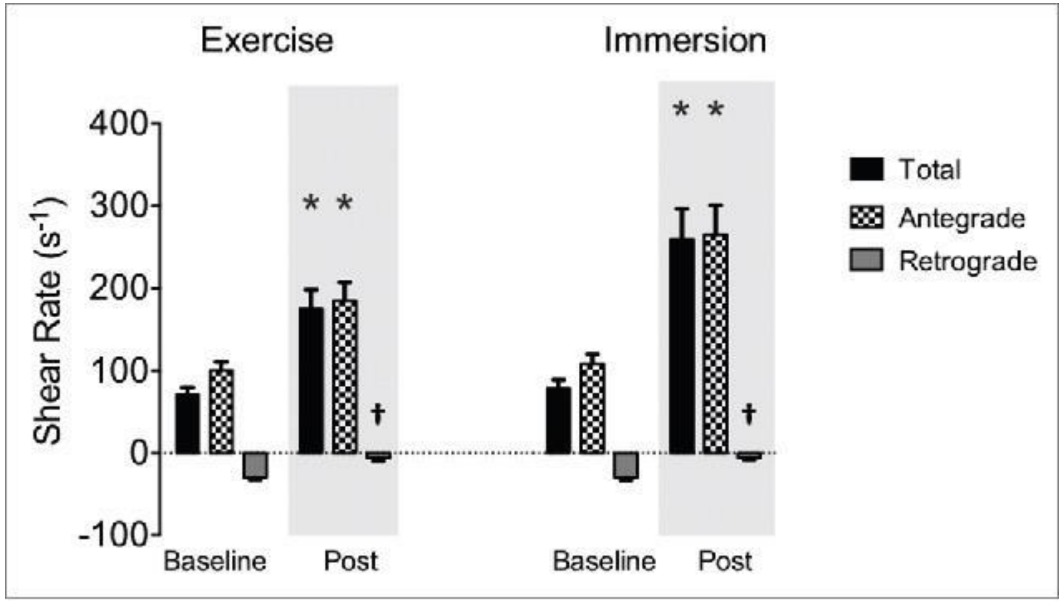
Green et al. *Physiol Rev* 2017

Passive heat stress (e.g. warm water bathing)

Stress → **Strain** → **Adaptation**



Warm bath vs exercise (Healthy adults)



Superficial femoral artery total (black bars), antegrade (checked bars) and retrograde (gray bars) shear rate at baseline and post-intervention. Bars represent group mean, error bars are SE. * interaction: intervention x time ($p<0.05$); † different from baseline ($p<0.05$).

Thomas *et al.*, 2016. *Temperature,* 3(2):286-297. doi: 10.1080/23328940.2016.1156215.

Potential to improve function for vascular disease patients…

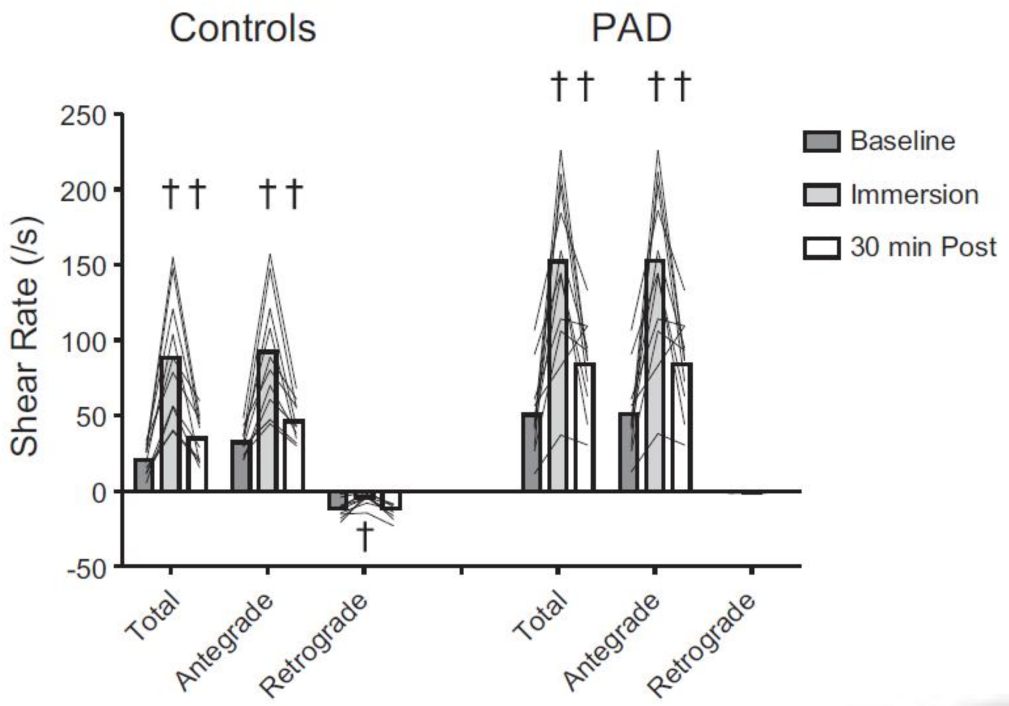
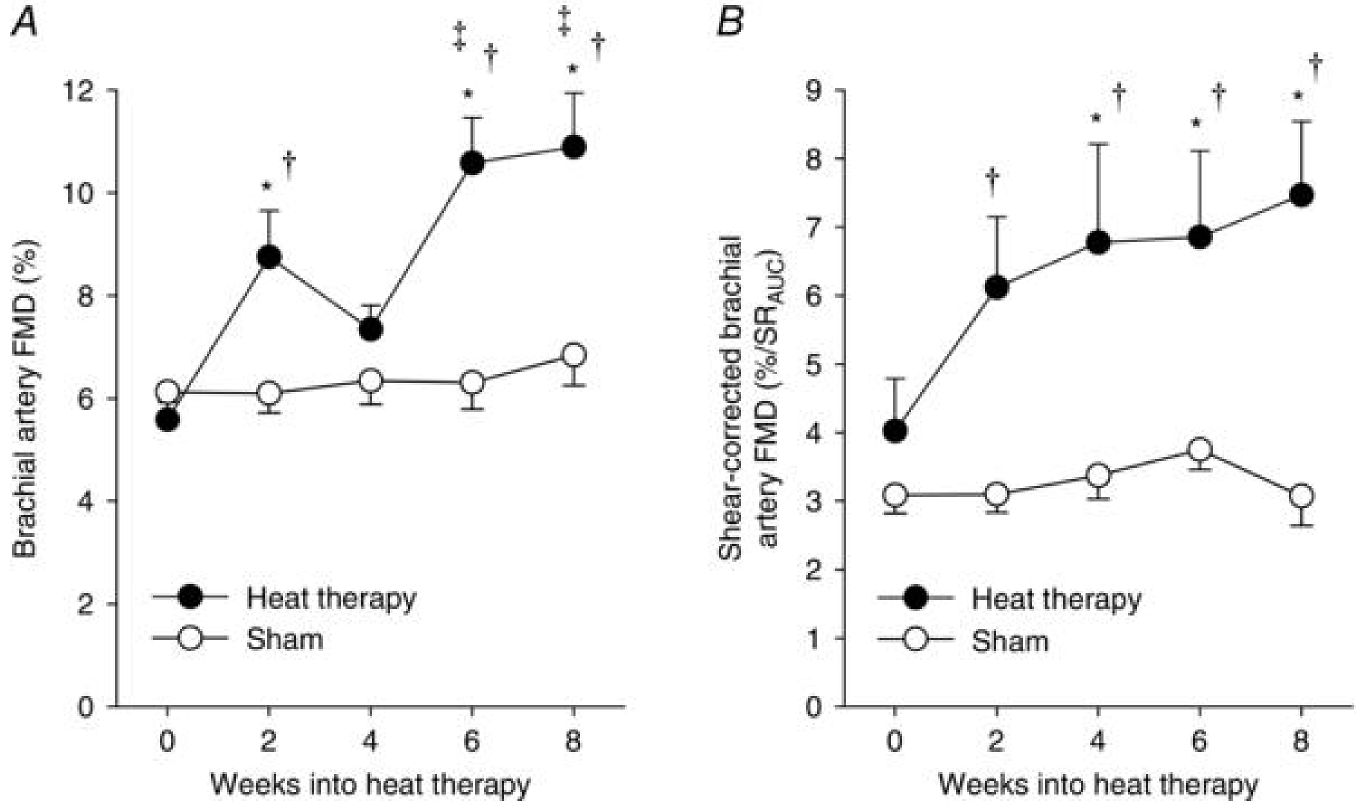


Fig. 2. Popliteal artery total, antegrade, and retrograde shear rate at baseline, during the last 3 min of immersion, and 30-min postimmersion. †Significantly different from baseline ($P < 0.05$).

Thomas *et al.*, 2017 Am J Physiol Regul Integr Comp Physiol. doi: 10.1152/ajpregu.00404.2016.

8-week thermal (passive heat stress) therapy training study in healthy participants

Brunt et al. 2016. J Physiol, 594: 5329-42

But what about the brain (esp. brain vascular health outcomes?)

…very few studies focussed on CBF responses…

UoB
SCHOOL OF SPORT, EXERCISE AND REHABILITATION SCIENCES



Figure: **Changes in brachial artery flow-mediated dilatation (FMD).** FMD presented as a percentage change from baseline diameter (*A*), and shear-corrected FMD (*B*), over 8 weeks of heat therapy (closed symbols) or thermoneutral water immersion (sham; open symbols). Data are mean ± SEM. Symbols denote results of *post hoc* analyses when significant main effects were observed. $^{*}P < 0.05$ from 0 weeks (within group). $^{‡}P < 0.05$ from 4 weeks (within group). $^{†}P < 0.05$ *vs* sham group at the same time point. SR_{AUC}, area under the curve of the shear rate stimulus for vasodilatation.

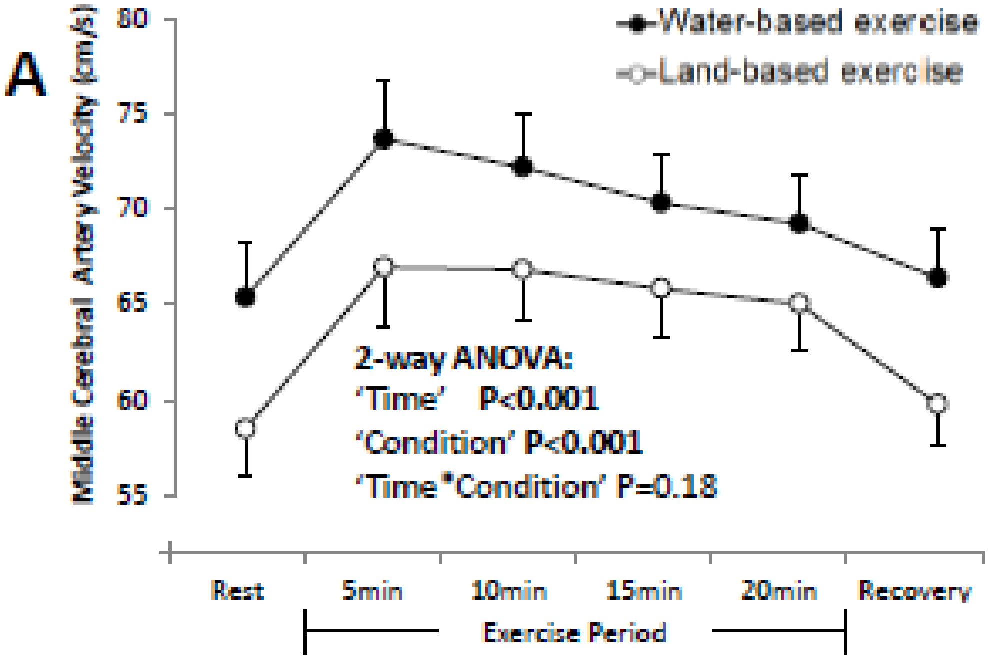
The Power of Water

HYDROSTATIC STRESS

- Water immersion elicits a hydrostatic stress that increases blood flow through vessels.
- Consequently, water-based activities have great potential to enhance shear stress-mediated adaptation within the vasculature

Exercise (box-stepping @≤100 bpm) in water augments exercise-induced increases in **brain blood flow**.

Pugh et al. *MSSE* (2015)

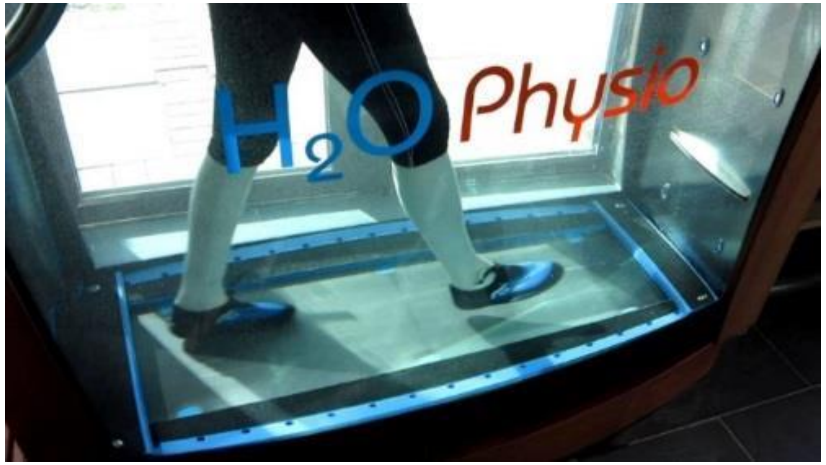


Aquatic treadmill exercise: Water-based walking

- Aquatic treadmills (ATM) provide an opportunity to assess the benefits of this form of exercise on vascular health, across range of exercise intensity.

Already evidence to show that:

- Allows for lower impact and increased resistance compared to land-based treadmills, thus decreased musculoskeletal loading of joints and provides potential for enhanced acute and chronic physiological adaptations (Barbosa *et al., J Sports Sci Med.* 2009).
- Mechanical unloading and bodyweight support useful in gait re-education for spinal cord injured and stroke patients, as well as for athletes recovering from injury.



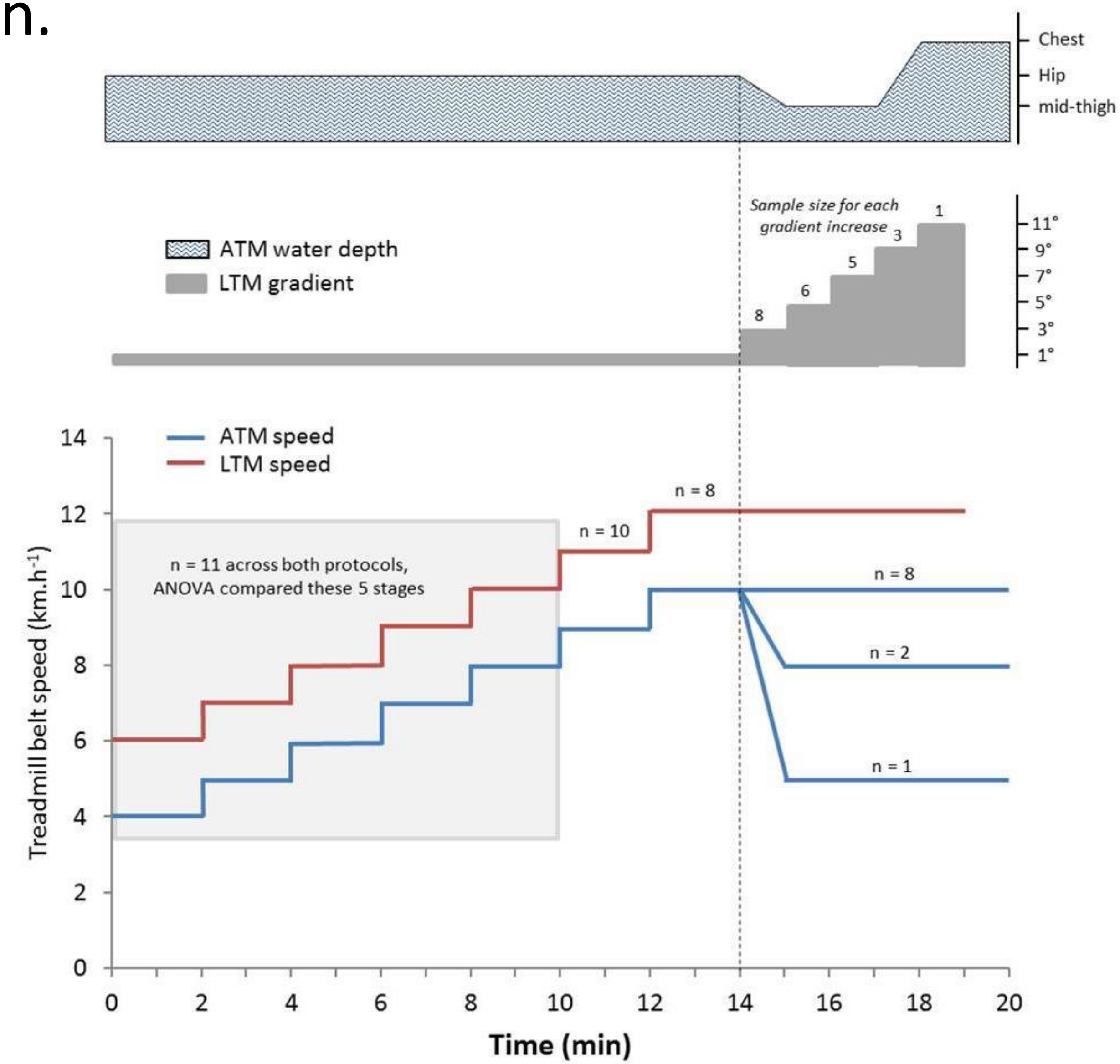
OptiSpine
Total back and joint care

Aim: To compare changes in CBF (velocity) and HR responses during an incremental exercise test using an ATM and an LTM, and examine CBF and HR responses at different levels of immersion.

Participants

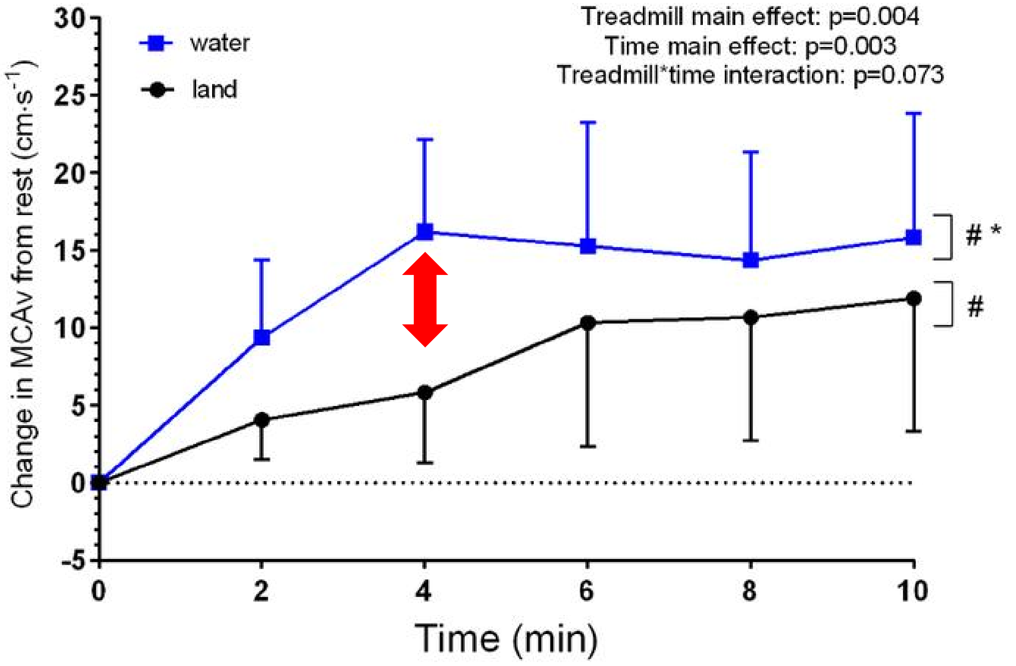
- 11 healthy adults
  - 7 females, 4 males; 27 ± 5 years

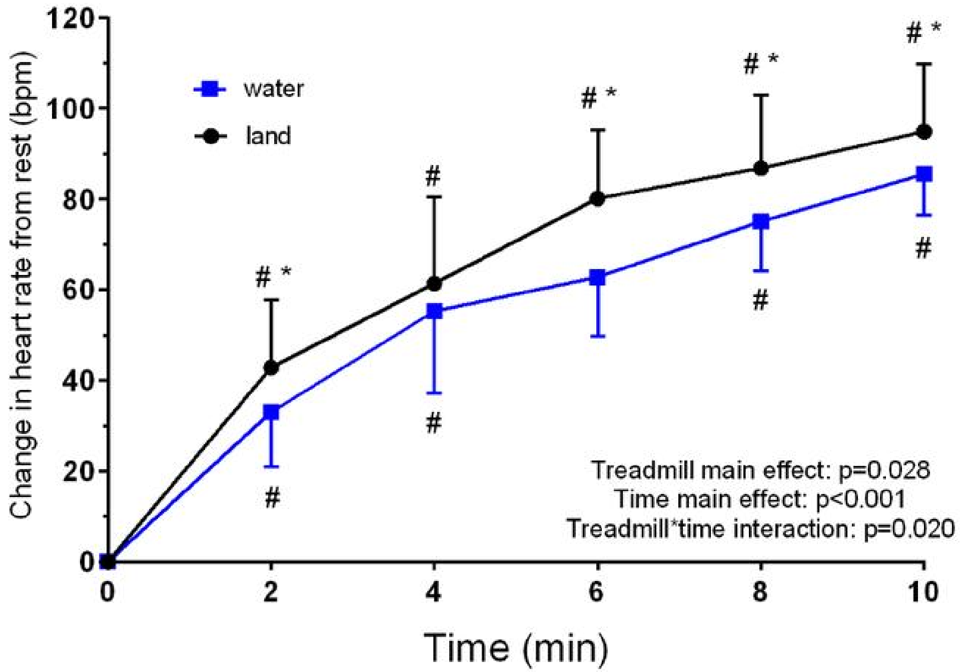
- Randomised, crossover study design.



Parfitt *et al*. MSSE. 2017; 49:1305-1312

Results

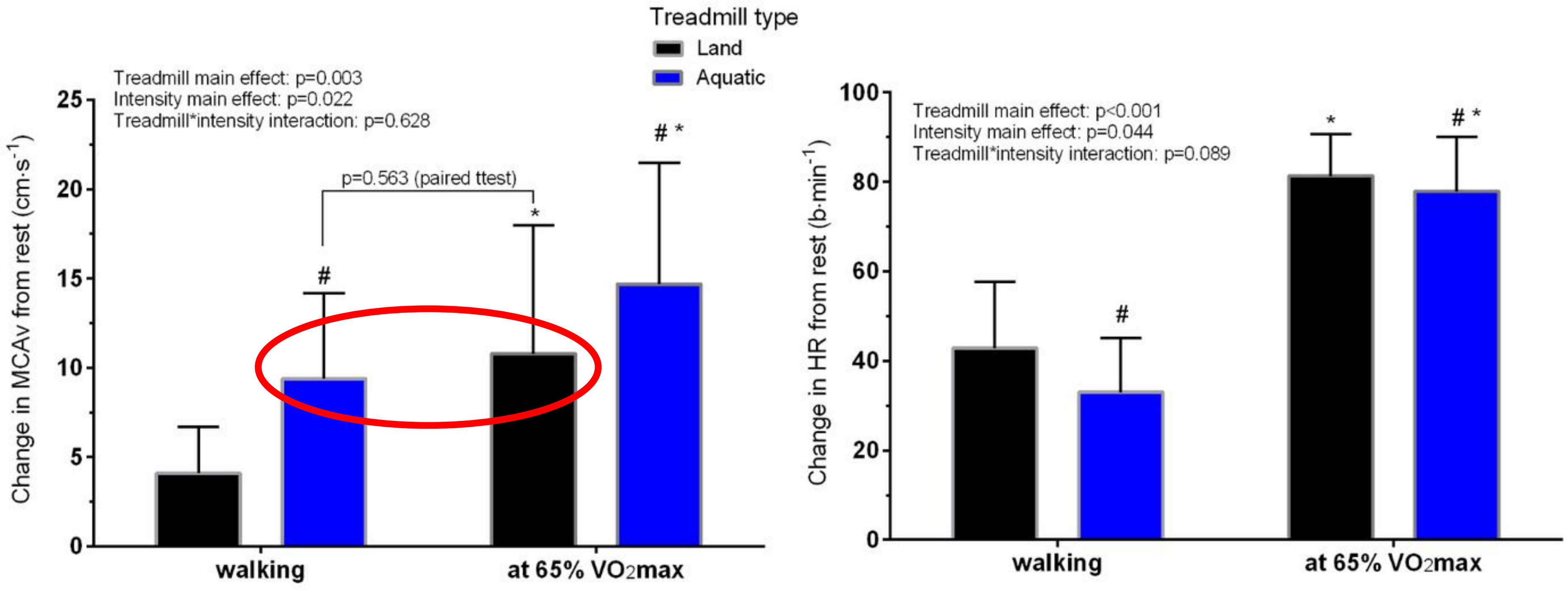




- MCAv peaked sooner (at 4-min stage) and remained higher for water treadmill exercise (peak change from baseline ~16 vs. ~12 cm·s^{-1})… (interaction effect: p=0.073)
- Difference at 4-min stage: ~11 cm·s^{-1} (pooled difference across 10 min: ~6 cm·s^{-1})
- Heart rate lower during water treadmill exercise (pooled difference: 11 bpm)

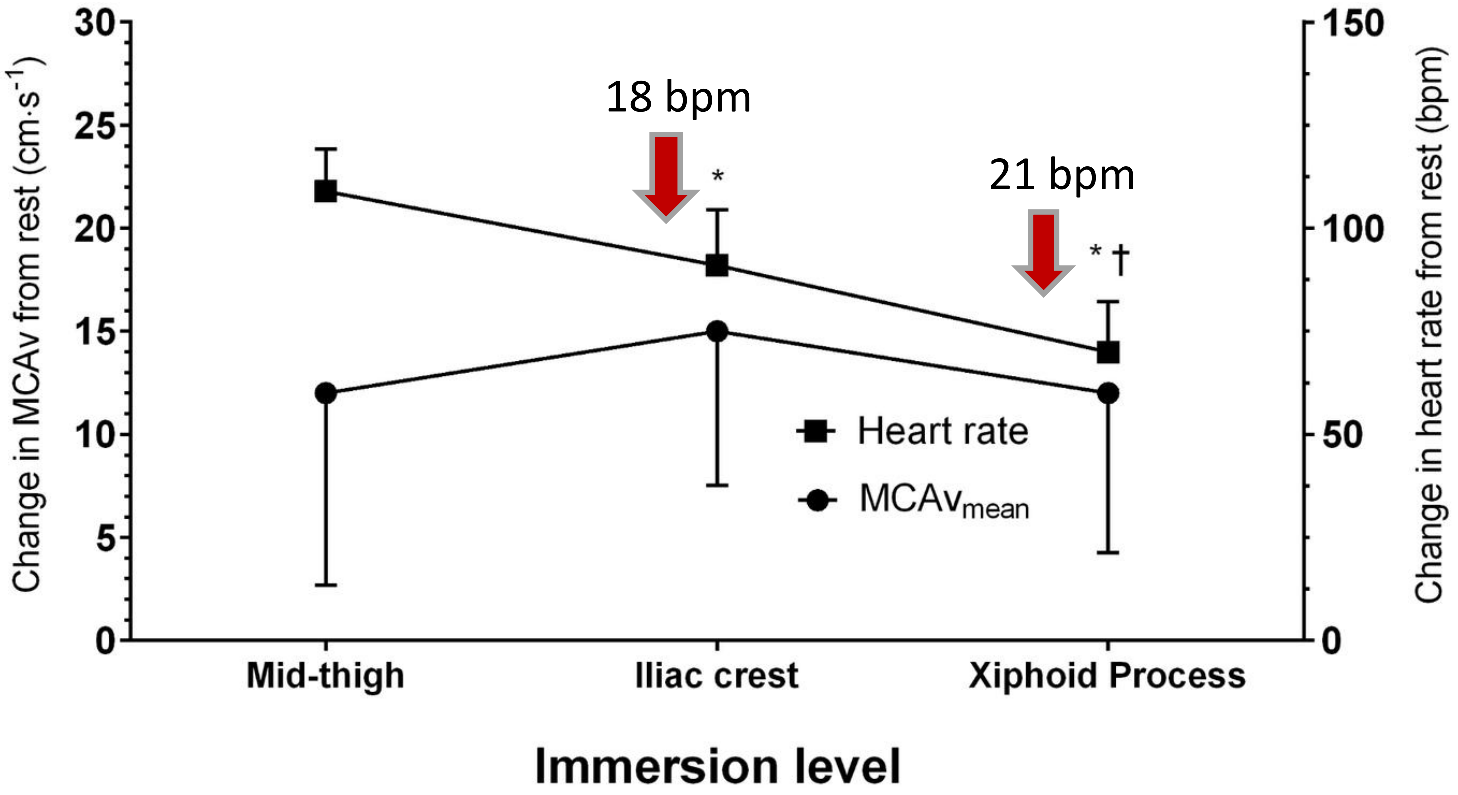
Parfitt *et al*. MSSE. 2017; 49:1305-1312

- Compared two exercise intensities:
  1) Walking (4 vs 6 km/h, for ATM and LTM respectively)
  2) Moderate exercise intensity (65% VO_2max) – estimated from HR
- Walking in water induces same increase in brain blood flow as running on land at traditionally recommended exercise intensity.
  - A more 'accessible' exercise intensity for clinical populations



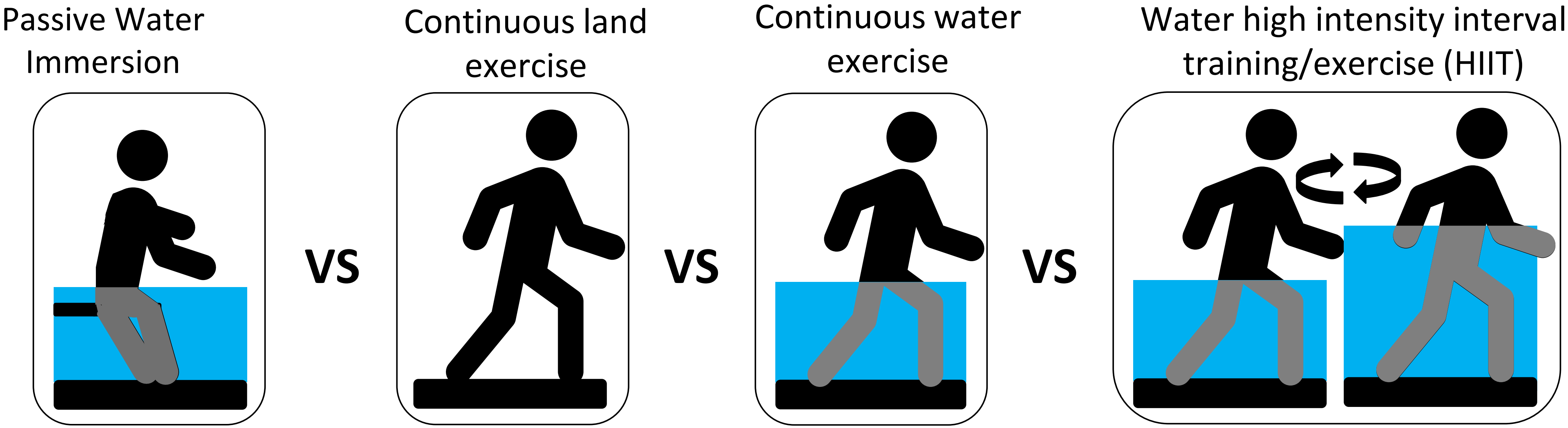
Effect of immersion level on CBF and HR responses

- HR decreased with greater levels of water immersion (at constant treadmill belt speed)
  - Mid-thigh water depth elicited near maximal HR (95 ± 5% of HR_{max})
- Exercise-induced increase in MCAv constant ($p=0.37$)



Pending study…

Could we manipulate the depth of water immersion within aquatic treadmill exercise, modify heart rate, and simulate periods of higher intensity interspersed with lower intensity (‘HIIT’)?



13:10-14:00 K2	Making Waves – The power of high-intensive (aquatic) exercise	Jens Bansi Switzerland

Key Conclusions

- Aquatic treadmill exercise augments cerebral blood velocity across a range of intensities for a relatively lower HR response, and **particularly so at lower exercise intensities** (i.e., walking/light jogging).
- This elevated blood velocity (*and flow*) has potential to enhance shear stress–mediated cerebrovascular adaptation and thus optimise exercise-induced adaptations linked with improved brain health.
- Therefore, aquatic treadmill exercise prevents as an ideal modality for those with reduced physical capacity (e.g. stroke survivors), where their reduced physical capacity limits the exercise-induced physiological strain necessary for stimulating adaptation.

😊 Consistent with findings of recent systematic review and meta-analyses examining (peripheral) vascular function

Dunlap E et al. (2025) Effects of aquatic exercise on arterial stiffness and endothelial function in adults: A systematic review and meta-analyses. PLoS One 20(12): e0338929.

AQUEOUS: Aquatic Exercise As An Optimal Exercise Strategy In Stroke Rehabilitation

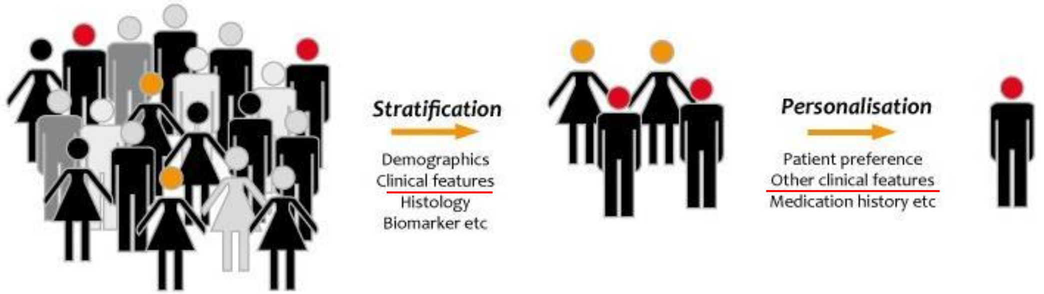
Current knowledge and clinical recommendation

- Regular exercise is a recommended strategy to improve physical function, fitness and quality of life after stroke, and to prevent subsequent strokes.

The problem

- Exercise guidelines for stroke survivors same as for the general population
  → **'one size fits all'** approach…
- Stroke-related loss of function and reduced physical fitness / muscle strength mean that **traditional exercise approaches (e.g. jogging) are not realistic for many stroke survivors living in the community with permanent disability.**
- Therefore, alternative approaches are needed to allow these patients to access the health benefits that exercise provides.

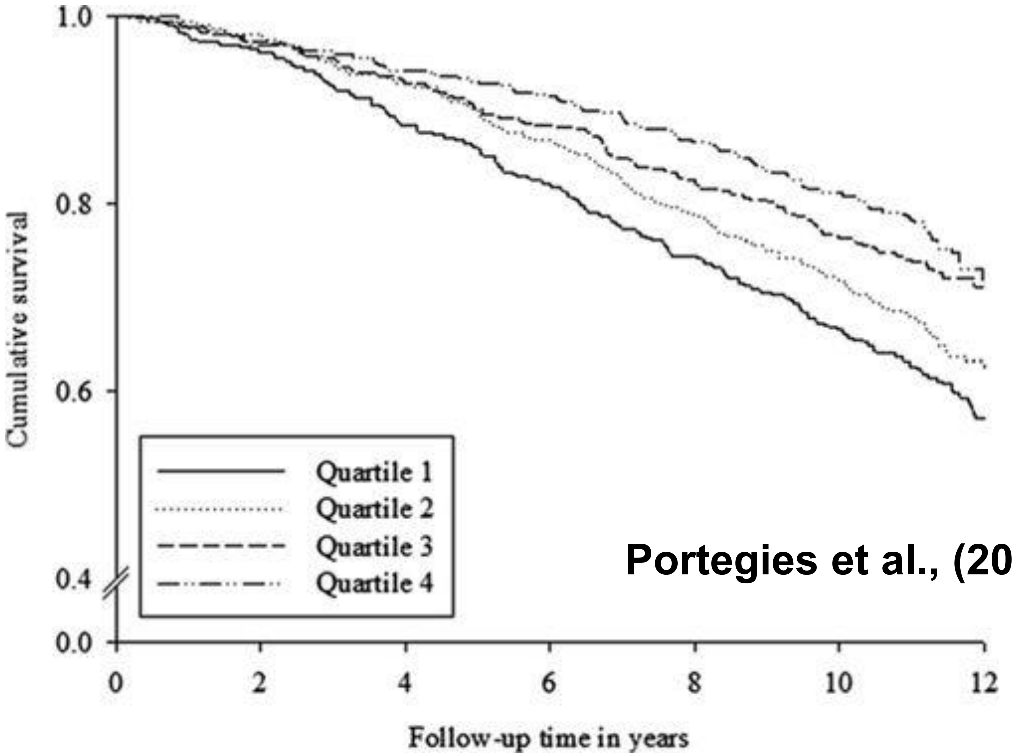
→ **Stratified/personalised approach**



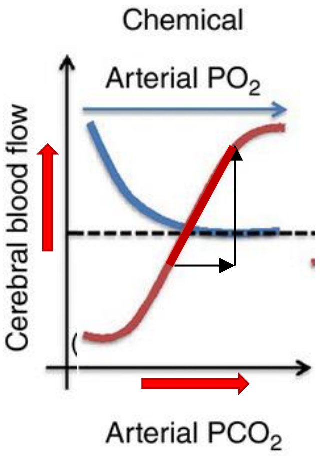
Pilot study assessing feasibility of aquatic-treadmill training in stroke survivors to affect changes in cerebrovascular responsiveness/reactivity

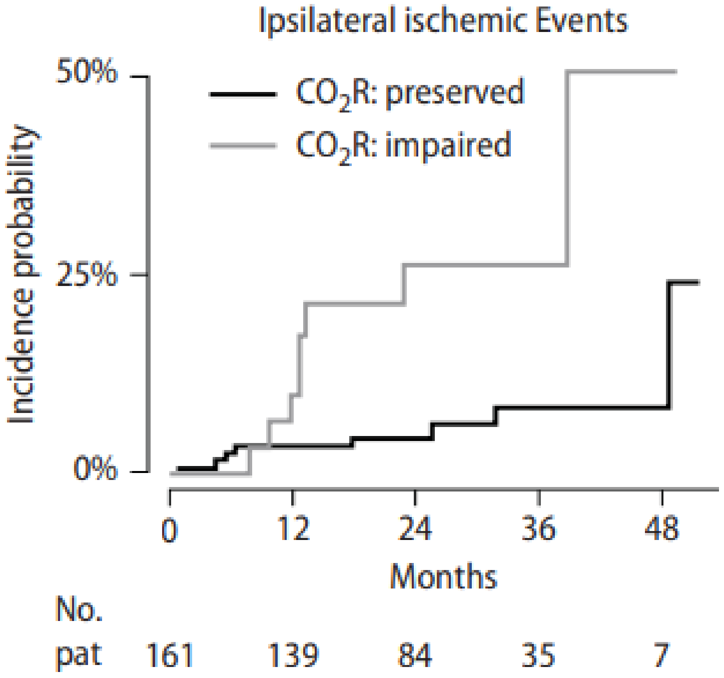
- Cerebrovascular CO_2 reactivity [CVR]) decreases with ageing and is impaired in clinical conditions such as stroke. (Guy et al, 1996; Kleiser et al, 1992; Markus and Cullinane, 2001)

- Impaired CVR associated with increased mortality/stroke risk (Portegies et al., 2014; Reinhard et al, 2008)



Portegies et al., (2014)





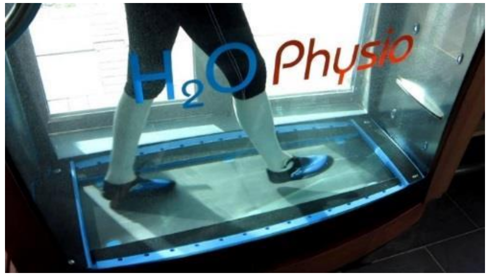
Reinhard et al, 2008

Pilot study assessing feasibility of aquatic-treadmill training in stroke survivors to affect changes in cerebrovascular responsiveness/reactivity

- Given the link between cerebral vascular reactivity and stroke risk, aquatic treadmill exercise may be an effective alternative approach to optimise the exercise stimulus for vascular adaptation and improve brain vascular health outcomes.

- **Primary aim:** Examine the feasibility of aquatic treadmill exercise to improve brain blood flow regulation in stroke survivors following a 4-week training intervention.

- **Secondary aim:** Assess changes in gait function, building upon previous work showing ATM exercise improves gait post stroke (Silvers et al, 2007).



Methods

Participants:

- 6 chronic stroke survivors (all >2 years post stroke)
  - 4 males, 2 females; 58 ± 11 years, 75.95kg ± 12.25kg, 174.5cm ± 12.5cm

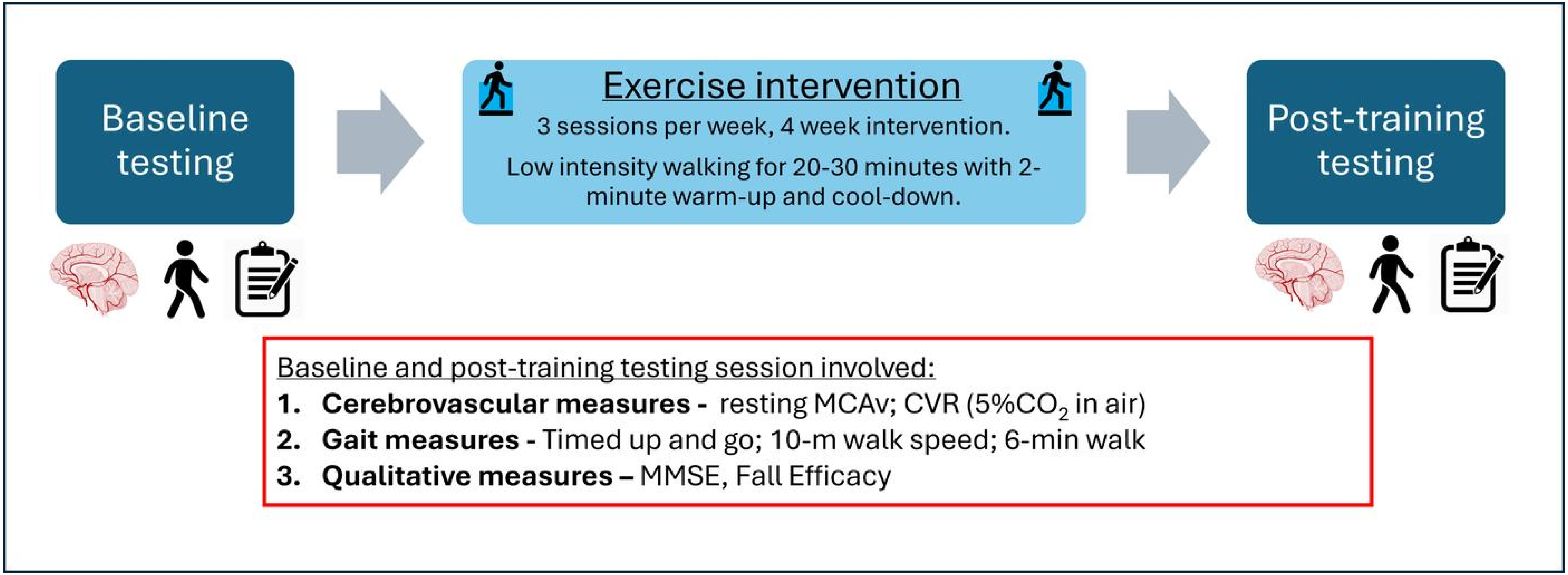
Inclusion criteria:

Medically stable

Able to walk with minimal assistance (Functional Ambulatory Category (FAC) >3); i.e. walk independently

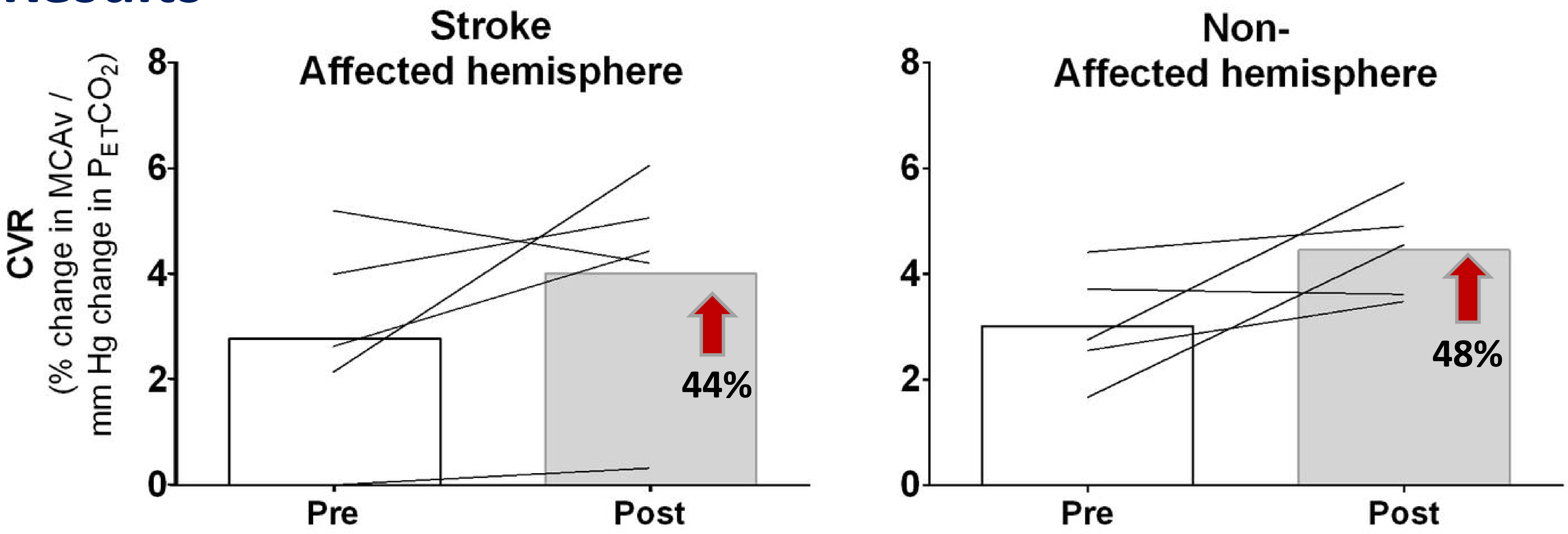
Participant ID	Age (years)	Weight (kg)	Height (cm)	Time since stroke (years)	Paretic Side	
A	51	76	177	14	R	
B	54	88.2	172	5	L	
C	64	80.8	156	14	R	
D	62	75.9	178	6	L	
E	33	72.3	187	8	R	
F	69	64	158.5	5	L	(no CVR measures)

Methods



Bevins RL, et al. (2026) Effect of aquatic-treadmill training on cerebrovascular function and gait in community-dwelling stroke survivors: a feasibility and preliminary efficacy study. Front. Sports Act. Living 7:1680250. doi: 10.3389/fspor.2025.1680250

Results

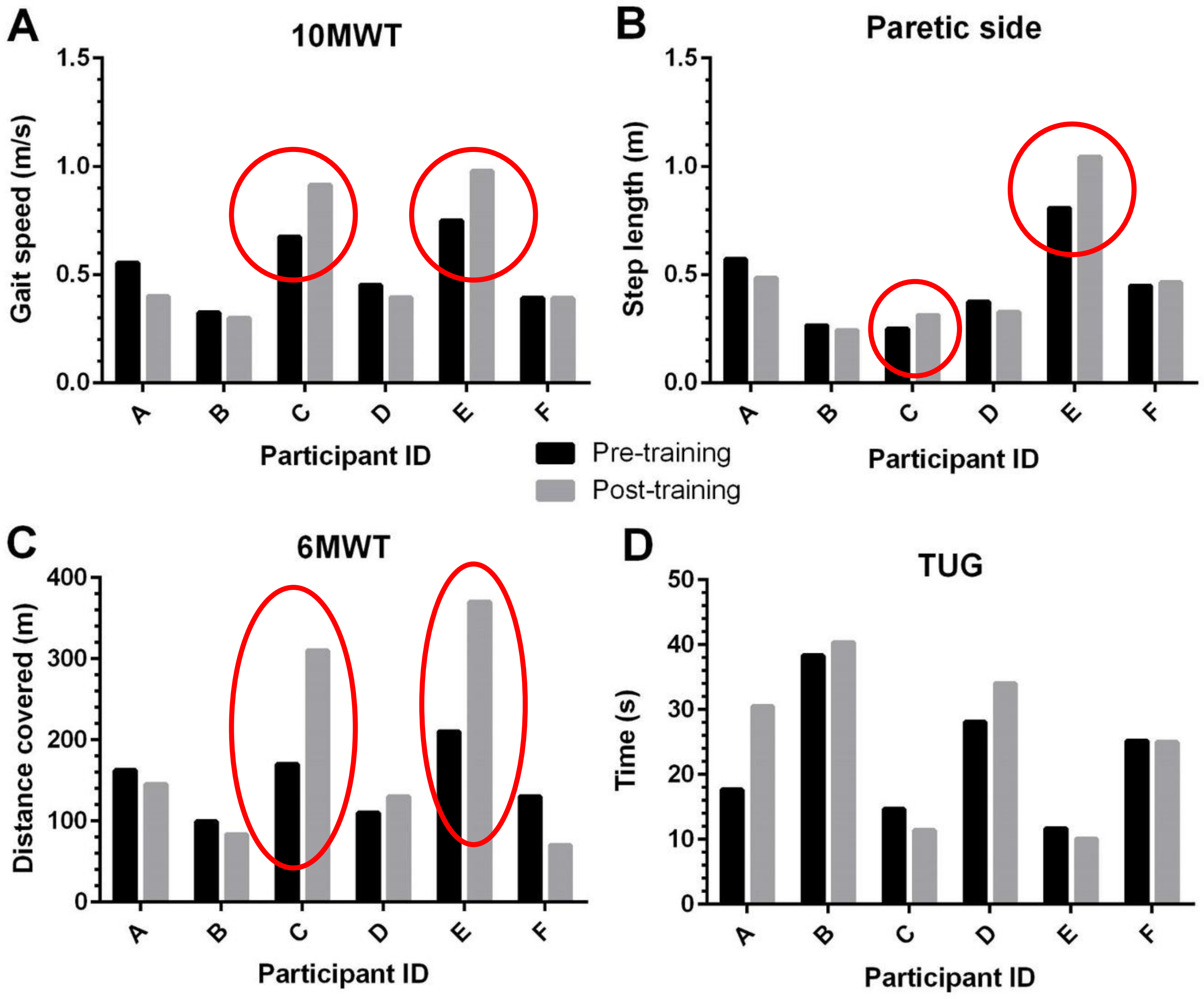


Key primary (vascular) finding:

- Big increase in brain vascular responsiveness
  - **~2x greater** than a traditional 6-month aerobic-based training programme

(Ivey *et al.*, 2011)

Secondary Outcomes: Gait



- Two participants increased 10-m walking speed by >0.15 $m \cdot s^{-1}$, exceeding the threshold for clinically meaningful change (0.10 $m \cdot s^{-1}$)
  - Participants C and E increased CVR by 185% / 110% and 28% / 11% (affected/non-affected sides)

- Training sessions were **enjoyable, well tolerated and no drop-outs.**

Bevins RL, et al. (2026) Front. Sports Act. Living 7:1680250. doi: 10.3389/fspor.2025.1680250

Summary

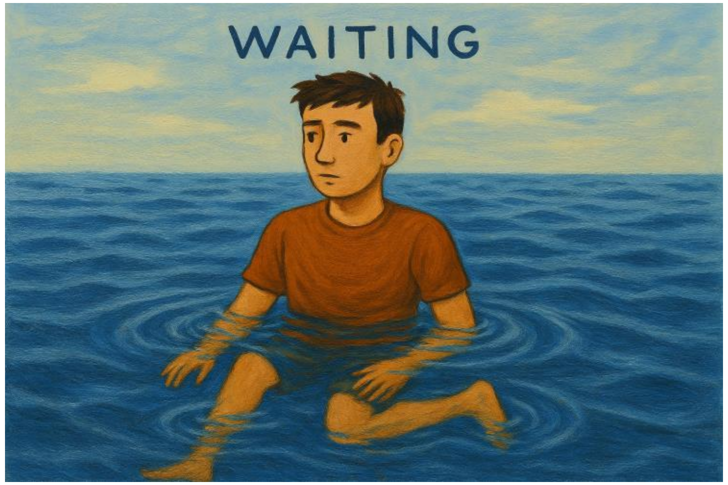
- This pilot study highlights that ATM training is an acceptable intervention for chronic stroke survivors, and is likely to positively affect brain health and gait function.
- The multi-factorial benefits may be key to its attractiveness / utility as a rehabilitation tool in this clinical cohort.

Future directions…

- Conduct the full trial to confirm these preliminary observations and with a more complete set of brain health vascular measures (incl. Doppler, MRI, NIRS)
- If there's utility in this approach, establish where best to work this exercise approach into the rehabilitation pathway for stroke…
  - Potential boost for mobility / walking ability to accelerate gaining independence?
  - When and how to use other water-based approaches with this cohort?

Our next (water) steps....

SCHOOL OF SPORT, EXERCISE AND REHABILITATION SCIENCES



Future work planned with Birmingham Community Healthcare Trust to explore feasibility of this as a service to support community-dwelling stroke survivors

- Student placement opportunity for Physiotherapy and Clinical Exercise Physiology programmes

Take home message...

1. Regular exercise/physical activity offsets age-related declines in brain blood flow.
2. Greater brain blood flow/perfusion linked to better brain function.
3. Exercise-induced changes in brain blood flow are dependent on the exercise modality and protocol used.
4. Water-based strategies target key mechanistic pathways linked to beneficial vascular changes.
5. Aquatic treadmill exercise can be used to enhance the physiological signal (or strain) to induce positive changes in brain vascular health.

Acknowledgements..

University of Birmingham

Post-Graduate Researchers

- **Dr Claire Burley – UNSW, Australia**
- Amelia Quirk
- Sophie Prosser
- Jacob Tenant
- **Dr Jack Feron**
- Rhodri Furlong
- Gabriella Imi
- **Dr Sam Weaver**
- Rory Sutherland
- Dr Beth Skinner
- **Rhodri Parfitt**
- **Dr Karen Thomas**

Collaborators

SportExR

- Prof Becky Lucas
- Dr Catarina Renderio
- Dr Tom Nightingale
- Dr Martin Whitham
- Dr Richard Elsworthy
- **Dr Rachel Bevins**
- Dr David Punt

- Prof Helen McGrettick, Institute of Inflammation and Ageing
- Prof Karen Mullinger, CHBH / SPMIC (Nottingham)
- Prof Katrien Segaert, CHBH

University of Otago, NZ

- **Prof Jim Cotter**
- **Dr Kate Thomas**
- Dr Olivia Faul
- Dr Ashley Akerman

Prof Patrice Brassard, Université Laval, Canada
Prof Damian Bailey, University of South Wales, UK
Prof Philip Ainslie, UBC Okanagan, Canada

Funding and Support Partners

- **Davinder Chatha, OptiSpine, Wolverhampton, UK**
- **SYSPAL Ltd, Cockshutt Lane, Broseley, TF12 5JA, England.**

Canada 2026
ICEBAT
GLOBAL TRENDS IN AQUATIC THERAPY

Surfing Clinical Reasoning in Aquatic Therapy in ASD

From Regulation to Participation

A 5-stage journey through evidence and practice

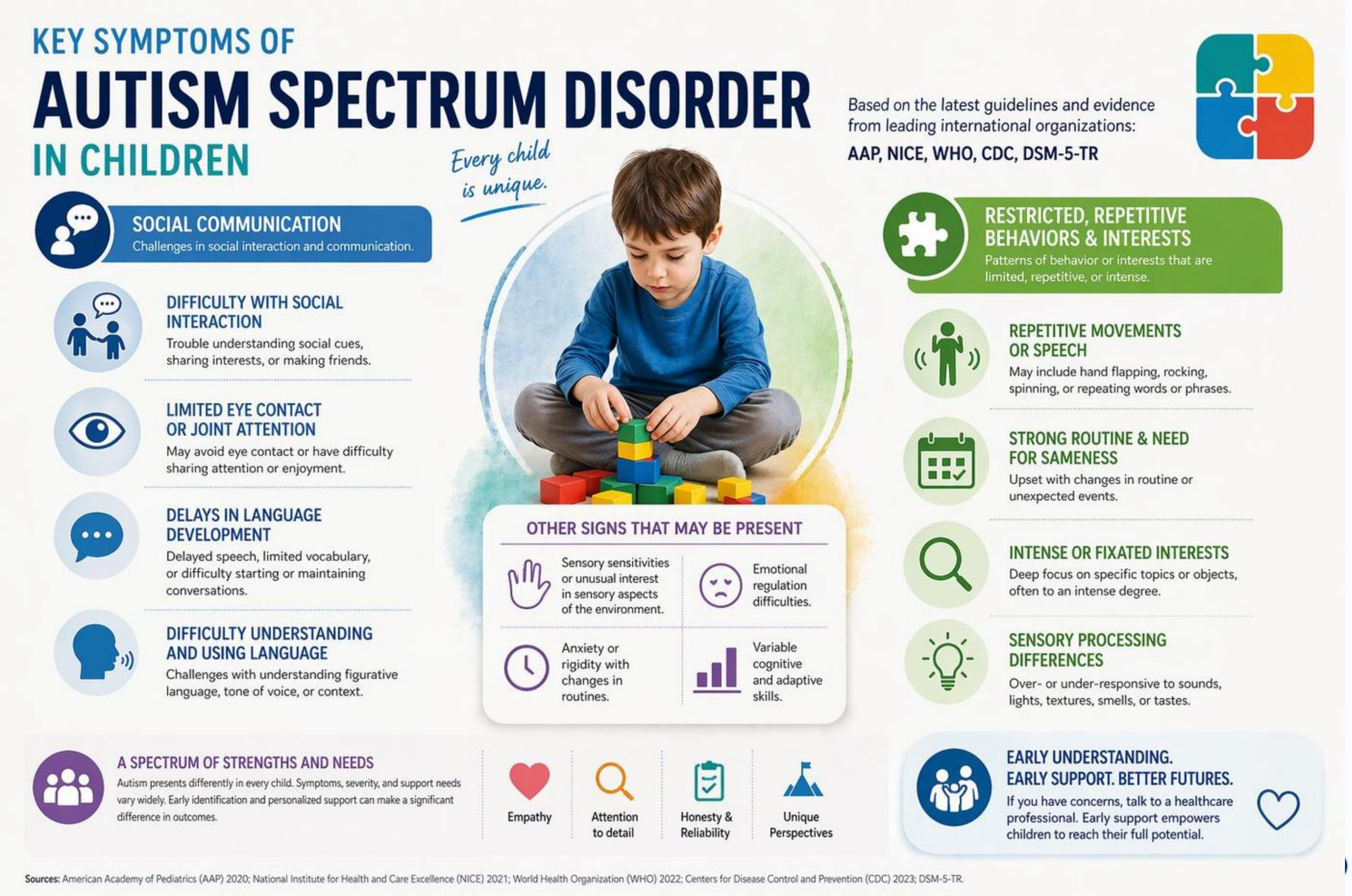
javier.gueita@urjc.es
javier.gueita@gmail.com

Javier Güeita-Rodríguez
IATF water specific therapy lecturer. Valens. CH
Rey Juan Carlos University, Madrid. Spain


Before we dive in...
MY BACKGROUND
The experience that has shaped me
I WORK IN SWIMMING POOLS
25 years ago
Experience in dynamic environments, focused on service, safety and teamwork.
REY JUAN CARLOS UNIVERSITY
MADRID, SPAIN
My base, my city, my starting point.
MADRID


INACU

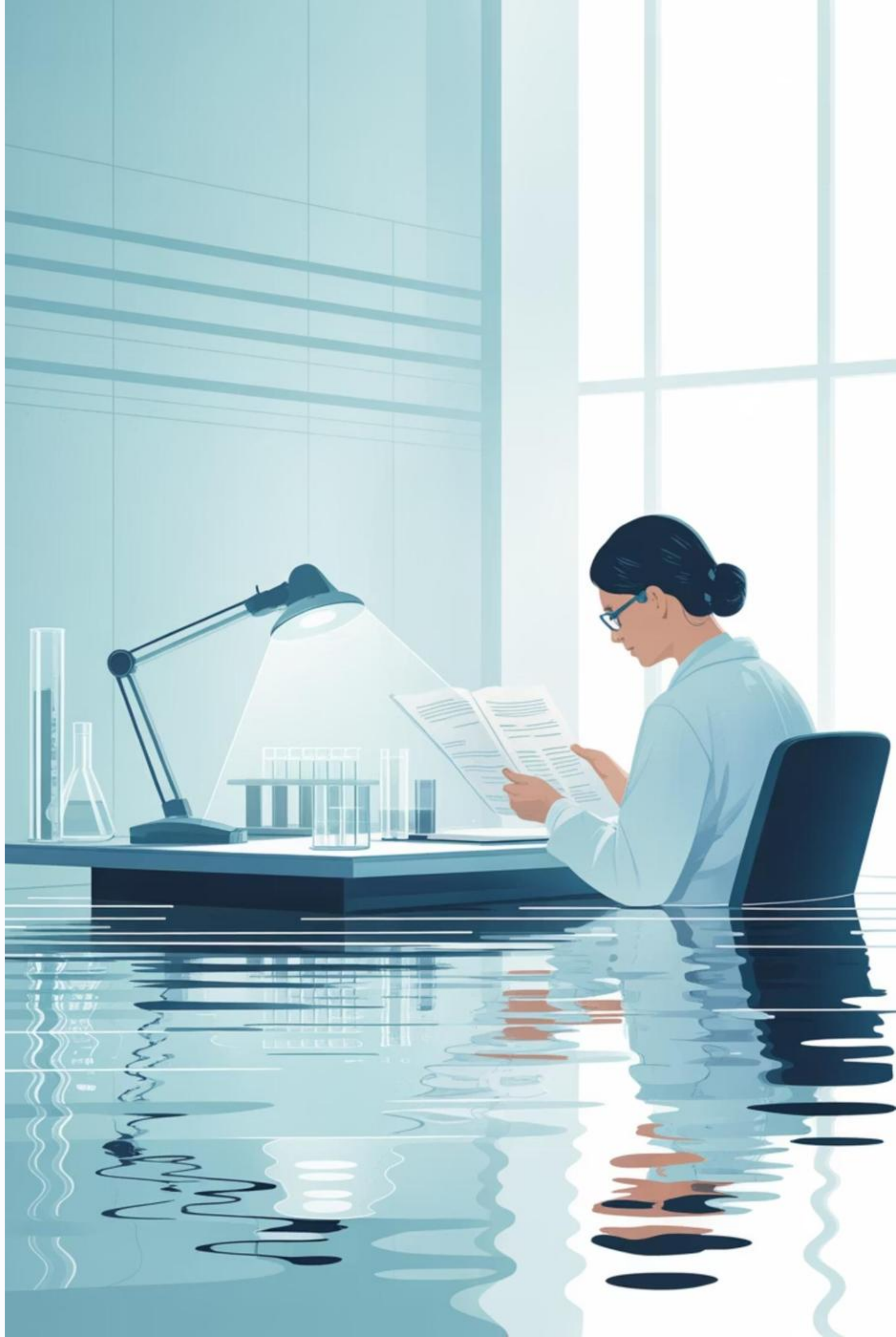

Universidad Rey Juan Carlos


KEY SYMPTOMS OF
AUTISM SPECTRUM DISORDER
IN CHILDREN
Every child is unique.
Based on the latest guidelines and evidence from leading international organizations:
AAP, NICE, WHO, CDC, DSM-5-TR
SOCIAL COMMUNICATION
Challenges in social interaction and communication.
DIFFICULTY WITH SOCIAL INTERACTION
Trouble understanding social cues, sharing interests, or making friends.
LIMITED EYE CONTACT OR JOINT ATTENTION
May avoid eye contact or have difficulty sharing attention or enjoyment.
DELAYS IN LANGUAGE DEVELOPMENT
Delayed speech, limited vocabulary, or difficulty starting or maintaining conversations.
DIFFICULTY UNDERSTANDING AND USING LANGUAGE
Challenges with understanding figurative language, tone of voice, or context.
OTHER SIGNS THAT MAY BE PRESENT
Sensory sensitivities or unusual interest in sensory aspects of the environment.
Emotional regulation difficulties.
Anxiety or rigidity with changes in routines.
Variable cognitive and adaptive skills.
RESTRICTED, REPETITIVE BEHAVIORS & INTERESTS
Patterns of behavior or interests that are limited, repetitive, or intense.
REPETITIVE MOVEMENTS OR SPEECH
May include hand flapping, rocking, spinning, or repeating words or phrases.
STRONG ROUTINE & NEED FOR SAMENESS
Upset with changes in routine or unexpected events.
INTENSE OR FIXATED INTERESTS
Deep focus on specific topics or objects, often to an intense degree.
SENSORY PROCESSING DIFFERENCES
Over- or under-responsive to sounds, lights, textures, smells, or tastes.
A SPECTRUM OF STRENGTHS AND NEEDS
Autism presents differently in every child. Symptoms, severity, and support needs vary widely. Early identification and personalized support can make a significant difference in outcomes.
Empathy
Attention to detail
Honesty & Reliability
Unique Perspectives
EARLY UNDERSTANDING. EARLY SUPPORT. BETTER FUTURES.
If you have concerns, talk to a healthcare professional. Early support empowers children to reach their full potential.
Sources: American Academy of Pediatrics (AAP) 2020; National Institute for Health and Care Excellence (NICE) 2021; World Health Organization (WHO) 2022; Centers for Disease Control and Prevention (CDC) 2023; DSM-5-TR.

Why This Matters

THE TRANSLATIONAL GAP

Research tells us **what** improves in aquatic therapy for ASD. Clinical reasoning tells us **how** and **why** it improves. Without a unified reasoning map, practice remains **SUBMERGED** (variable, inconsistent, and disconnected) from the evidence base…. **SO WE HAVE TO SURF IT**



Water properties have been leveraged **to address the core and co-occurring** symptoms of Autism Spectrum Disorder (ASD).

However, as the field has matured, there **has been a significant shift** in how clinicians and researchers conceptualize aquatic therapy.

Aquatic interventions for children with ASD have evolved from simple recreational activities into a specialized field of therapeutic practice.

This evolution is not an accumulation of techniques, but **a transformation in clinical reasoning.**

Existing systematic reviews, such as those by **Mortimer et al. (2014) and Van ’t Hooft et al. (2024)**, have provided critical evidence-based aggregations of intervention efficacy and effect sizes

Synthesizing

the **reasoning embedded in the literature itself**

not synthesizing intervention techniques, nor clinicians' real-time decisions

Key Insight: Research articles routinely articulate *why* an intervention is used, what change is expected, and how that change is hypothesized to occur. Together, these constitute **documented clinical reasoning within the literature**.

Therapeutic Intent

Sensory regulation, motor learning, participation goals

Outcome Variables

The measurable endpoints chosen to reflect intended change

Mechanisms of Change

Hypothesized pathways linking intervention to outcome

Why This Synthesis Matters

The field of aquatic therapy for ASD is characterized by **fragmented rationales** and techniques that remain largely **disconnected from shared theory**. A systematic organization of embedded reasoning is overdue.

1

Taxonomy of Rationales

A structured classification of therapeutic reasoning types across published aquatic therapy studies

2

Historical Map

A chronological account of how intervention goals and theoretical frameworks have evolved in the literature

3

Research-Practice Bridge

A link between research constructs and the clinical decision-making frameworks practitioners apply

The contribution is **not adding new reasoning** … it is **organizing the reasoning already embedded in the literature** into a coherent, usable structure.

Why Aquatic Clinical Reasoning Matters

Fragmented Evidence

Four decades of aquatic ASD research remain siloed inconsistent protocols lead to variable clinical outcomes across settings.

Align Goals & Outcomes

Clinicians need a reasoning framework that connects therapeutic goals, aquatic mechanisms, and measurable functional outcomes.

Beyond Exposure

Effective practice moves from simple water exposure toward deliberate multisystem integration (**sensory, motor, social, and cognitive)**

The Translational Gap

Aquatic interventions for children with ASD have evolved over **four decades** from simple recreation to specialized therapy leveraging buoyancy, hydrostatic pressure, and viscosity as a multisensory "lab."

Yet the evidence base remains **fragmented**. Existing reviews focus on *what* outcomes are achieved, not the *how* and *why* of therapeutic decision-making. This review presents a **novel five-stage framework** of aquatic clinical reasoning to bridge that gap.

FOUNDATIONAL SCIENCE

Mechanisms: Physics to Physiology

→ **Water Calms the System**

Thermal and tactile input modulates arousal, reducing sympathetic activation.

→ **Buoyancy Reduces Fear**

Unweighting the body lowers the perceived threat of movement — courage becomes accessible.

→ **Trust Emerges**

Repeated safe exposures in a predictable environment allow the therapeutic relationship to take root.

Buoyancy

Reduces axial loading, enabling movement in individuals with low tone or motor-planning deficits.

Hydrostatic Pressure

Provides uniform proprioceptive and vestibular input, modulating sensory reactivity.

Viscosity & Drag

Offers graded resistance that scales naturally with movement speed and effort.

Thermoneutral Warmth

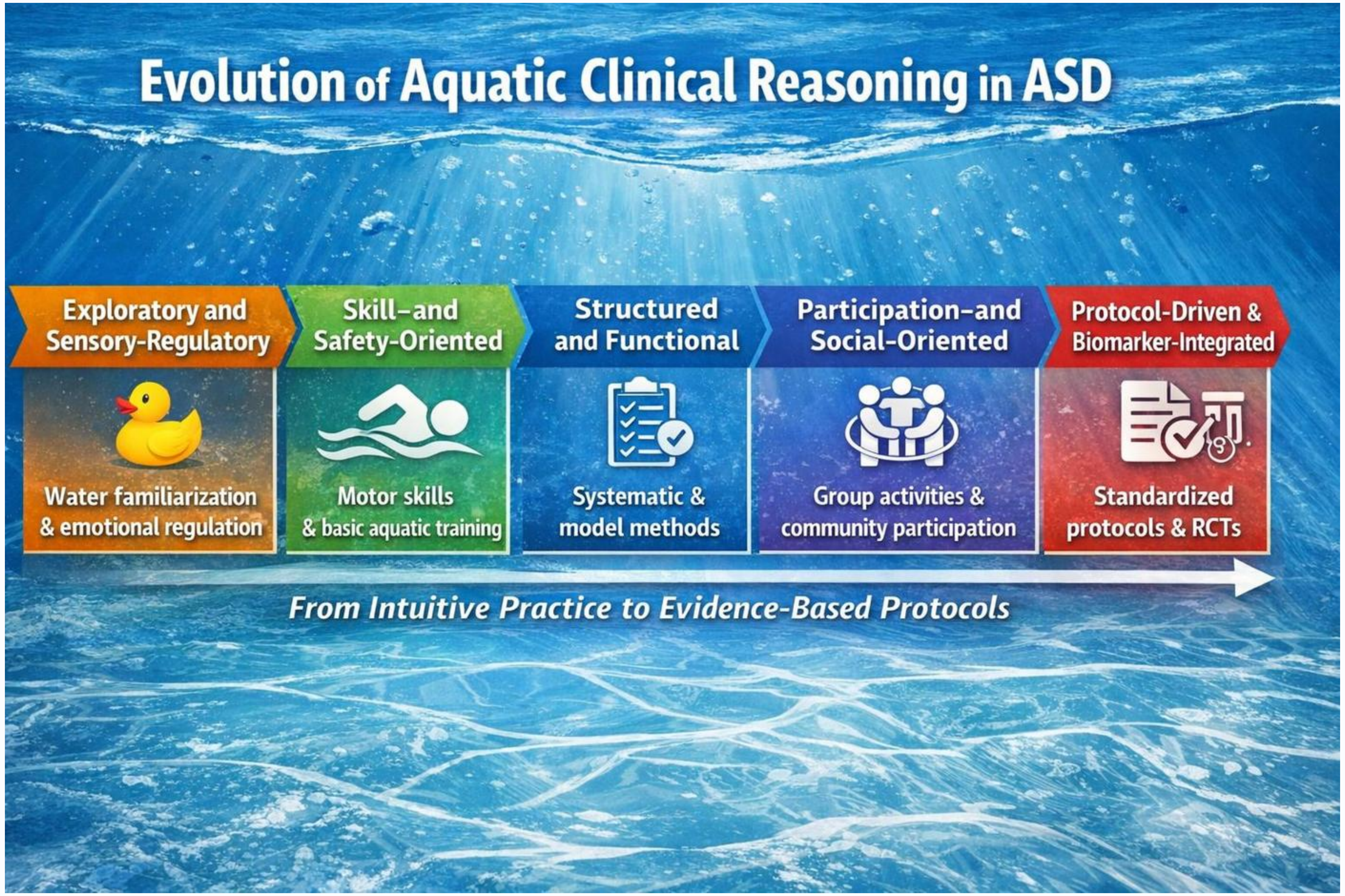
Promotes parasympathetic engagement, an autonomic downshift that supports calm alertness.

1984 – 2025

Evolution of Aquatic Clinical Reasoning

Aquatic reasoning for ASD has progressed through five distinct stages. **From exploratory sensory work to biomarker-integrated protocols.**

1. Stage 1
   Exploratory & Sensory-Regulatory
2. Stage 2
   Skill& Safety-Oriented
3. Stage 3
   Structured Methods & Functional
4. Stage 4
   Participation & Social-Oriented
5. Stage 5
   Protocols & Biomarker-Integrated



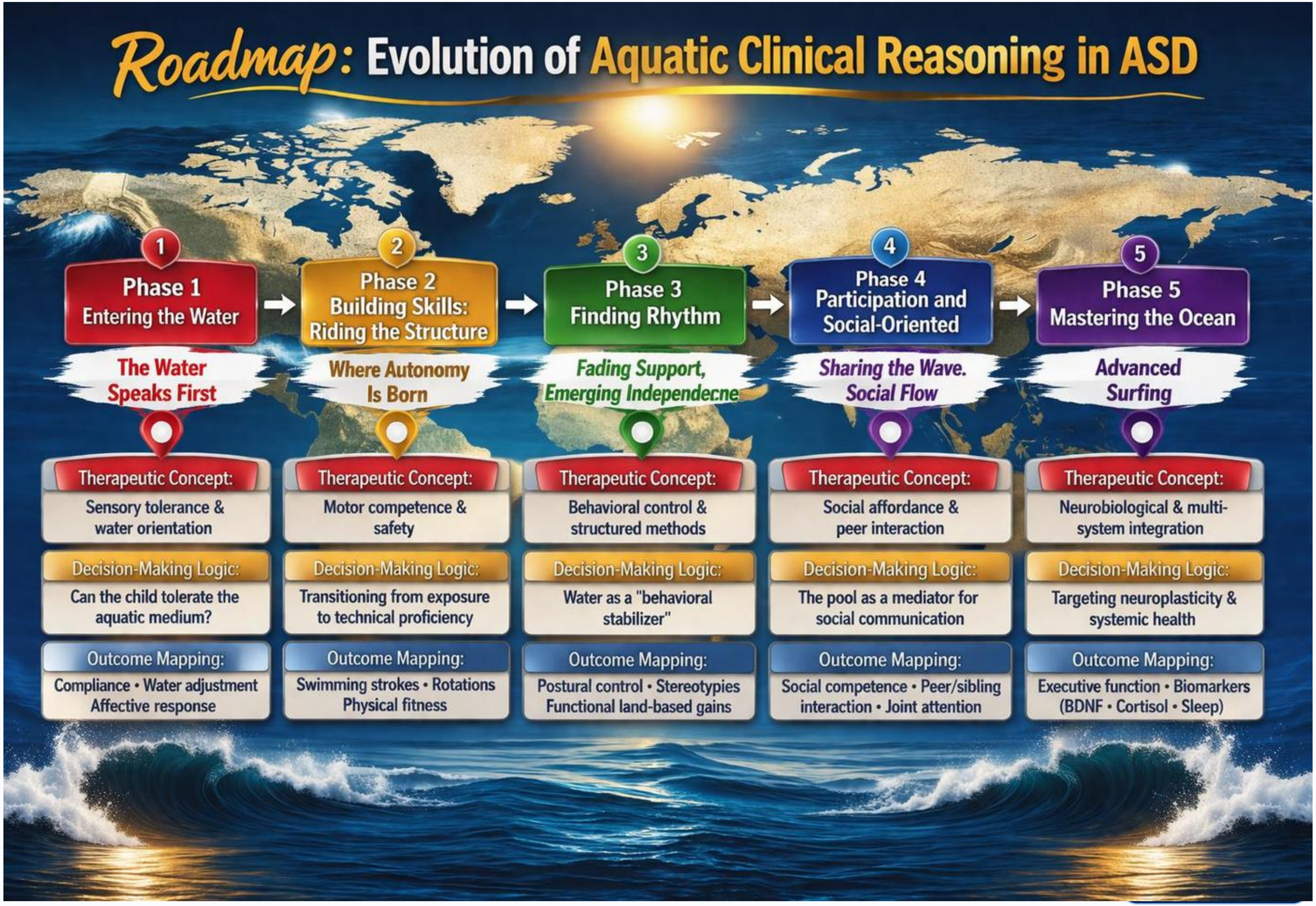
1 Stage 1
Exploratory & Sensory-Regulatory

2 Stage 2
Skill& Safety-Oriented

3 Stage 3
Structured Methods & Functional

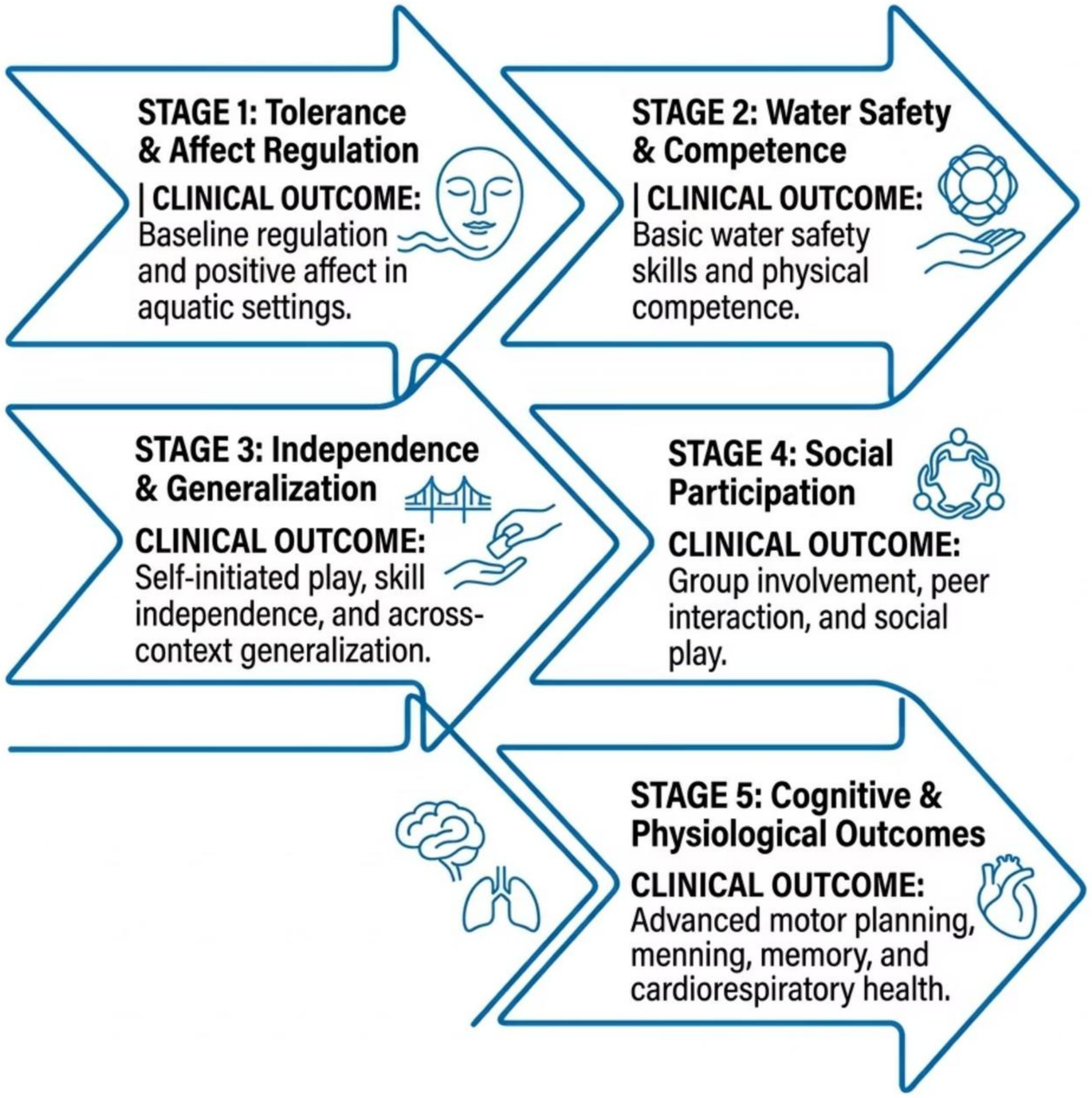
4 Stage 4
Participation & Social-Oriented

5 Stage 5
Protocols & Biomarker-Integrated



Outcome Mapping

MATCH STAGE TO OUTCOME



Each stage carries its own outcome logic. **Mixing outcomes across stages** (applying Stage 4 social metrics to a Stage 1 sensory regulation protocol, for example) undermines the validity of both the intervention rationale and the evaluation framework.

Clinical Principle: Outcome selection is not a post-hoc decision. It must be fixed to the stage-specific therapeutic intent from the outset of intervention design.

STAGE 1

1980s – mid-1990s

Exploratory & Sensory-Regulatory

Goal

Achieve **calm alertness** and water tolerance through graded sensory exposure.

Format

1:1 therapist-to-child ratio with carefully graded immersion depth and duration.

Outcomes

Compliance with entry routines, reduced distress responses, and successful water adjustment. **Engagement**, **sensory tolerance**, and **behavioral compliance**

Core Question

"Can the child tolerate the aquatic medium?"

Key refs: Killian et al. (1984); Dorval et al. (1996)

STAGE 2 *mid-1990s-2010*

Skill & Safety-Oriented

Goal

Build aquatic competencies and reduce drowning risk (a critical safety concern for the ASD population).

Methods

Task analysis, systematic repetition, and criterion-referenced skill ladders to track mastery.

Formats

1:1 or 1:2 ratios; evidence suggests intensive blocks accelerate skill acquisition over distributed sessions.

STAGE 3

2010-2015

Structured Methods & Functional Goals

1

Acquisition → Generalization → Independence

Skills are taught, practiced in varied contexts, and faded toward autonomous performance.

2

Evidence-Based Supports

Visual schedules, prompt hierarchies, and Halliwick elements structure each session with predictability.

3

Hybrid 1:1-in-Group

Individual rigor is maintained while introducing social exposure — blending fidelity with real-world context.

WEEK-END DE PERFECTIONNEMENT

Halliwick et trouble du spectre autistique : un programme d'apprentissage pédagogique.

Nov 2013 Geneva (CH)

Halliwick in Autism Spectrum Disorder: A Pedagogical Learning Programme.

Javier Güeita Rodriguez, PT, MSc. Aquatic Therapy Lecturer in Association IATF (International Aquatic Therapy Faculty). Lecturer at the Universidad Rey Juan Carlos.

STAGE 4

2015-2020

Participation & Social -Oriented

The aquatic environment offers a uniquely **low-pressure social context**-shared physical experience creates natural opportunities for peer interaction without the full cognitive and emotional demands of unstructured social settings.

Goal

Foster **peer interaction**, joint attention, and role-taking within aquatic group settings.

Methods

Cooperative aquatic games embedded in predictable, structured frames that reduce anxiety and support engagement.

Dose

Minimum **≥8 weeks** of consistent sessions, with booster blocks recommended for successful community transfer.

STAGE 5 *2020-2026*

Protocols & Biomarker-Integrated

Key refs: Ansari et al. (2021); Zhao et al. (2024); Kemp et al. (2024)

Hypothesis-Driven Outcomes

Each intervention decision is framed as a testable clinical hypothesis, with outcome data informing next-session modifications and cross-stage adjustments.

Holistic, Evidence-Based Paradigm

Aquatic intervention is now conceptualized as a **catalyst for neuroplasticity** and long-term functional participation.

Biomarkers

BDNF, cortisol, sleep architecture

Multi-Domain Outcomes

Outcomes across **sensory-motor, behavioral, social,** and **biomarker** domains- building the comprehensive evidence base for aquatic intervention in pediatric rehabilitation.

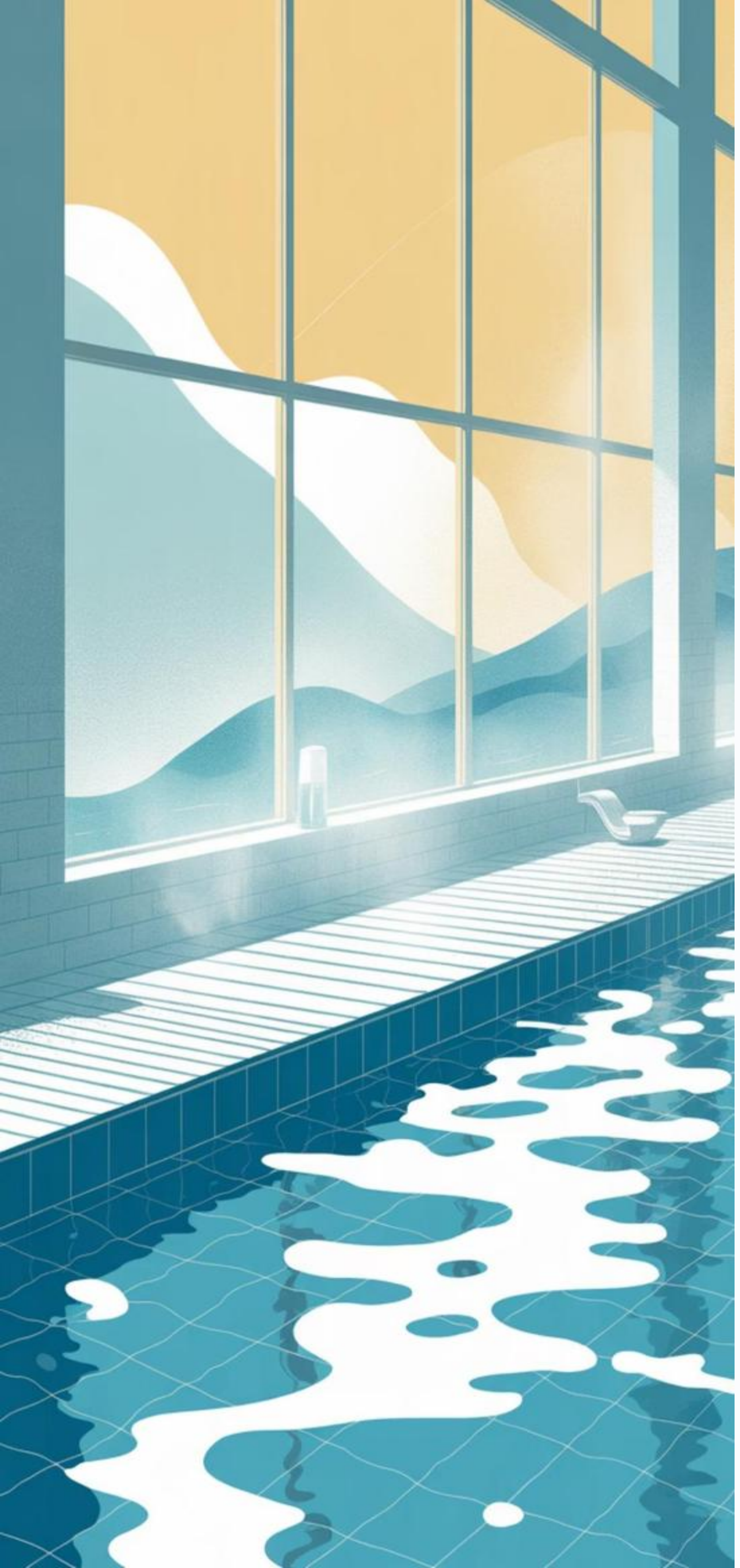
Dynamic Shifting

Reverting to sensory-regulatory strategies during dysregulation

EVIDENCE SUMMARY

Stage Goals, Tactics, Dosage & Results

Stage	Primary Goals	Tactics & Format	Dose	Results
1. **Sensory**	Calm alertness; tolerance	1:1 graded immersion; short regulatory loops	1×/week	Reduced internalizing (CBCL)
2. **Skills**	Water orientation; safety skills	Buddy + instructor; criterion ladders	Daily ×5 blocks	Improved swim level
3. **Structured**	Acquisition & generalization	Visual schedule; fading prompts	1×/wk ≥8 wks	Social competence gains
4. **Social**	Group participation; turns	Role-based aquatic games; first–then	1×/wk ≥8 wks	Increased interaction
5. **Protocols**	Fidelity; standardized outcomes	Component checklists; dose logs	Weekly or intensive	RCT-level evidence



Clinical Architecture

Architecture of an Aquatic Therapy Session

From Regulation → Adaptation (Format → Dose → Results)

REGULATION	SKILLS	STRUCTURE	SOCIAL	ADAPTATION
1:1 immersion Low dose Calm alertness	Task repetition High intensity Motor learning	Schedules Distributed Generalization	Group tasks Repeated Interaction	Dynamic rules Flexible Adaptability

Increasing Complexity & Integration →

Recommended Dose: Weekly sessions × ≥8 weeks, or intensive camp formats with concentrated daily sessions for accelerated skill acquisition.

Clinical Take-Home Messages 🌊

1. **Stage defines strategy**

   Clinical decisions …goals, structure, cues, and progressions … must align with the client's current stage of aquatic reasoning.

2. **Structure enables progress**

   Predictable environments support regulation, learning, and generalization in individuals with ASD.

3. **Outcomes must match the stage**

   Evaluating social participation in a sensory-regulatory stage is both clinically misleading and analytically invalid.

4. **The pool is a multisystem therapeutic space**

   Aquatic environments simultaneously engage sensory, motor, cognitive, and social domains.

5. **Reasoning bridges research and practice**

   This synthesis is a tool for translating documented evidence into principled clinical action.

Conclusions

Surf the Process, Not Just the Outcome

> Clinical reasoning is not a checklist. It is a living, dynamic practice that evolves with every child, every session, and every wave you ride together.

Every Child

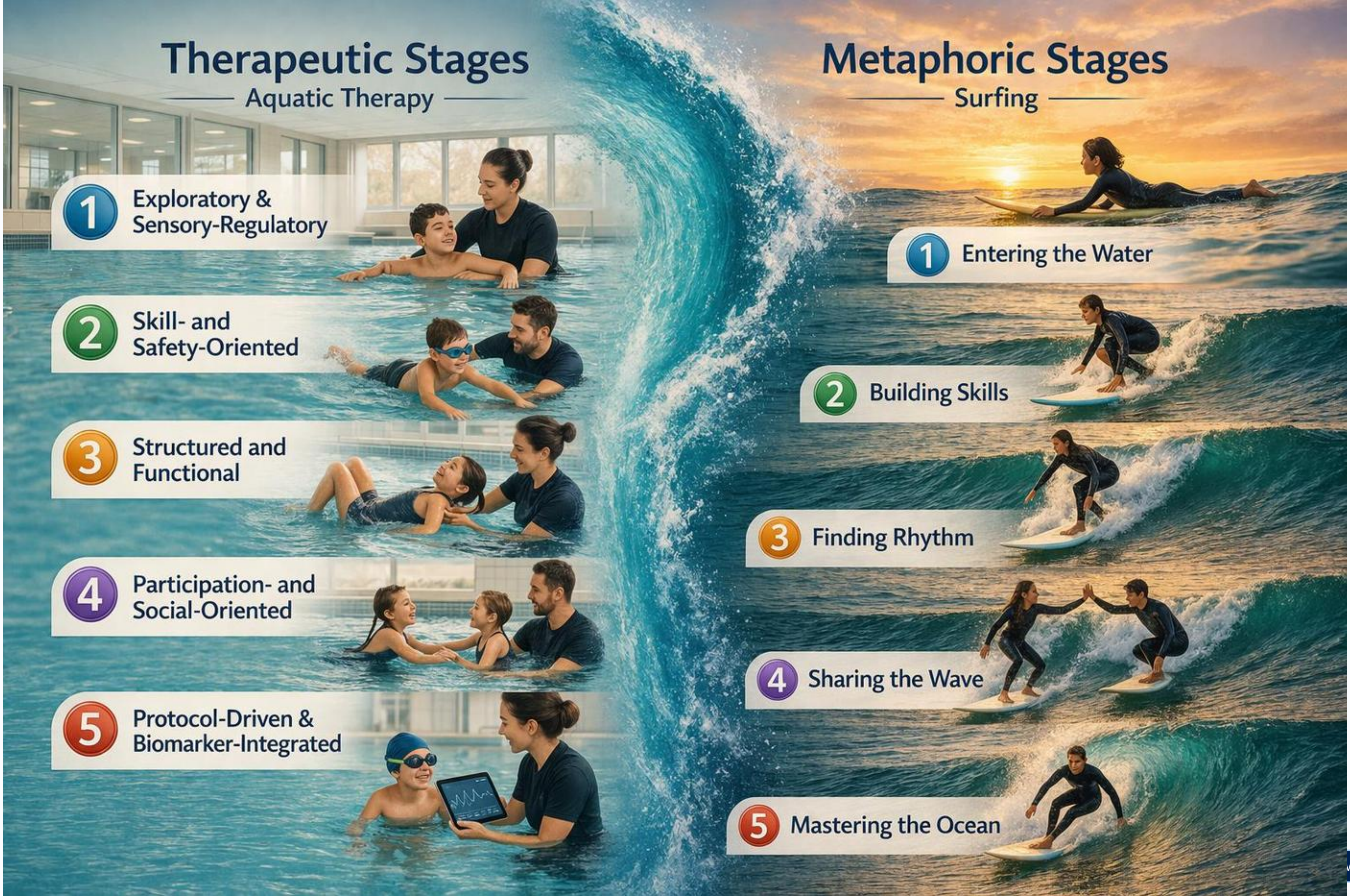
Bring full presence and individuation to each young person you serve

Every Session

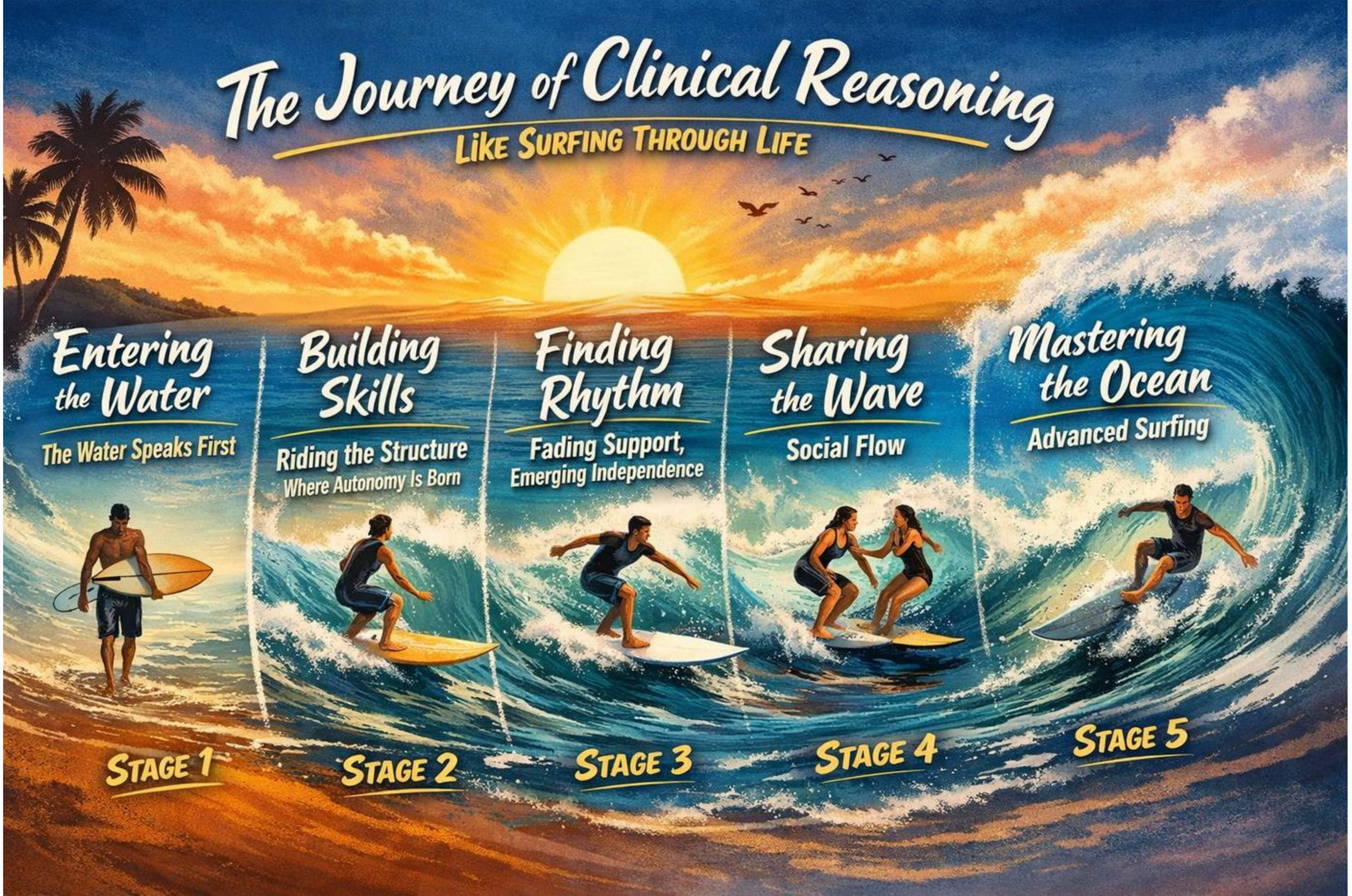
Each encounter is a fresh opportunity to read, respond, and refine your approach

Every Wave

Trust the process. The momentum builds when you stay curious, flexible, and grounded in evidence



Therapeutic Stages
Aquatic Therapy
1 Exploratory & Sensory-Regulatory
2 Skill- and Safety-Oriented
3 Structured and Functional
4 Participation- and Social-Oriented
5 Protocol-Driven & Biomarker-Integrated
Metaphoric Stages
Surfing
1 Entering the Water
2 Building Skills
3 Finding Rhythm
4 Sharing the Wave
5 Mastering the Ocean


The Journey of Clinical Reasoning
Like Surfing Through Life
Entering the Water
The Water Speaks First
Building Skills
Riding the Structure
Where Autonomy Is Born
Finding Rhythm
Fading Support, Emerging Independence
Sharing the Wave
Social Flow
Mastering the Ocean
Advanced Surfing
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5

THANK YOU!!!

TO ALL THE CHILDREN I HAVE LEARNED FROM

TO ALL THE FAMILIES HAVE SUPPORTED US

TO EVERYONE WHO HAS COLLABORATED IN INTERDISCIPLINARY COURSES AND PROJECTS

TO THE PEOPLE WHO HAVE HELPED ME TO THINK AND MOVE FORWARD

Surfing Clinical Reasoning in Aquatic Therapy in ASD

From Regulation to Participation

A 5-stage journey through evidence and practice

javier.gueita@urjc.es

javier.gueita@gmail.com

Javier Güeita-Rodríguez

IATF water specific therapy lecturer. Valens. CH

Rey Juan Carlos University, MadrId. Spain

7th International Conference on Evidence Based Aquatic Therapy (ICEBAT)

Riding the trend: Aquatic therapy for Cerebral Palsy recovery after orthopedic surgery and neuromuscular blocks.

MSc, PT, Caio Roberto Ap. de Paschoal Castro

AACD
vida é movimento

Canada 2026
ICEBAT
GLOBAL TRENDS
IN AQUATIC THERAPY

Acknowledgements

MSc, PT, Douglas Martins Braga
Coordinator of Aquatic Therapy- AACD

Aquatic Therapy Team – AACD/Central

AACD
vida é movimento

Lecture Outline

- Cerebral Palsy
- Orthopedic surgeries and neuromuscular blocks
- Rehabilitation planning
- Functional Aquatic Therapy – AACD
- ICF and F-Words
- Technology for all

vida é movimento

Cerebral Palsy

"Cerebral Palsy (CP) is a group of permanent movement disorder caused by a non-progressive injury to the developing brain."

- Group of disorders
- Movement and posture
- Non-Progressive brain injury
- Focus on motor impairments

→

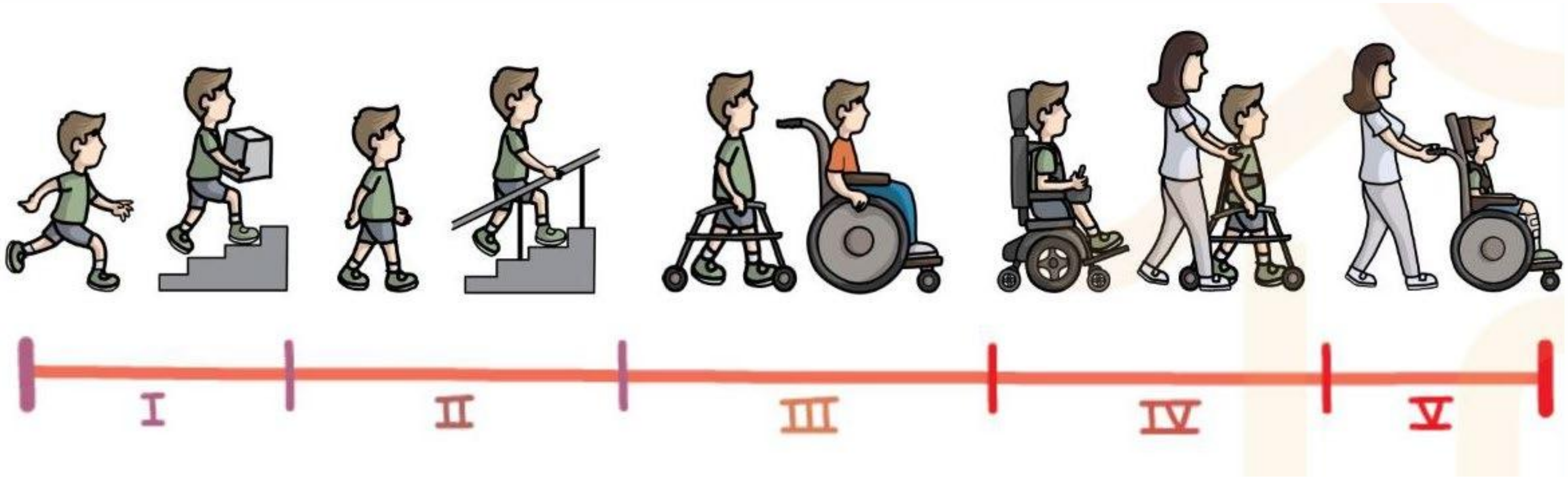
- Descriptive term (spectrum)
- Lifelong condition
- Function and Participation
- Lived experience
- Global and inclusive perspecives

AACD vida é movimento

Rosenbaum P, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl. 2007 Fev;109:8-14
Dan B, et al. Updated description of cerebral palsy. Dev Med Chuld Neurol. 2026;68:465-476

Cerebral Palsy

Gross Motor Function Classification System (GMFCS)



Motor type
Spastic
Dyskinetic
Ataxic
Mixed

Motor distribution — **Unilateral** / **Bilateral**

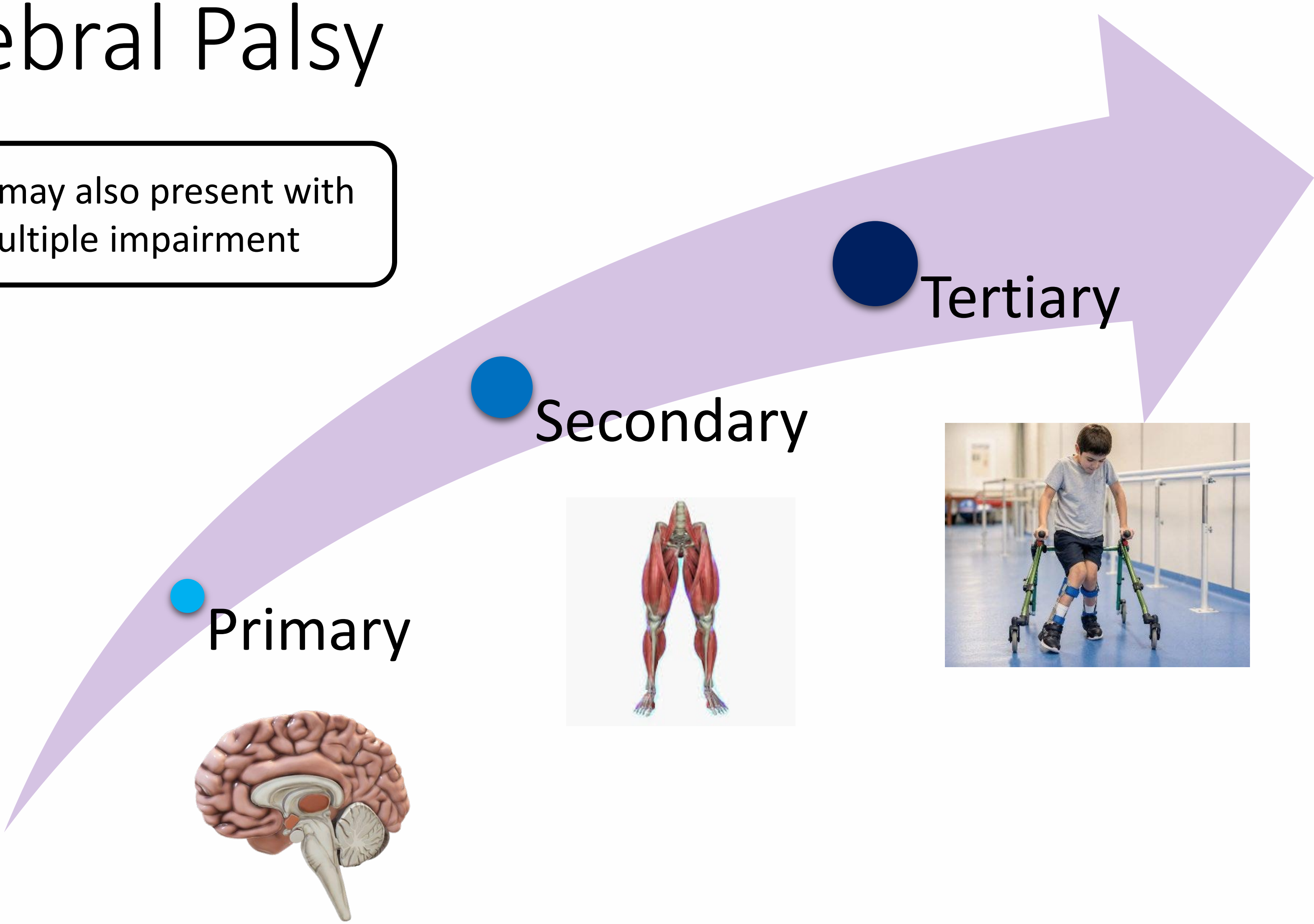
What is happening behind this?

AACD vida é movimento

Rosenbaum P, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl. 2007 Fev;109:8-14
Novak I, Morgan C, Adde L, *et al.* Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment. JAMA Pediatr. 2017;171(9):897-907.

Cerebral Palsy

They may also present with multiple impairment



Novak I, Morgan C, Adde L, *et al.* Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment. JAMA Pediatr. 2017;171(9):897-907.

Novak I, Morgan C, Fahey M, *et al*. State of the evidence traffic lights 2019: Systematic review of interventions for preventing and treating children with cerebral palsy. Dev Med Child Neurol. 2020;62(10):1253-1296.

Cerebral Palsy

Primary
- Brain injury
- Abnormal tone
- Poor motor control

Secondary
- Muscle shortening
- Contractures
- Bone deformities

Tertiary
- Functional limitation
- Fatigue
- Participation restriction

Primary interventions:
- **Medications**
- **Neurosurgical approaches**

Secondary interventions:
- **Orthopedic surgery**
- **Neuromuscular blocks**
- **Stretching**
- **Orthoses**

Tertiary interventions:
- **Physical therapy**
- **Task-specific training**
- **Aquatic therapy**

Novak I, Morgan C, Fahey M, *et al*. State of the evidence traffic lights 2019: Systematic review of interventions for preventing and treating children with cerebral palsy. Dev Med Child Neurol. 2020;62(10):1253-1296.

Cerebral palsy

HHS Public Access

Author manuscript

JAMA Pediatr. Author manuscript; available in PMC 2022 November 08.

Published in final edited form as:

JAMA Pediatr. 2017 September 01; 171(9): 897–907. doi:10.1001/jamapediatrics.2017.1689.

Early, Accurate Diagnosis and Early Intervention in Cerebral Palsy Advances in Diagnosis and Treatment

Early intervention is essential to improve motor outcomes in children with cerebral palsy

It's a problem

- Limited access to rehabilitation centers
- Lack of health education
- Social inequality (tranporting, Housing, employment)
- Lack of social support

Novak I, Morgan C, Fahey M, *et al*. State of the evidence traffic lights 2019: Systematic review of interventions for preventing and treating children with cerebral palsy. Dev Med Child Neurol. 2020;62(10):1253-1296.

Orthopedic surgeries

Soft tissue lengthening

Tendon transfers

Bone procedures

Single-event multilevel surgery

- Hip – II and V
- Hip – II, III, IV and V
- Knee – II, Ankle and Foot – III and IV
- Ankle (Tibialis Anterior) – I, II and IV
- Foot and Ankle – II
- Foot and Ankle – I, II, III and IV

Morais Filho MC, Fujino MH, Kawamura CM, *et al*. Patients and parents' satisfaction and self-reported evaluation after single-event multilevel surgery in cerebral palsy. J Pediatr Orthop. 2023;43(7):e583-e590.

Alcalde GP, Castro CRAP, Braga DM, *et al.* Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica. Rev Neurocienc. 2024. 32:1-20

Orthopedic surgeries

Indications for orthopedic surgery:

- Function
- Positioning
- Pain

Morais Filho MC, Fujino MH, Kawamura CM, *et al*. Patients and parents' satisfaction and self-reported evaluation after single-event multilevel surgery in cerebral palsy. J Pediatr Orthop. 2023;43(7):e583-e590.
Alcalde GP, Castro CRAP, Braga DM, *et al.* Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica. Rev Neurocienc. 2024. 32:1-20

vida é movimento

Orthopedic surgeries

Recovery

Tissue healing
Cast
Splint
Orthoses

Consequences

Muscle weakness
Immobilization
Hypersensitivity
Temporary functional loss

Morais Filho MC, Fujino MH, Kawamura CM, *et al*. Patients and parents' satisfaction and self-reported evaluation after single-event multilevel surgery in cerebral palsy. J Pediatr Orthop. 2023;43(7):e583-e590.
Alcalde GP, Castro CRAP, Braga DM, *et al.* Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica. Rev Neurocienc. 2024. 32:1-20

Neuromuscular blocks

Bottulinum toxin → Intramuscular injection

One muscle per injection

Onset effect: 3 – 7 days
Temporary effect: 3 – 6 months

Phenol → Injected near the motor nerve

Muscle group

Onset effect: Immediate
Temporary effect: weeks to months (variable)

vida é movimento

Heinen F, Desloovere K, Schroeder AS, *et al*. The updated European Consensus 2009 on the use of botulinum toxin for children with cerebral palsy. Eur J Paediatr neurol. 2010;14(1):45-66.

Neuromuscular blocks

Consequences

Muscle weakness
Temporary functional loss

Indications for neuromuscular blocks:

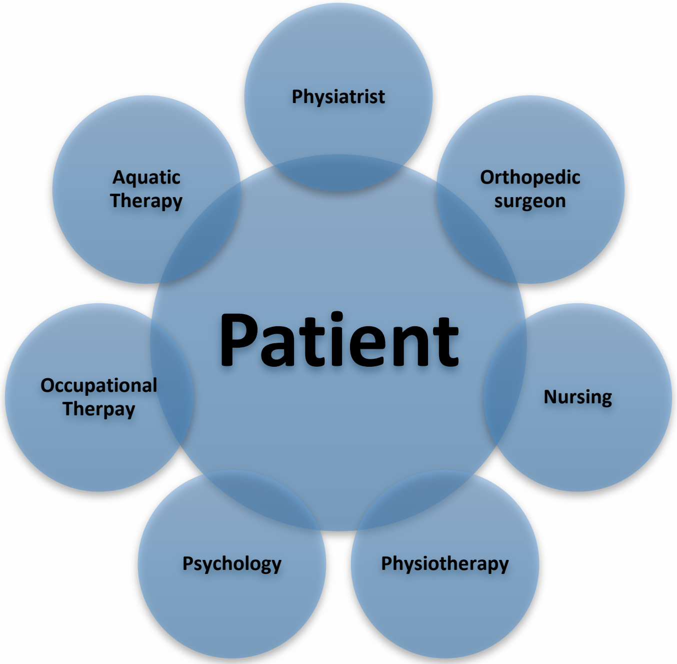
- Function
- Positioning
- Pain

vida é movimento

Heinen F, Desloovere K, Schroeder AS, *et al*. The updated European Consensus 2009 on the use of botulinum toxin for children with cerebral palsy. Eur J Paediatr neurol. 2010;14(1):45-66.

Rehabilitation planning

Secondary and/or Tertuary impairments → Orthopedic surgery or Neutomuscular blocks → Recovery → Rehabilitation



vida é movimento

Rehabilitation planning

AACD
vida é movimento

Rehabilitation planning

Othopedist or Physiatrist → Global assessment → Therapy

The therapist determines the therapeutic protocol.

vida é movimento

Rehabilitation planning

Since 2017

- Therapeutic protocols
- Based on professional expertise
- According to the best available evidence

Once or Twice a week for 3 – 12 months (depending on the procedure underwent and clinical presentation)
35 minutes

vida é movimento

Rehabilitation planning

Therapeutic protocols ✗

Functional outcomes protocols ✓

- Fitness protocol – GMFCS Level III and IV from 6 Years old
- Analgesia protocol – GMFCS Level V

Castro CRAP, Barbosa JL, Braga DM. Efeito da fisioterapia aquática no pós-operatório de quadril em crianças com paralisia cerebral GMFCS V. Cad PG em DM. 2018.10(2):83-93.

Functional Aquatic Therapy - AACD

1950

2026

AACD/Central
23 aquatic therapists
3.200 sessions per month
80% public healthcare system
572 patients
All outpatients

202 Cerebral Palsy (postoperative or neuromuscular block)
88% achievement of functional goals

vida é movimento

Functional Aquatic Therapy - AACD

Canada 2026 ICEBAT GLOBAL TRENDS IN AQUATIC THERAPY

Assessment →
- Patients preference
- Type of procedures
- Functional level
- Age

Functional Goals →
- ICF Global assessment
- Focus on participation*

Specific Goals →
- Based on Functional Goals
- Stratifies Functional Goal

Conducts
- Based on Specific Goals
- Stratifies Specific Goal

Reassessment every 3 months

Always on land

AACD vida é movimento

Functional Aquatic Therapy - AACD

REVISTA NEUROCIÊNCIAS

Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica

Aquatic physiotherapy in patients with cerebral palsy undergoing orthopedic surgery

Fisioterapia acuática en pacientes con parálisis cerebral sometidos a cirugía ortopédica

Gabriela Alcalde Pereira[1], Caio Roberto Aparecido de Paschoal Castro[2], Douglas Martins Braga[3], Mariana Sivieri Lambertucci[4], José Luis Rodrigues Barbosa[5]

- Between 2017 and 2022
- Age – 13 Years old
- Duration – 9 months
- 141 patients (45 GMFCS III)
- Most common goals identified

AACD vida é movimento

Alcalde GP, Castro CRAP, Braga DM, *et al.* Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica. Rev Neurocienc. 2024. 32:1-20

Functional Aquatic Therapy - AACD

Canada 2026
ICEBAT
GLOBAL TRENDS IN AQUATIC THERAPY

- Optimize weigth-bearing in the lower limbs
- Optimize muscle activation of dorsiflexors, knee extensors and hip extensors
- Increase range of motion of hip adductors and knee flexors
- Optimize balance
- Hip pain relief
- Improve physical fitness

AACD
vida é movimento

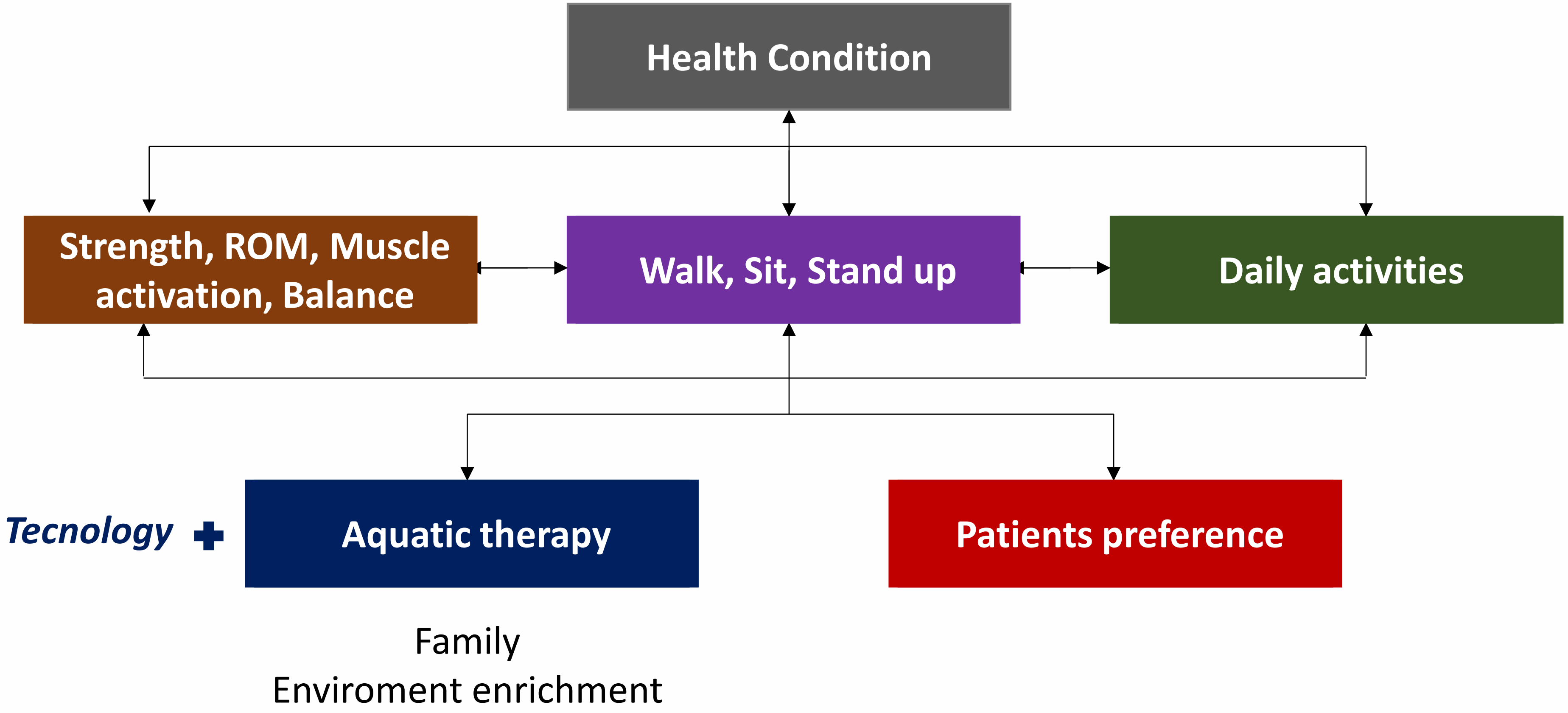
Functional Aquatic Therapy - AACD

Canada 2026 ICEBAT GLOBAL TRENDS IN AQUATIC THERAPY

- Sit to stand
- Standing
- Indoor walking
- Outdoor walking
- Short-distance walking
- Long-distance walking

AACD vida é movimento

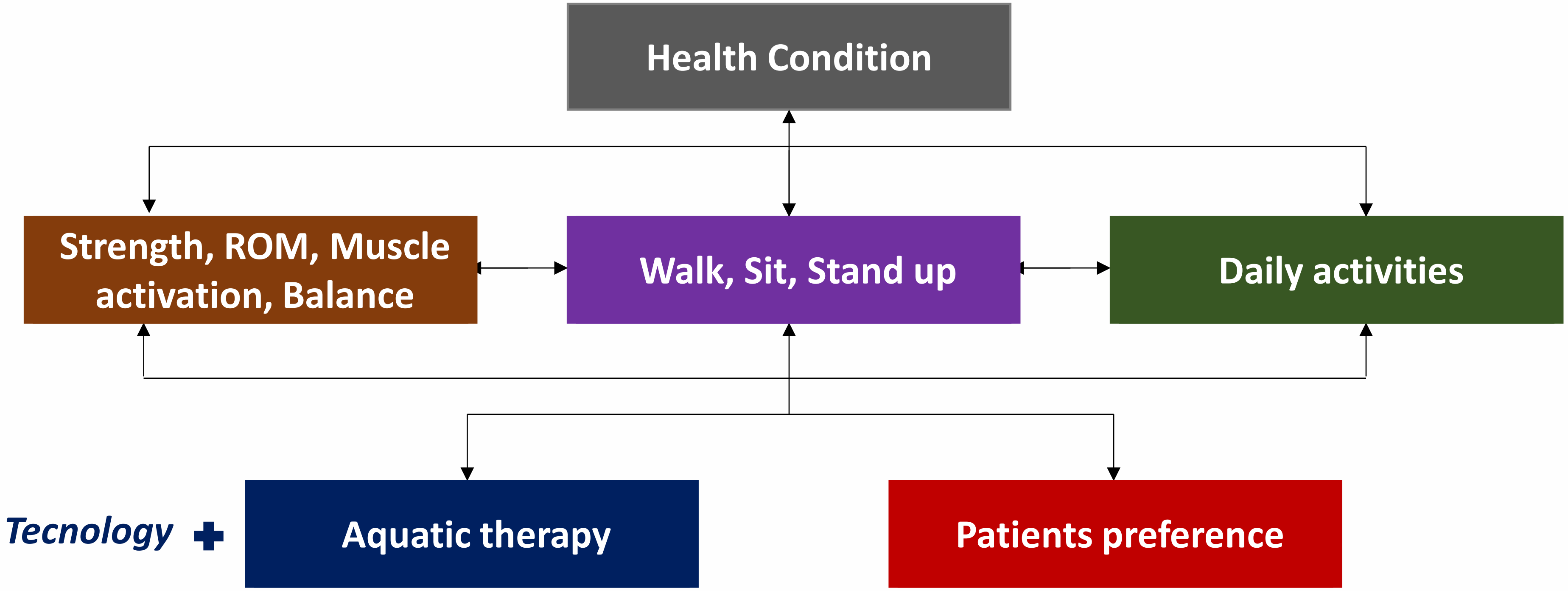
ICF



World Health Organization (WHO). International Classification of Functioning, Disability and Health (ICF). 2001.

vida é movimento

ICF



Family
Enviroment enrichment

World Health Organization (WHO). International Classification of Functioning, Disability and Health (ICF). 2001.

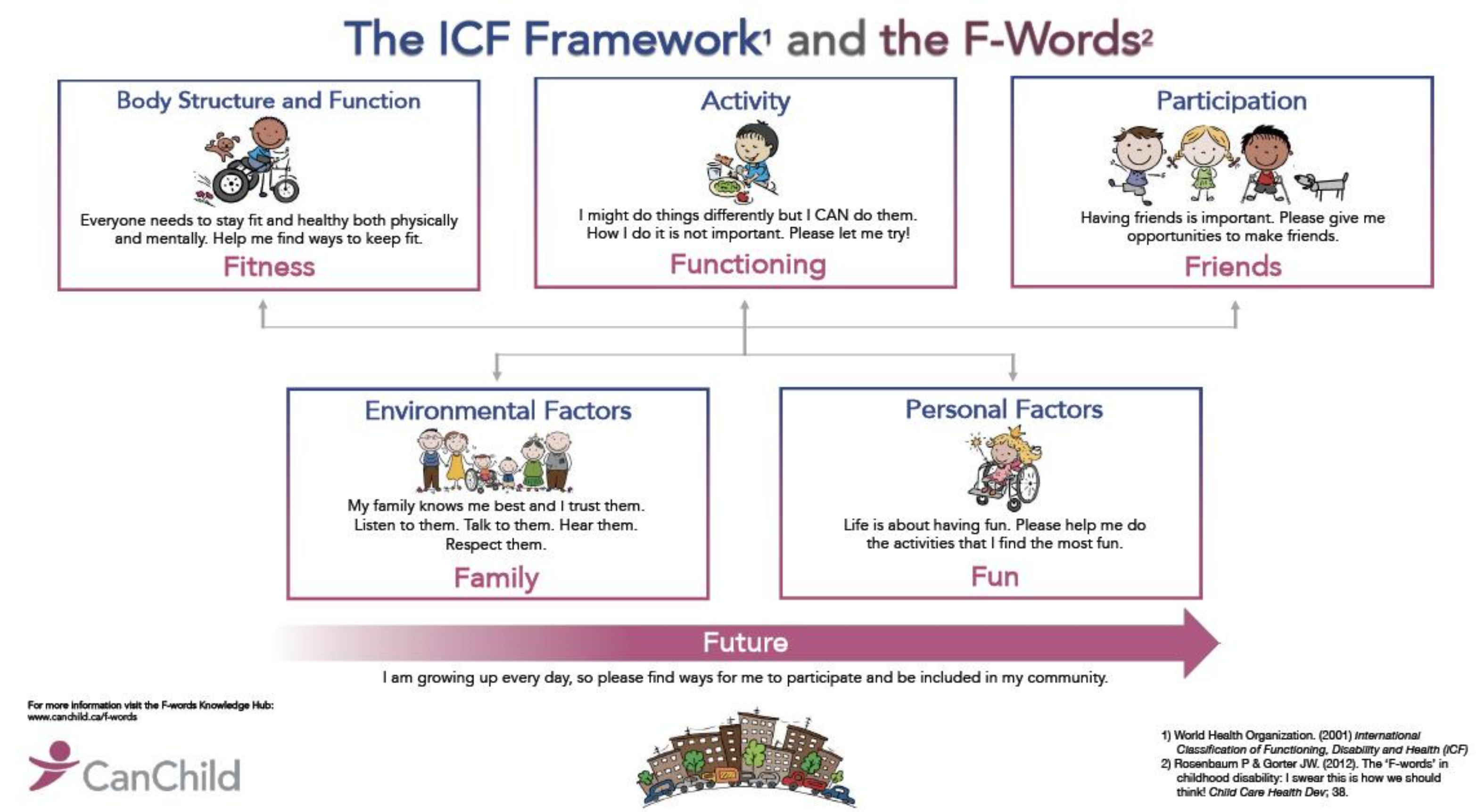
ICF

ICF	Global assessment		Initial assessment			Assessment				Patient discharge			
d4600	4	0	4	0	3	4	0	3	1	4	0	-	1
d4601	4	2	4	2	4	4	2	4	3	4	2	-	3

This represents the functional perspective integrated into aquatic therapy

vida é movimento

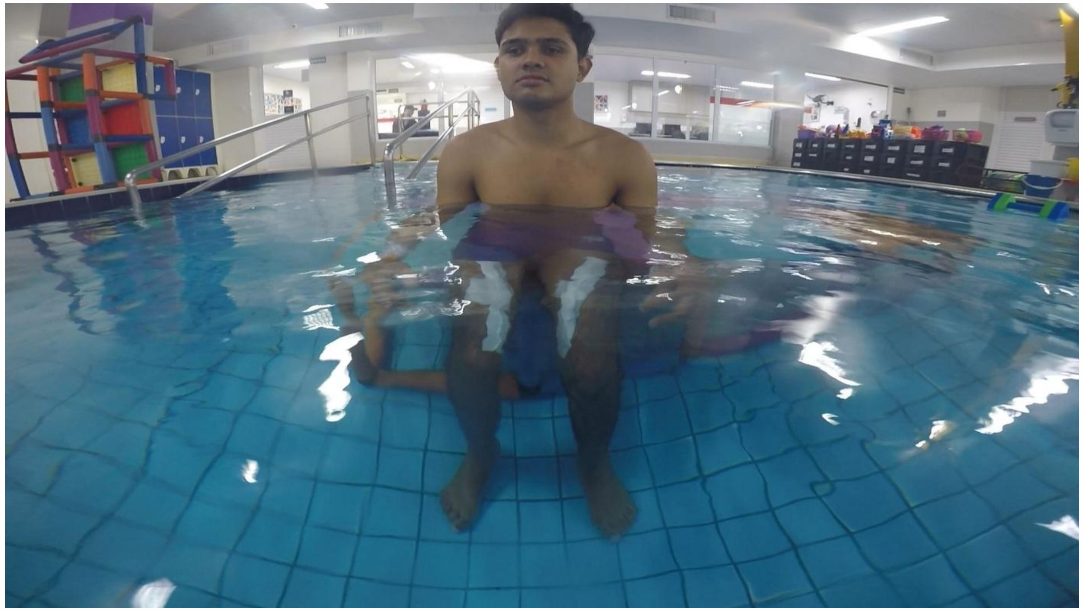
F-Words



Rosenbaum PL. The F-Words for child development: functioning, family, fitness, fun, friends, and future. Dev Med Child Neurol. 2022. 64(2):141-142.

Technology for all

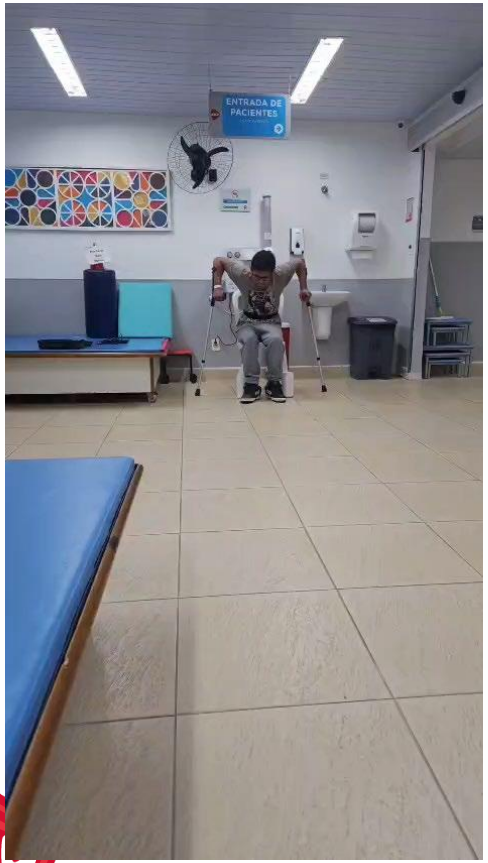
Surface electromyography



vida é movimento

Technology for all

Inertial sensor



PACIENTE:

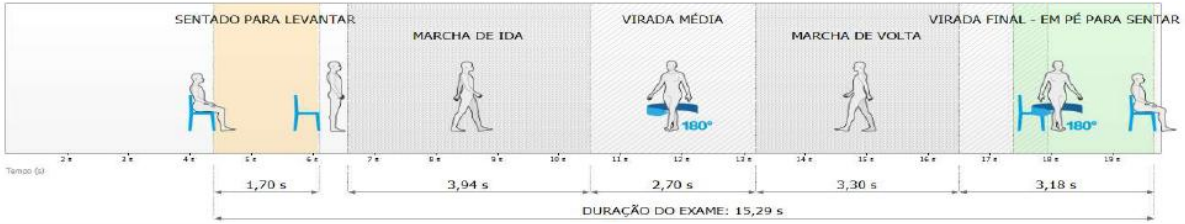
DATA DE NASCIMENTO: **PESO:** 58 Kg **ALTURA:** 162 cm **SEXO:** M

Timed Up and Go

Descrição dos Parâmetros	Valor	Unidades
Duração da Análise	15,29	s
Habilidade de Mobilidade Funcional	Independente	

Descrição dos Parâmetros	Sentado para Levantar	Em pé para Sentar	Unidades
Duração da Fase	1,70	2,30	s
Aceleração Anterior-Posterior	2,2	3,4	m/s²
Aceleração Lateral	2,3	5,0	m/s²
Aceleração Vertical	4,6	3,0	m/s²
Descrição dos Parâmetros	**Virada Média**	**Virada Final**	**Unidades**
Duração da Fase	2,70	1,44	s
Velocidade Máxima de Rotação	129,0	183,2	°/s
Velocidade Média de Rotação	59,5	98,8	°/s

Fases do Teste



vida é movimento

Technology for all

Wave generator

vida é movimento

Technology for all

Motorized underwater treadmill

vida é movimento

Technology for all

Werable metabolic system K5 (AAMed – Brazil)

AAMed

Alta tecnologia
a serviço da saúde

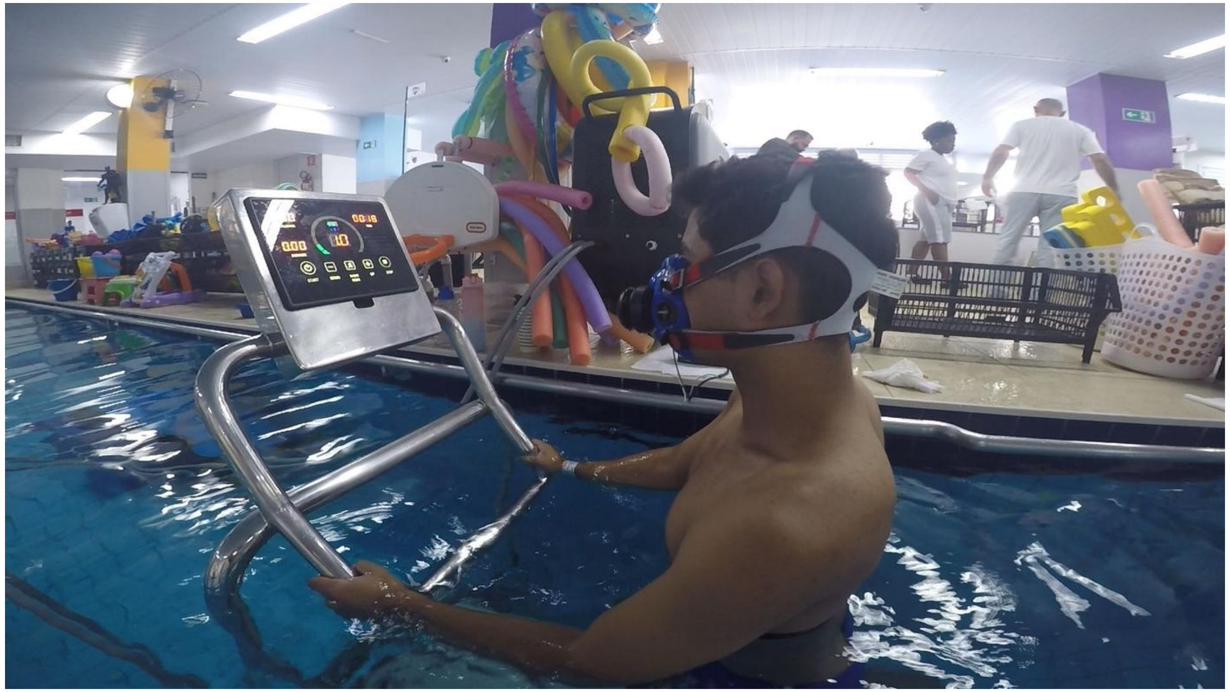
AACD
vida é movimento

Technology for all

Werable metabolic system K5 (AAMed – Brazil)

AAMed

Alta tecnologia
a serviço da saúde



AACD
vida é movimento

Canada 2026
ICEBAT
GLOBAL TRENDS IN AQUATIC THERAPY

Canada 2026 ICEBAT GLOBAL TRENDS IN AQUATIC THERAPY

What Should we think about from now?

Do we really know what to do?

AACD vida é movimento

What Should we think about from now?

Do we really know what to do?

vida é movimento

Canada 2026
ICEBAT
GLOBAL TRENDS
IN AQUATIC THERAPY

Canada 2026
ICEBAT
GLOBAL TRENDS
IN AQUATIC THERAPY

AACD
vida é movimento

AACD
vida é movimento

References

Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M. A report: The definition and classification of cerebral palsy. April 2006. Dev Med Child Neurol. 2007;49(s2):8-14.

Novak I, Morgan C, Adde L, *et al.* Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment. JAMA Pediatr. 2017;171(9):897-907.

Novak I, Morgan C, Fahey M, *et al*. State of the evidence traffic lights 2019: Systematic review of interventions for preventing and treating children with cerebral palsy. Dev Med Child Neurol. 2020;62(10):1253-1296.

McIntyre S, Goldsmith S, Webb A, *et al*. Global prevalences of cerebral palsy: A systematic analysis. Dev Med Child Neurol. 2022.64(12):1494-1506.

Morais Filho MC, Fujino MH, Kawamura CM, *et al*. Patients and parents' satisfaction and self-reported evaluation after single-event multilevel surgery in cerebral palsy. J Pediatr Orthop. 2023;43(7):e583-e590.

Heinen F, Desloovere K, Schroeder AS, *et al*. The updated European Consensus 2009 on the use of botulinum toxin for children with cerebral palsy. Eur J Paediatr neurol. 2010;14(1):45-66.

Ballaz L, Plamondon S, Lemay M. Group aquatic training improves gait efficiency in adolescents with cerebral palsy. Disabil Rehab. 2011;33(15-16):1202-1208.

Alcalde GP, Castro CRAP, Braga DM, *et al.* Fisioterapia aquática em pacientes com paralisia cerebral submetidos à cirurgia ortopédica. Rev Neurocienc. 2024. 32:1-20.

Castro CRAP, Barbosa JL, Braga DM. Efeito da fisioterapia aquática no pós-operatório de quadril em crianças com paralisia cerebral GMFCS V. Cad PG em DM. 2018.10(2):83-93.

World Health Organization (WHO). International Classification of Functioning, Disability and Health (ICF). 2001.

Rosenbaum PL. The F-Words for child development: functioning, family, fitness, fun, friends, and future. Dev Med Child Neurol. 2022. 64(2):141-142.

vida é movimento

Obrigado!

Thank you!

Contacts:
@caio_castro.fisio
ccastro@aacd.org.br

Canada 2026 ICEBAT GLOBAL TRENDS IN AQUATIC THERAPY

AACD vida é movimento

Getting the Dosage Right – Graded Exercise Testing

ICEBAT 2026, Toronto

Disclosures

No conflicts of interests

Always welcome to the Tamina Valley → *Open* for exchange!

1. **Future Challenges – Focus non communicable diseases**
2. Clinical evidence for HIAE → Prescription and progression strategies →
3. Conclusions / *Take Home*

• What if we had this pill that…

1. …reduced the prevalence of breast cancer by 50%? → e.g. *McTieran et al.2019*;
2. …that of colon cancer even by 66%? → e.g. *McTieran et al.2019*;
3. …reduced the prevalence of Alzheimer diesease by 50% reduziert? → e.g. *De la Rosa et al. 2020*;
4. …reduces the risk of cardiovascular dieseases (e.g. hypertension) by 50%? e.g. *LaVie et al. 2015*;
5. … the risk of stroke by 33%? → e.g. *Han et al. 2017*;
6. …the prevalence of diabetes by 66% reduziert? → e.g. *Kumar et al. 2019*;
7. …has equal effects on depressive symptoms as cognitive behavioural therapy?
   → *Zhao et al. 2020*

Then *why* are we not taking it?

Clear Recommendations by the WHO

Focus on Physical Activity

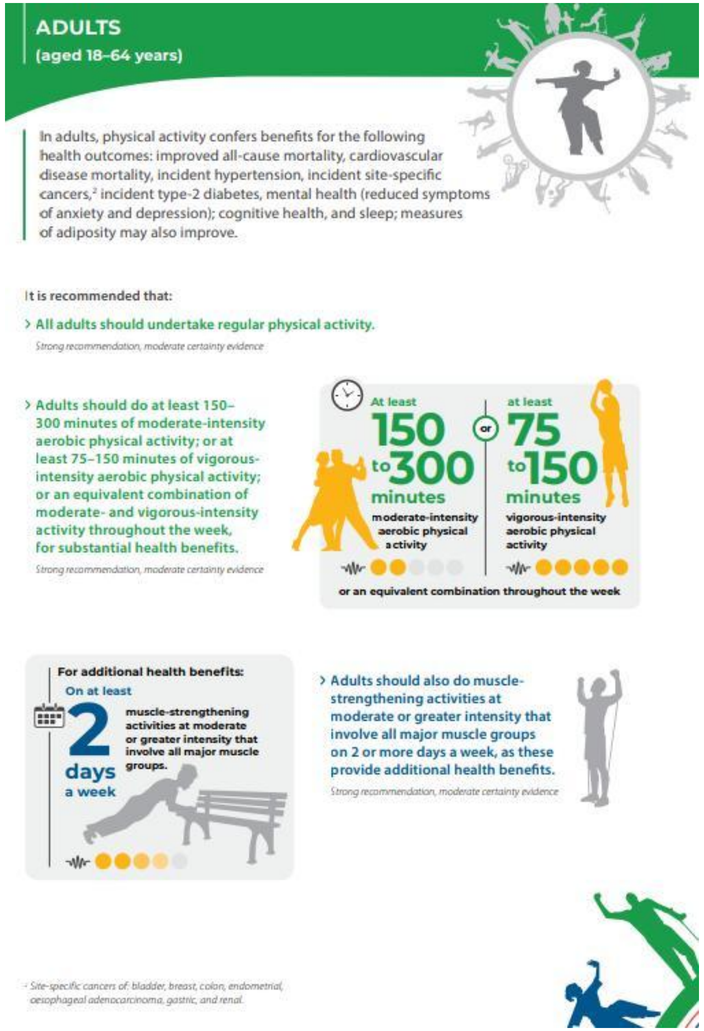
Recommendations for :

150 Min per week of *moderate* activities and

30 Min per week of *strength training*

OR take the Short Cut:

75 Min per week of vigorous activities and strength training



Training programs are medicine («Exercise is Medicine») and impact straight (brain) health

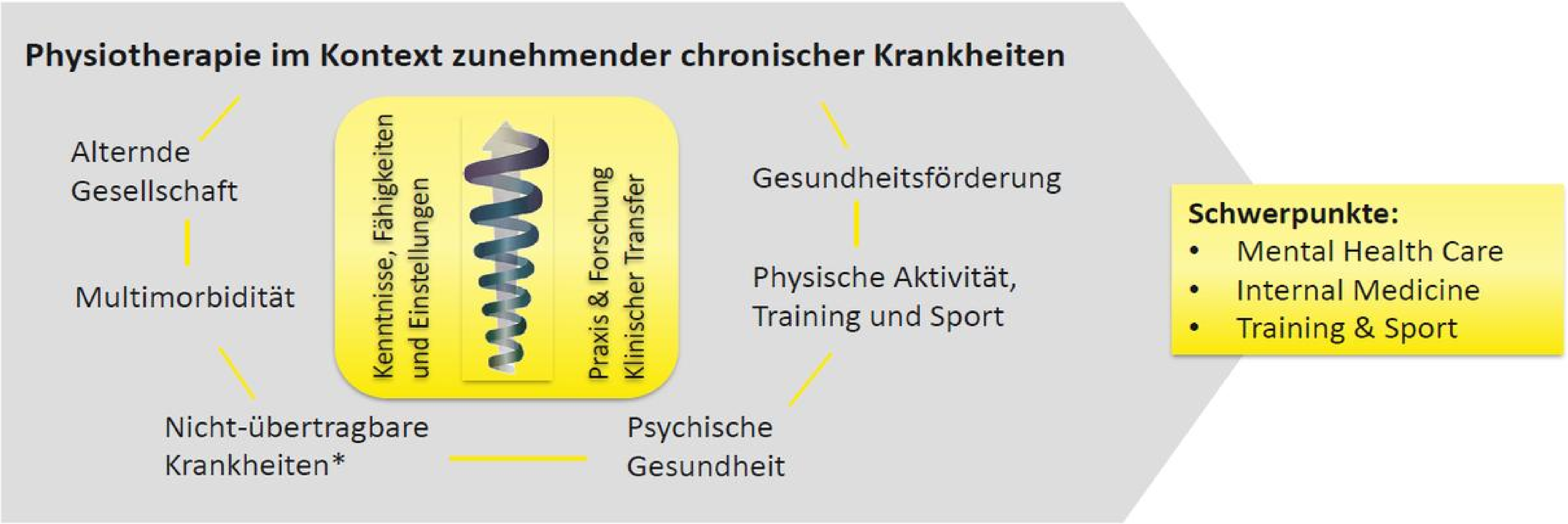
Physical Activity and ***Training*** are highly **effective**, non-pharmacological ***easy available*** methods to ***impact*** brain health – <u>*independent*</u> of age, fitness level and cognitive status

Thank you for the attention....BUT

Future Challenges for Physiotherapy

valens

Demographics, *Lifstyle* and *Mental Health* will dramaticaly impact health care systems



We will have to learn many new things and let go of existings methods

Blackbox Daily Life

Articles

National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5·7 million participants

*Tessa Strain, Seth Flaxman, Regina Guthold, Elizaveta Semenova, Melanie Cowan, Leanne M Riley, Fiona C Bull, Gretchen A Stevens, and the Country Data Author Group**

Costs of non communciable diseases on the rise

→ 2017 the costs for chronic pain were **CHF 5 Billion** [BAG 2017];
→ 2023 the costs for obesity and following side diseases (e.g. Diabetes) were **CHF 26 Billion** [BAG 2023];
→ Costs world wide for obesity were **US$ 500 Billion** and are predicted to rise till 2030 to min. **US$ 745 Billion** [WHO 2023].

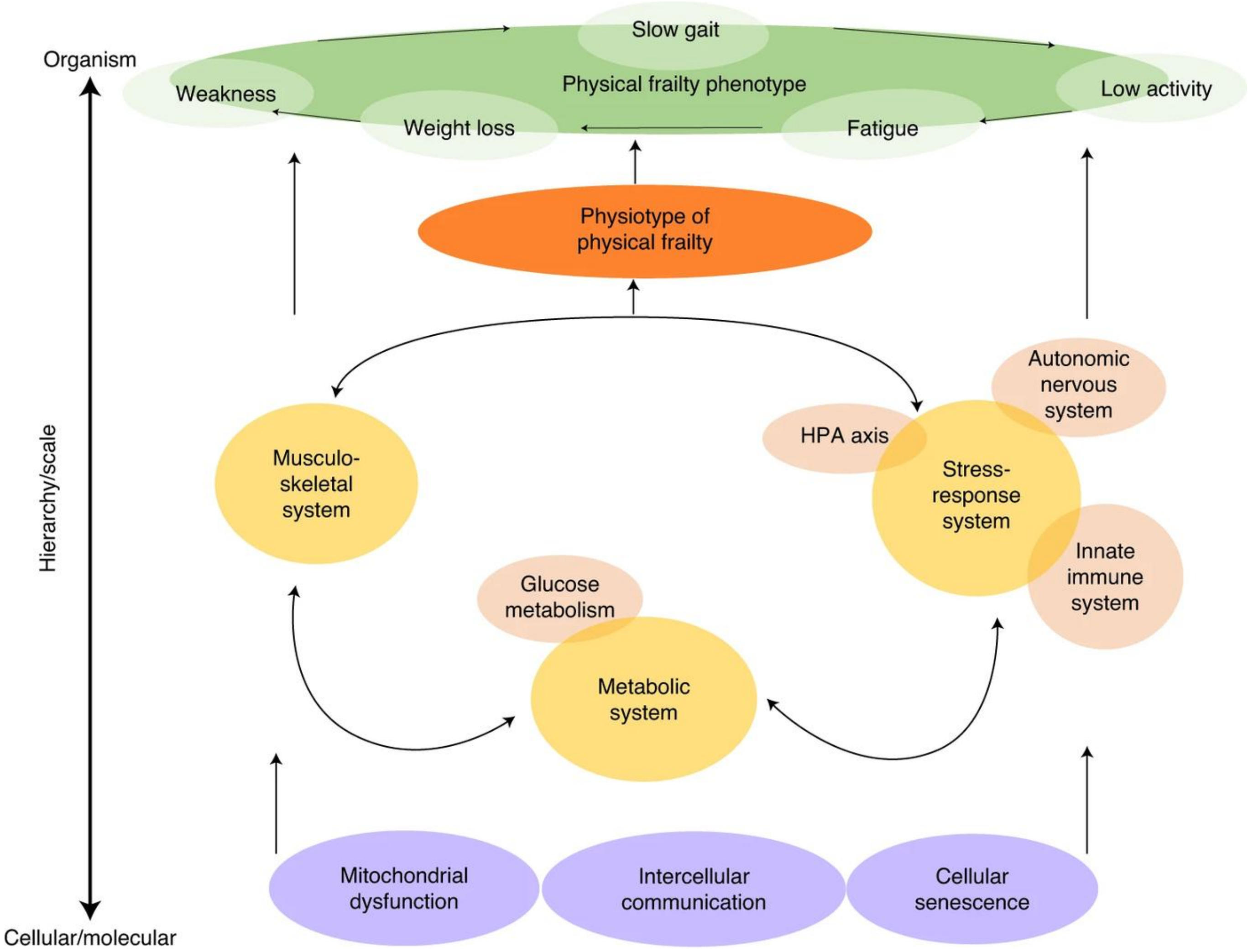
Frailty Syndrome – Cakophonia of Systems

Inefficient interactions and feedback between different systems underline physiological vulnerability of *frailty*

PERSPECTIVE
https://doi.org/10.1038/s43587-020-00017-z
nature aging
Check for updates

The physical frailty syndrome as a transition from homeostatic symphony to cacophony

Linda P. Fried[1], Alan A. Cohen[2], Qian-Li Xue[3], Jeremy Walston[4], Karen Bandeen-Roche[3,5,7] and Ravi Varadhan[6,7]



scientific reports

Explore content ⌄ About the journal ⌄ Publish with us ⌄

nature › scientific reports › articles › article

Article | Open access | Published: 23 January 2024

Acute effects of high intensity interval training versus moderate intensity continuous training on haemostasis in patients with coronary artery disease

Daniel Košuta, Marko Novaković, Mojca Božič Mijovski & Borut Jug

Scientific Reports 14, Article number: 1963 (2024) | Cite this article

ESC European Society of Cardiology
European Journal of Preventive Cardiology
doi:10.1093/eurjpc/zwab007

POSITION PAPER
Cardiac Rehabilitation

Exercise intensity assessment and prescription in cardiovascular rehabilitation and beyond: why and how: a position statement from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology

frontiers in Cardiovascular Medicine

Front Cardiovasc Med. 2024 Aug 27;11:1380639. doi: 10.3389/fcvm.2024.1380639

Exercise intensity prescription in cardiovascular rehabilitation: bridging the gap between best evidence and clinical practice

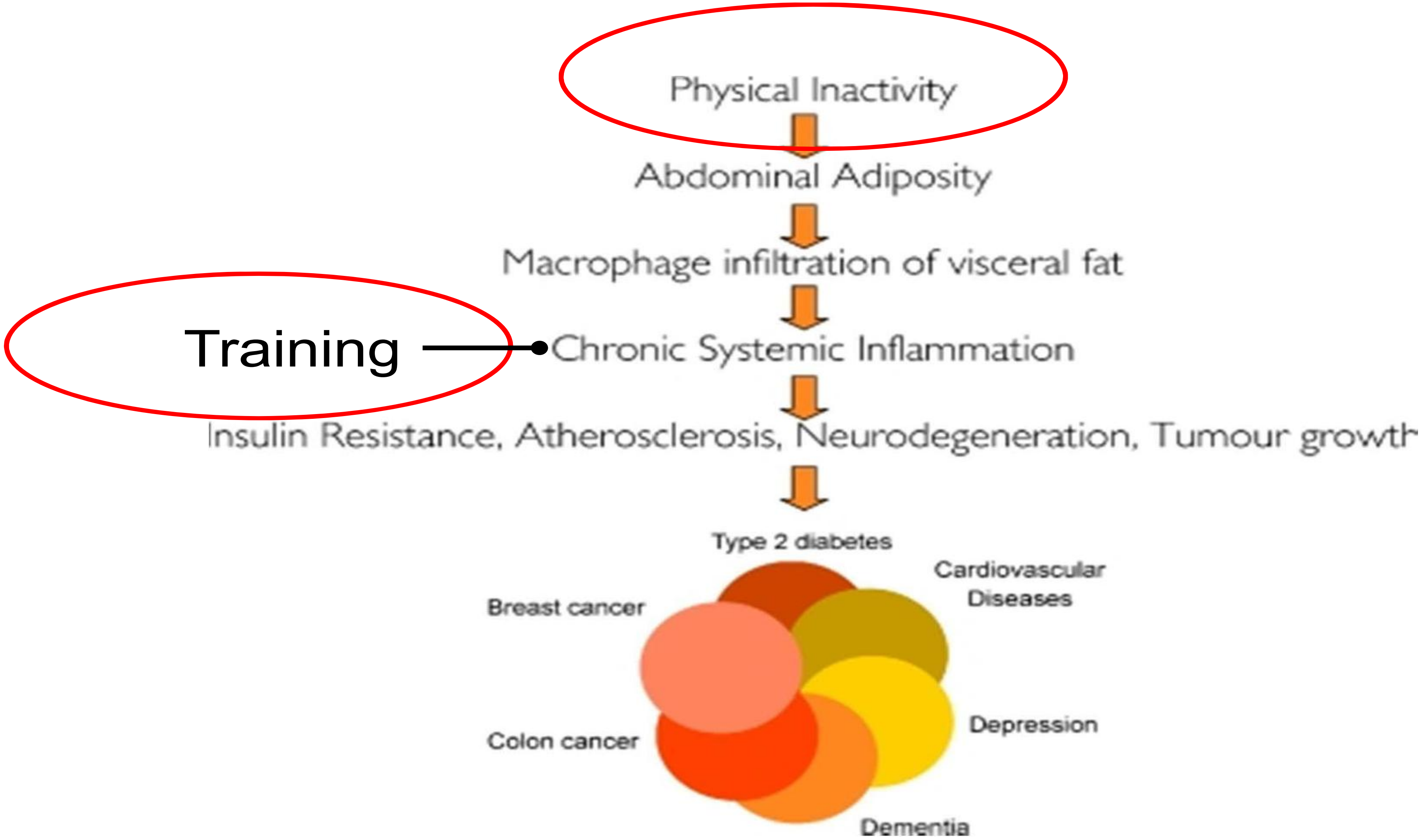
Juliana Goulart Prata Oliveira Milani [1,2], Mauricio Milani [1,2,3], Kenneth Verboven [1,4], Gerson Cipriano Jr [2,5,†], Dominique Hansen [1,3,4,*,†]

Author information ‣ Article notes ‣ Copyright and License information

PMCID: PMC11383788 PMID: 39257844

To effciently cope with these challenges we are in need of individually tailored *training programms that impact ALL systems!*

Inactivity is always a risk factor

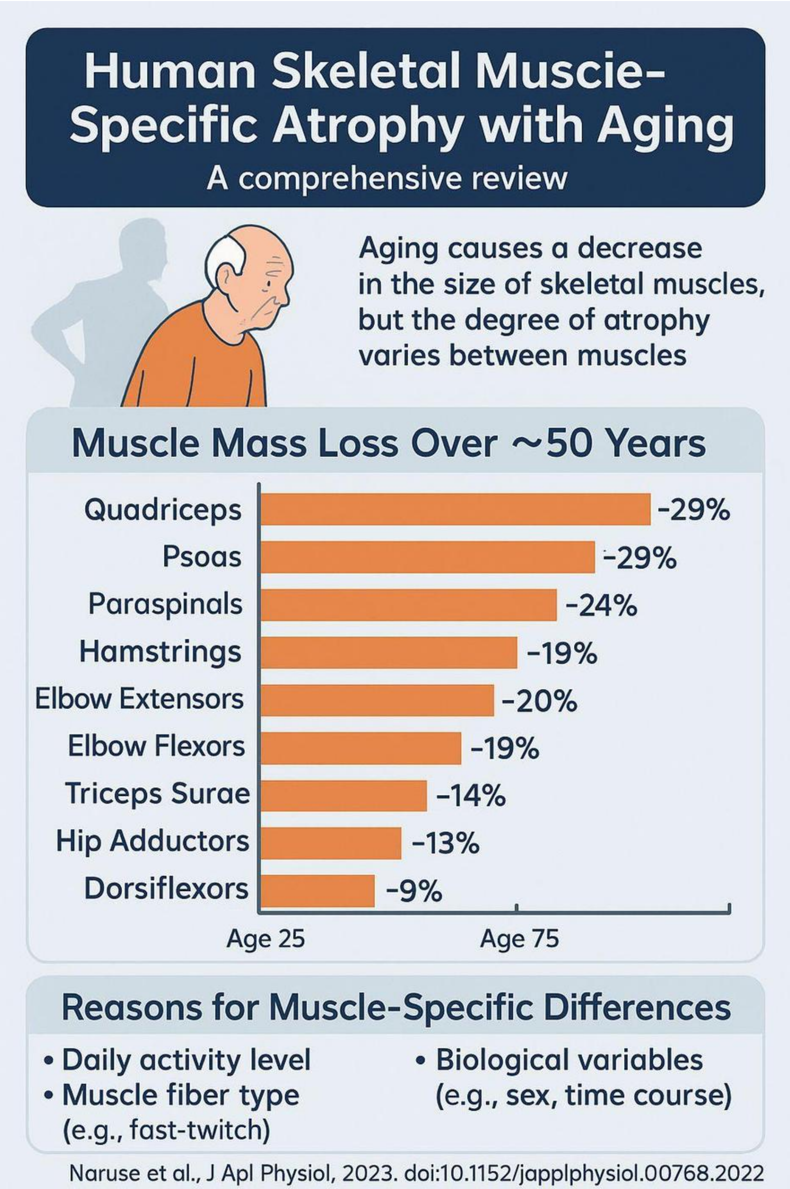


Loss of force and falling are first symptoms – not only in the elders

- Significant loss of force and postural control ↓ ↓
  Naruse et al. 2023, *J Agi Physiol*; 4):317-43.

- **40%** of the agers over 65 show signs of cognitive decline;
  Crimmins 2015; *Gerontologist*; 55(6):901-11.

- **30%** of the agers over 65 say they had minimum one falling incident per year;
  Ohr, Raymond Fiatarone 2008, *Sports Med*; 38(4):317-43.



1. Future Challenges – Focus non communicable diseases

2. Clinical evidence for HIAE → Prescription and progression strategies →

3. Conlusion / *Take Home*

Rationale, Evidence and Acceptence

valens

Sage Journals
Journal of Parkinson's Disease
OnlineFirst, July 31, 2025

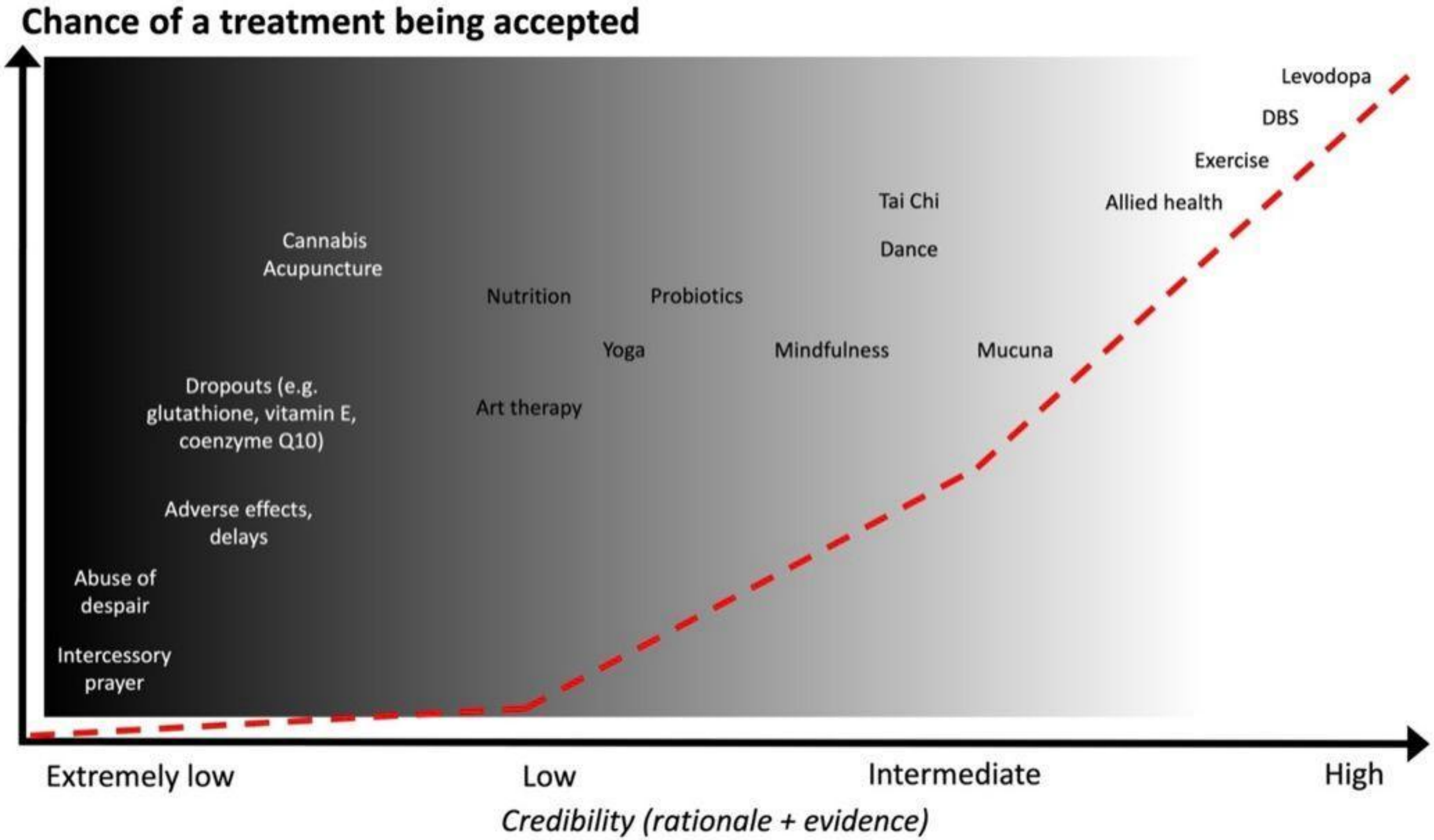
https://doi.org/10.1177/1877718X251361441

Review

Shades of grey: The continuum of therapies for Parkinson's disease along the spectrum of credibility

Araceli Alonso-Canovas[1,2], Olaf M Dekkers[3], and Bastiaan R. Bloem[4,5,6]

Very good acceptence and evidence of *physical therapies* over all neurological diagnosis groups



To HIIT or not to HIIT

valens

ACRM AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2024;105: 1545—58

SYSTEMATIC/META-ANALYTIC REVIEWS

Is High-Intensity Interval Training More Effective Than Moderate Continuous Training in Rehabilitation of Multiple Sclerosis: A Comprehensive Systematic Review and Meta-analysis

Check for updates

Hussein Youssef, MSc,[a,b,c] Mine Nur Gönül, BSc,[a,b,d] Mohamed Gomaa Sobeeh, PhD,[e,f] Kardelen Akar, MSc,[a,b] Peter Feys, PhD,[c,g] Koen Cuypers, PhD,[c,h,i] Atay Vural, MD, PhD[a,b,j]

From the [a]Koç University Research Center for Translational Medicine (KUTTAM), İstanbul, Türkiye; [b]Koç University Graduate School of Health Sciences, İstanbul, Türkiye; [c]Hasselt University, Faculty of Rehabilitation Sciences, REVAL Rehabilitation Research Center, Diepenbeek, Belgium; [d]University of Health Sciences, Department of Physical Therapy, İstanbul, Türkiye; [e]Cairo University, Faculty of Physical Therapy, Department of Physical Therapy for Musculoskeletal and its surgeries, Giza, Egypt; [f]Sinai University, Faculty of Physical Therapy, Department of Physical Therapy for Orthopedics and Orthopedic Surgery, Ismailia, Egypt; [g]Universitair MS Centrum Hasselt-Pelt, UMSC, Belgium; [h]Movement Control and Neuroplasticity Research Group, Biomedical Sciences, KU Leuven, Tervuurse Vest 101, Leuven 3001, Belgium; [i]Leuven Brain Institute, KU Leuven-LBI, Leuven, Belgium; and [j]Koç University School of Medicine, Department of Neurology, İstanbul, Türkiye.

Youssef et al. *Arch Phys Med Rehab* 2024;105(8):1045-1058.

EVERY MINUTE COUNTS... BUT SOME COUNT MORE

Outcome *For reducing risk of:*	Vigorous activity		Moderate activity		Light activity
T2D incidence	1 min	=	9.4 min	=	94 min
Cardiovascular mortality	1 min	=	7.8 min	=	72.5 min
Major adverse cardiovascular events	1 min	=	5.4 min	=	86.1 min
All-cause mortality	1 min	=	4.1 min	=	52.7 min

Data from: Biswas RK et al., (2025), *Nat Commun*, 16, 8315.

Jackson Fyfe, PhD *@jacksonfyfe*

Same effects on symptoms **BUT** HIIT always achieves greater effects on **oxygen consumption** (cardiorespiratory fitness), is more **time effcient a**nd rated as «**Not so monotonous»** by the patients

In MSers HIIT has positive effects on *neurofilaments* and the Kynurenin pathway

Exercise Diminishes Plasma Neurofilament Light Chain and Reroutes the Kynurenine Pathway in Multiple Sclerosis

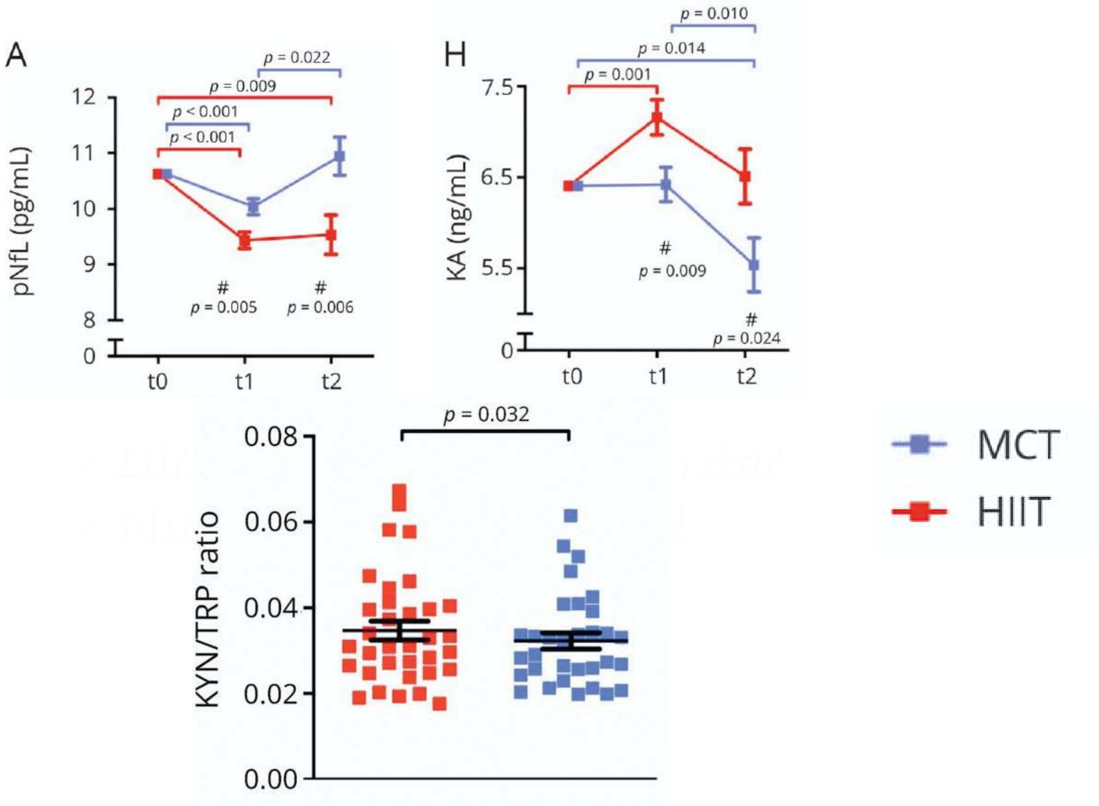
Niklas Joisten, PhD,* Annette Rademacher,* Clemens Warnke, MD, Sebastian Proschinger, Alexander Schenk, PhD, David Walzik, Andre Knoop, PhD, Mario Thevis, PhD, Falk Steffen, Stefan Bittner, MD, Roman Gonzenbach, MD, Jan Kool, PhD, Wilhelm Bloch, MD, Jens Bansi, PhD,† and Philipp Zimmer, PhD†

Correspondence
Dr. Zimmer
philipp.zimmer@tu-dortmund.de

Neurol Neuroimmunol Neuroinflamm 2021;8:e982. doi:10.1212/NXI.0000000000000982

- 69 PmMS
- EDSS 3.0 – 6.0
- RRMS und SPMS

3x / week HIT (5x 1.5 Min Intervals at 95-100% HR_{peak})
3x / week continous (30 Min at 70% HR_{peak})



Joisten et al Neruology 2021;8(3): 1-9

To sum it up: Overland HIT achieves greater effects

In MSers HIIT has positive effects on *neurofilaments* and the Kynurenin pathway

valens

Exercise Diminishes Plasr Chain and Reroutes the K Multiple Sclerosis

Niklas Joisten, PhD,* Annette Rademacher,* Clemens Warnke, MD, Sebastia
Alexander Schenk, PhD, David Walzik, Andre Knoop, PhD, Mario Thevis, PhD,
Roman Gonzenbach, MD, Jan Kool, PhD, Wilhelm Bloch, MD, Jens Bansi, PhD,

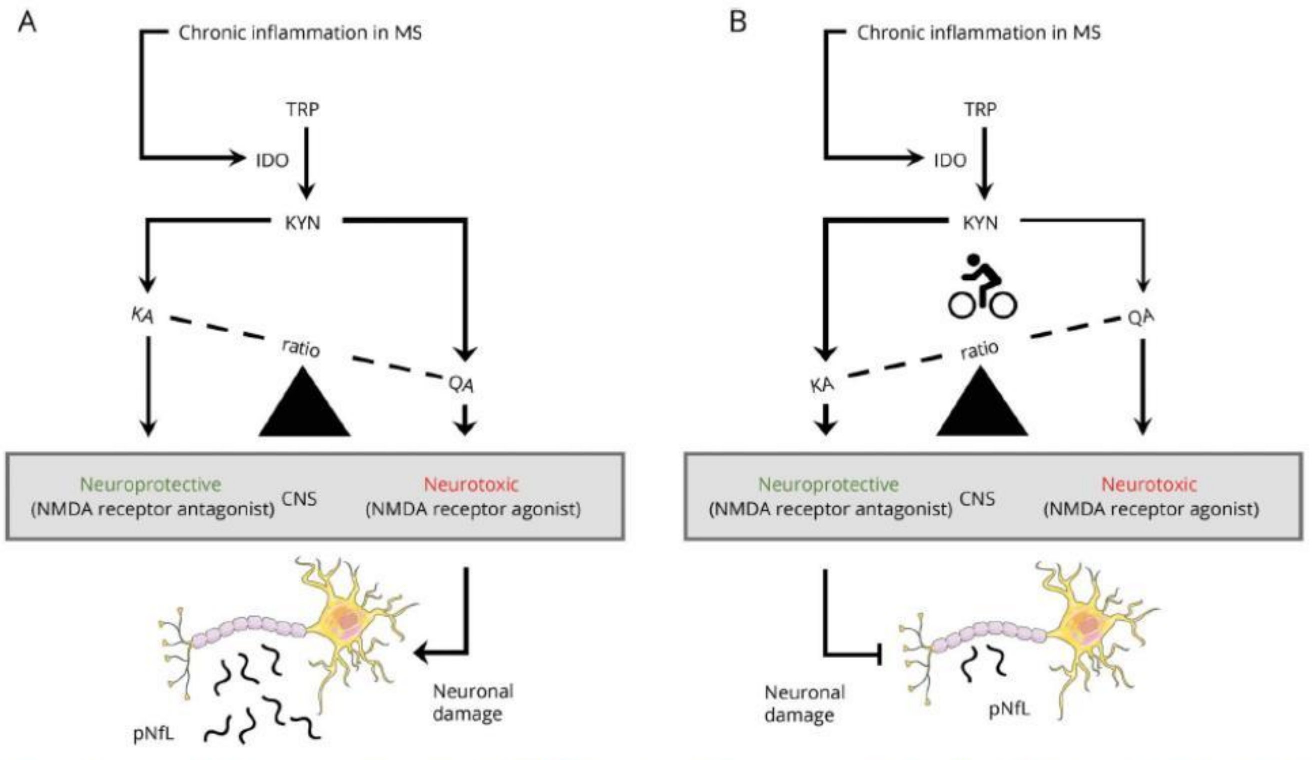
Neurol Neuroimmunol Neuroinflamm 2021;8:e982. doi:10.1212/NXI.000000

- 69 PmMS
- EDSS 3.0 – 6.0
- RRMS und SPMS

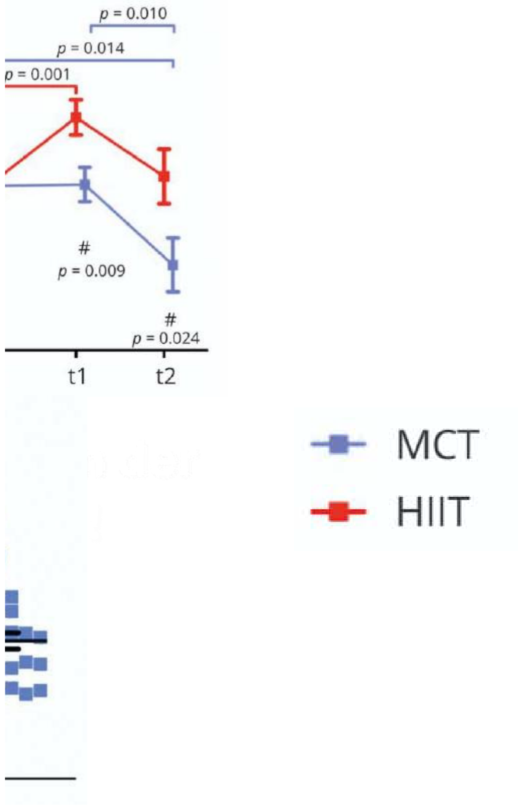
3x / week HIT (5x 1.5
3x / week contir

Youssef et al. *Arch Phys Med Rel*

Figure 4 Theoretical Hypothesis Based on the Current Results



(A) Interaction of chronic inflammatory conditions in MS, the KYN pathway, and neurodegeneration assessed by pNfL levels. (B) Exercise-induced rerouting of the KYN pathway toward KA leads to reductions in pNfL levels. KA = kynurenic acid; KYN = kynurenine; pNfL = plasma neurofilament light chain; QA = quinolinic acid; TRP = tryptophan.



Overland HIT achieves greater effects

In MSers HIIT has positive effects on *neurofilaments* and the Kynurenin

Exercise Dimini
Chain and Rerc
Multiple Sclero

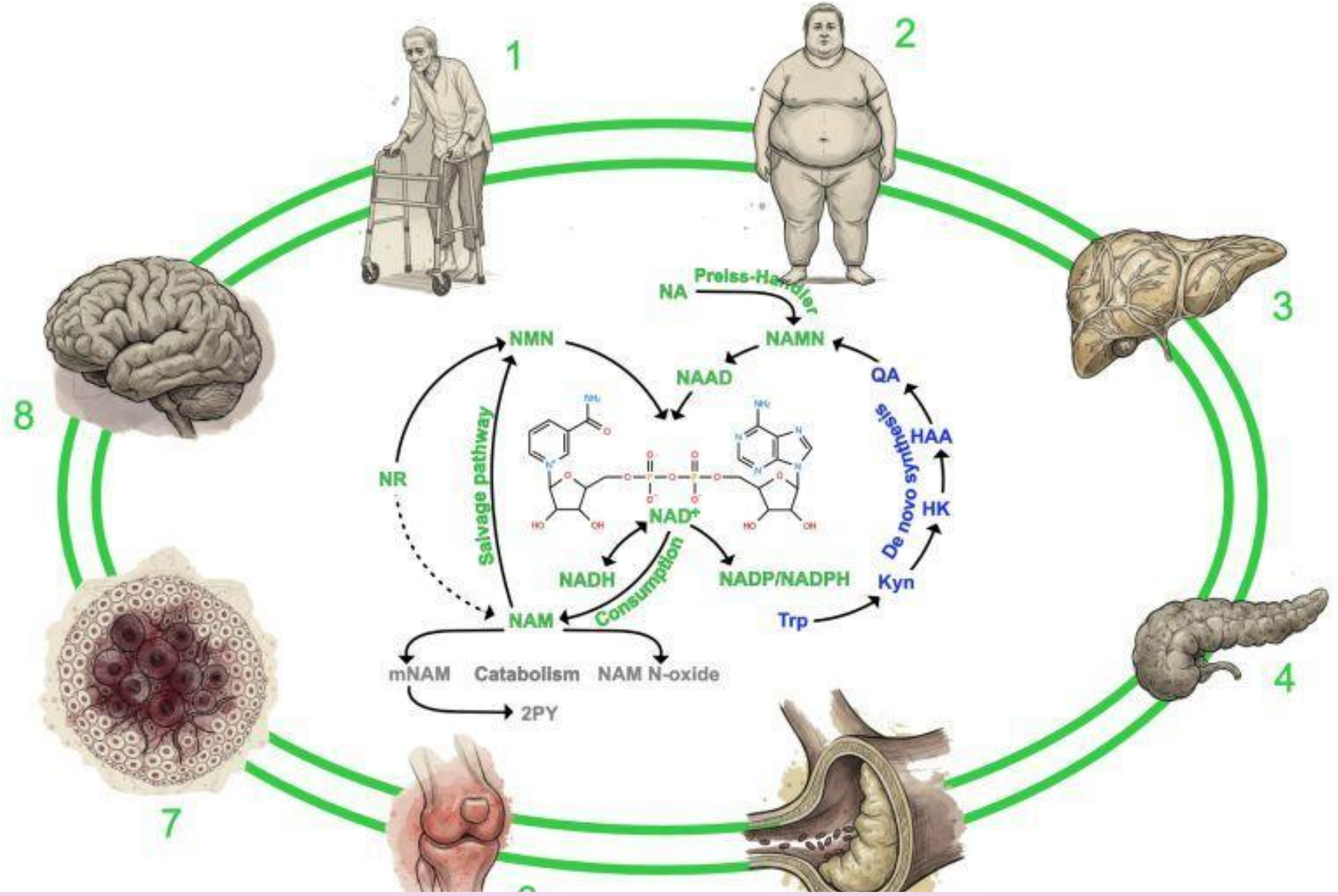
Niklas Joisten, PhD,* Annette Rademacher,* C
Alexander Schenk, PhD, David Walzik, Andre K
Roman Gonzenbach, MD, Jan Kool, PhD, Wilhe

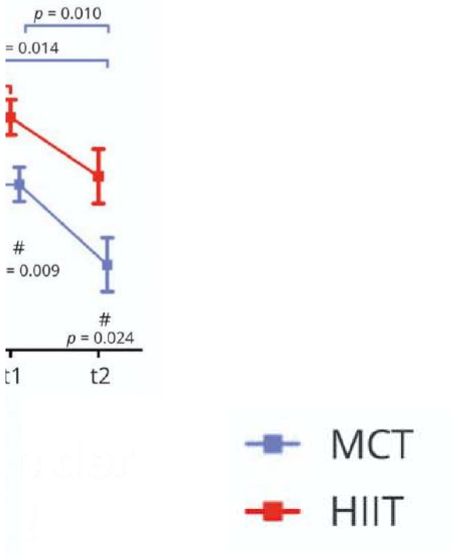
Neurol Neuroimmunol Neuroinflamm 2021;8:e

- 69 PmMS
- EDSS 3.0 –
- RRMS und

3x / week H
3x / we

Youssef et al. *Arch F*



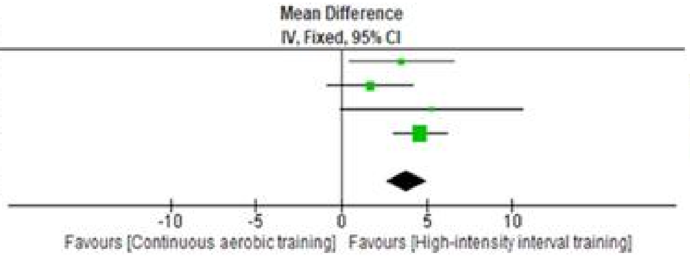


Overland HIT achieves greater effects

Relevance of training intensity also in stroke

Study or Subgroup	High-intensity interval training Mean	SD	Total	Continuous aerobic training Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Boyne et al, 2016	2.2	3.3	11	-1.3	2.7	5	15.2%	3.50 [0.43, 6.57]
Hsu et al, 2020	3.4	1.9	10	1.7	4.1	13	22.5%	1.70 [-0.82, 4.22]
Munari et al, 2016	4.5	5.3	8	-0.8	5.6	8	5.0%	5.30 [-0.04, 10.64]
Soh et al, 2020	4.7	2.1	18	0.1	2.7	18	57.3%	4.60 [3.02, 6.18]
Total (95% CI)			47			44	100.0%	3.82 [2.62, 5.01]

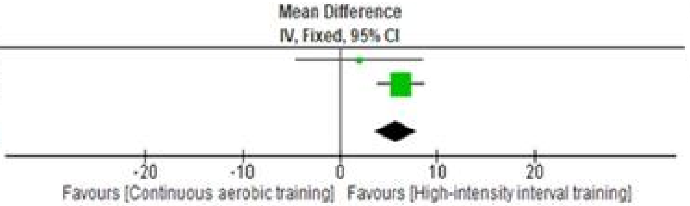
Heterogeneity: $Chi^2 = 3.99$, df = 3 (P = 0.26); $I^2 = 25\%$
Test for overall effect: Z = 6.25 (P < 0.00001)



A. Change in peak VO_2

Study or Subgroup	High-intensity interval training Mean	SD	Total	Continuous aerobic training Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lau et al, 2011	9.9	7.3	15	7.9	9.7	13	11.7%	2.00 [-4.44, 8.44]
Soh et al, 2020	6.5	3	18	0.3	4.1	18	88.3%	6.20 [3.85, 8.55]
Total (95% CI)			33			31	100.0%	5.71 [3.50, 7.91]

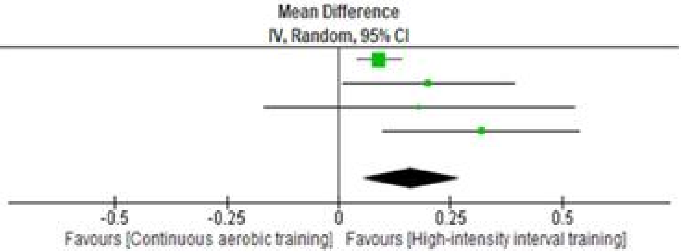
Heterogeneity: $Chi^2 = 1.44$, df = 1 (P = 0.23); $I^2 = 31\%$
Test for overall effect: Z = 5.07 (P < 0.00001)



B. Change in balance

Study or Subgroup	High-intensity interval training Mean	SD	Total	Continuous aerobic training Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Boyne et al, 2016	0.1	0.06	11	0.01	0.04	5	52.4%	0.09 [0.04, 0.14]
Lau et al, 2011	0.4	0.2	15	0.2	0.3	13	21.2%	0.20 [0.01, 0.39]
Munari et al, 2016	0.14	0.3	8	-0.04	0.4	8	8.7%	0.18 [-0.17, 0.53]
Pohl et al, 2002	0.5	0.3	20	0.18	0.4	20	17.7%	0.32 [0.10, 0.54]
Total (95% CI)			54			46	100.0%	0.16 [0.05, 0.27]

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 5.14$, df = 3 (P = 0.16); $I^2 = 42\%$
Test for overall effect: Z = 2.87 (P = 0.004)



C. Change in gait speed

***HIIT* is more efficient but only few studies**

Anjos et al. Clinical Rehabilitation 2022; 36:726-739.

BUT be careful with the agers >75

valens

Systematic review

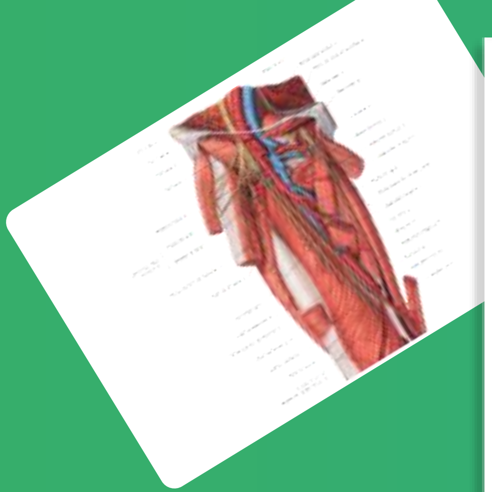
OPEN ACCESS

Effectiveness of exercise for improving cognition, memory and executive function: a systematic umbrella review and meta-meta-analysis

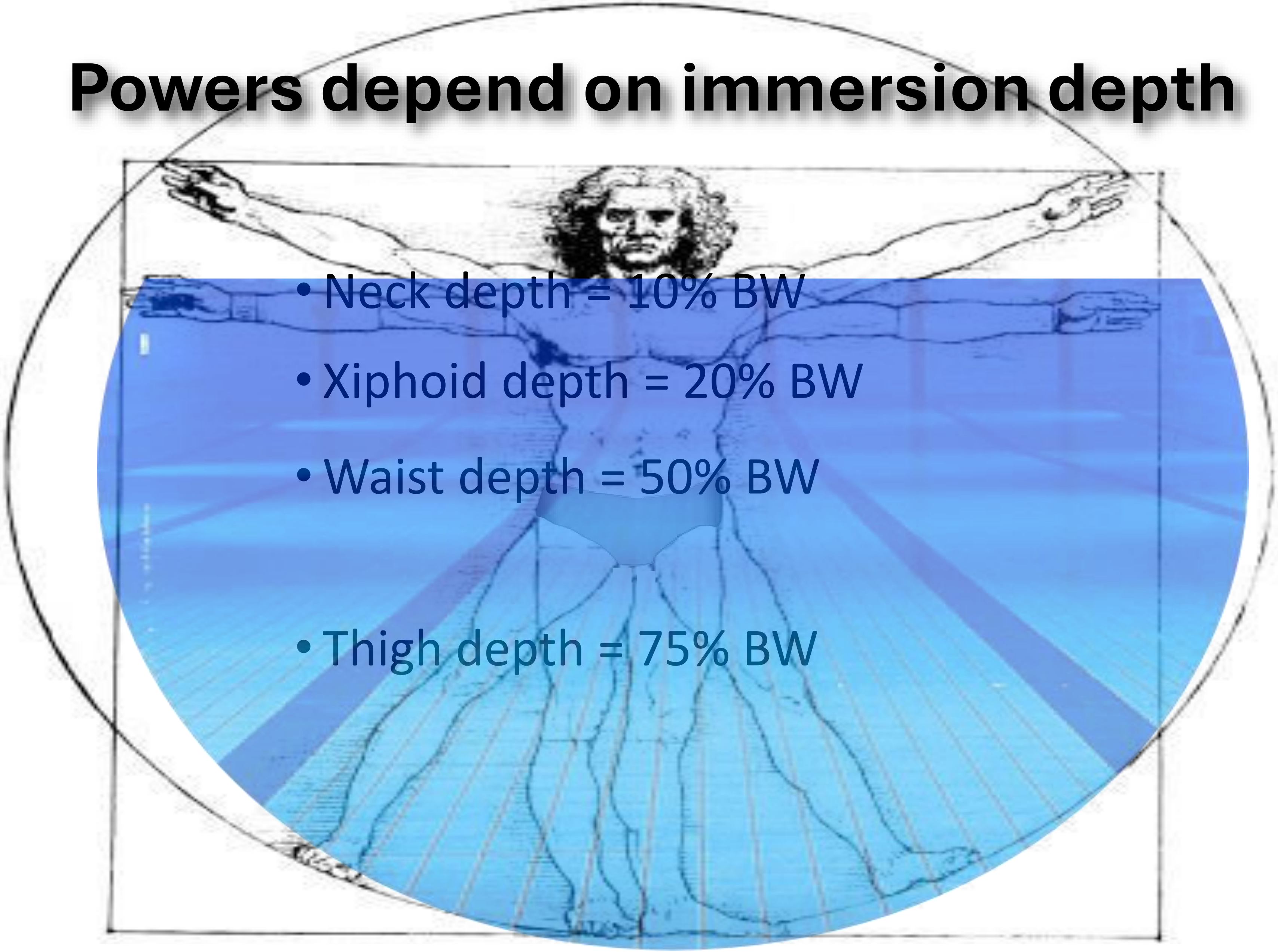
Ben Singh,[1] Hunter Bennett,[1] Aaron Miatke,[1] Dorothea Dumuid,[1] Rachel Curtis,[1] Ty Ferguson,[1] Jacinta Brinsley,[1] Kimberley Szeto,[1] Jasmine M Petersen,[1] Claire Gough,[2] Emily Eglitis,[1] Catherine EM Simpson,[1] Christina L Ekegren,[3] Ashleigh E Smith,[1] Kirk I Erickson,[4,5] Carol Maher[1]

- For brain health activities performed with low to moderate intensities were more effcient than the intensive Training;
- The combination of *Exergaming* (e.g. Wii Fit, VR-Fitness) and *Body-Mind-Exercise* (e.g. Yoga, Tai-Chi) showed best effects on cognition!

8



Powers depend on immersion depth



- Neck depth = 10% BW
- Xiphoid depth = 20% BW
- Waist depth = 50% BW
- Thigh depth = 75% BW

Thanks to Bruce
Adapted from Becker 2016

Clinical Evidence – Training in water will <u>always</u> influence brain (blood flow) health

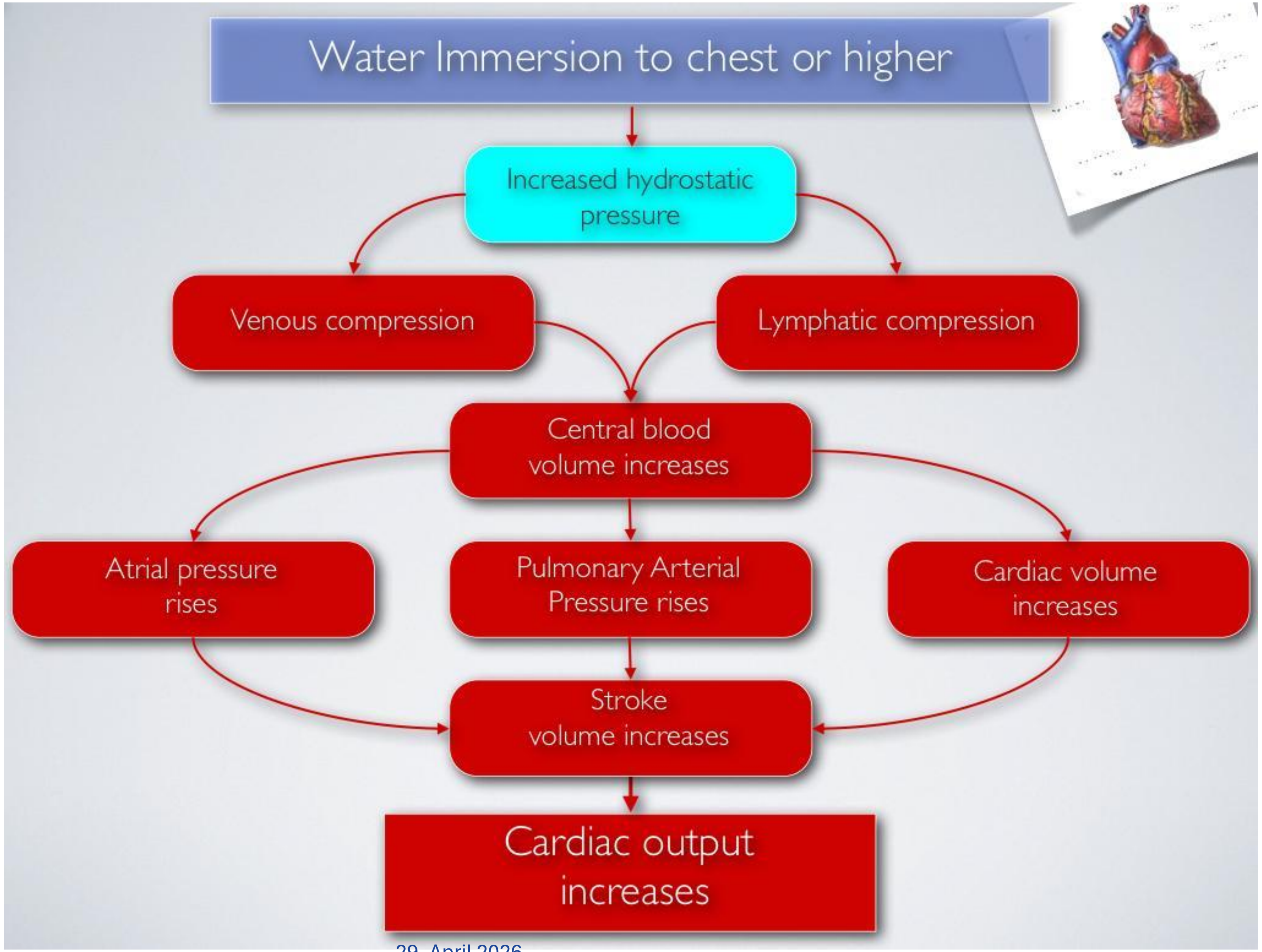
Most discussed aspects of aquatic exercise:

- Increased stroke volume
(Stroke volume / cardiac output +700 ml
→HR decreases by 12%) e.g. Pendergast et al. 2015, *Compr Physiol*;

- Increased breathing resistance (+60%)
→ e.g. Hoshi et al. 2022, *Physiol Rep*;

- Increased wash-out of inflammatory metabolites = better muscle regeneration.
→ e.g. Bunæs-Næss et al. 2023, *BMJ Open Sport Exerc Med*.

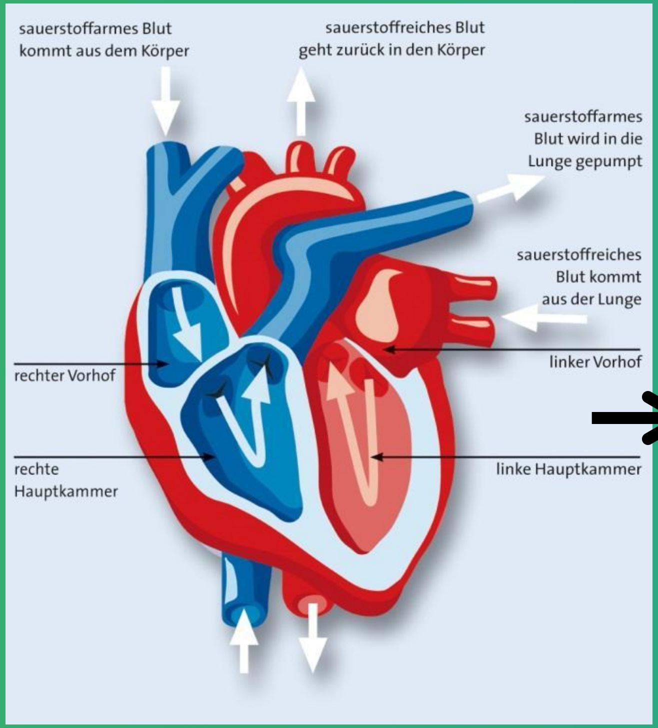
Key differences in Water

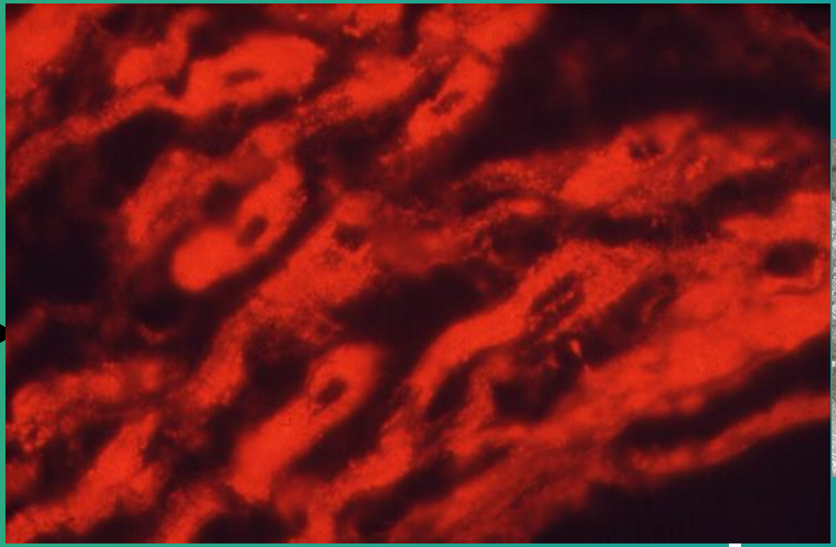


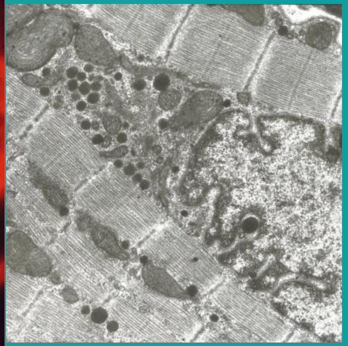
Modified from Becker 2016

Water compression leads to enhanced expressions of *Atrial Natriurectic Peptide* (ANP)

Effects on kidney functions and vasodilating of the vessels





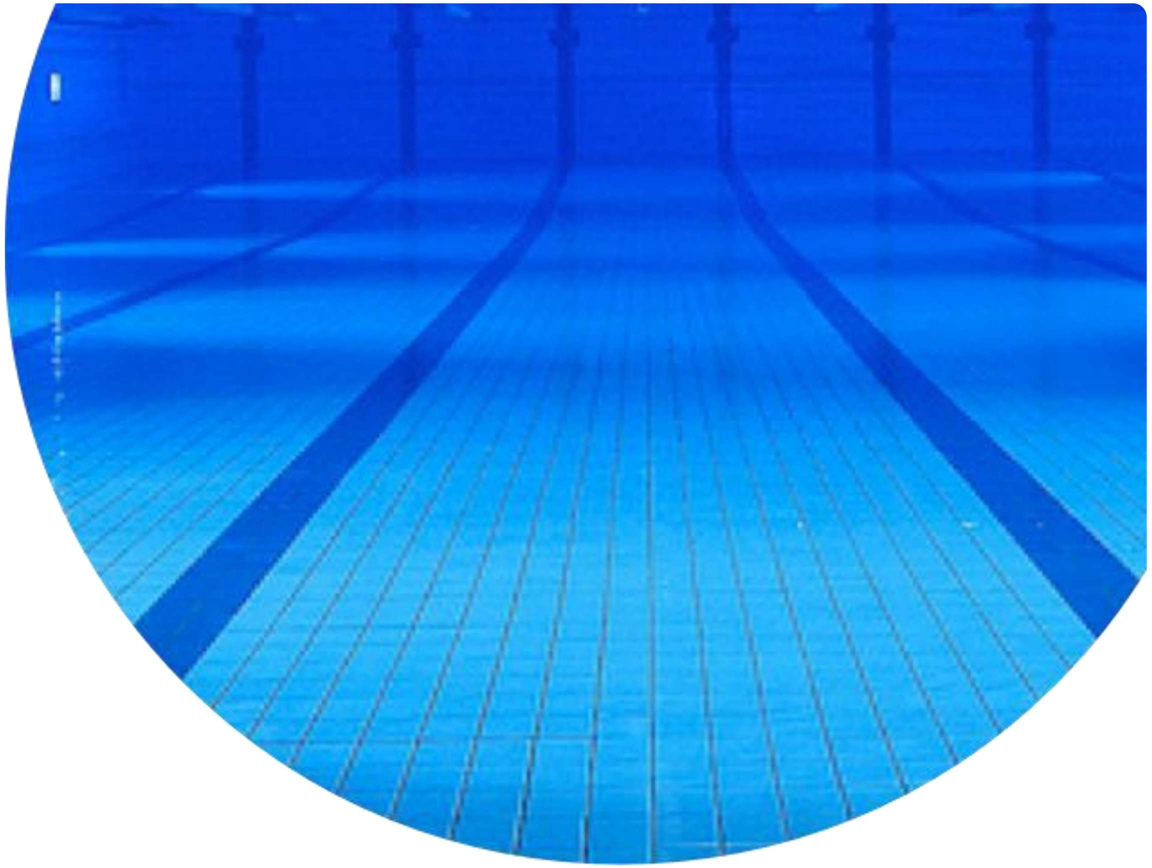


Adapted from Bloch 2018

Additional atrium distention that leads to ANP Release

Intensity regulation is more challenging in Water

- Regulation relies on the *combination* of *HR monitoring* (adjusted to immersion depth and temperatures);
- *Ratings of perceived exertions (RPE→ Borg 6-20);*
- *Movement velocity* and/or *task complexity*
- *Overload* is achieved through *interval durations, work-rest ratios, speed, turbulences, surface area devices and coordinative demands*



Schnitzer W, Fenzl M et al. *Phys Med Rehab Kuror* 2006;16:330-336.

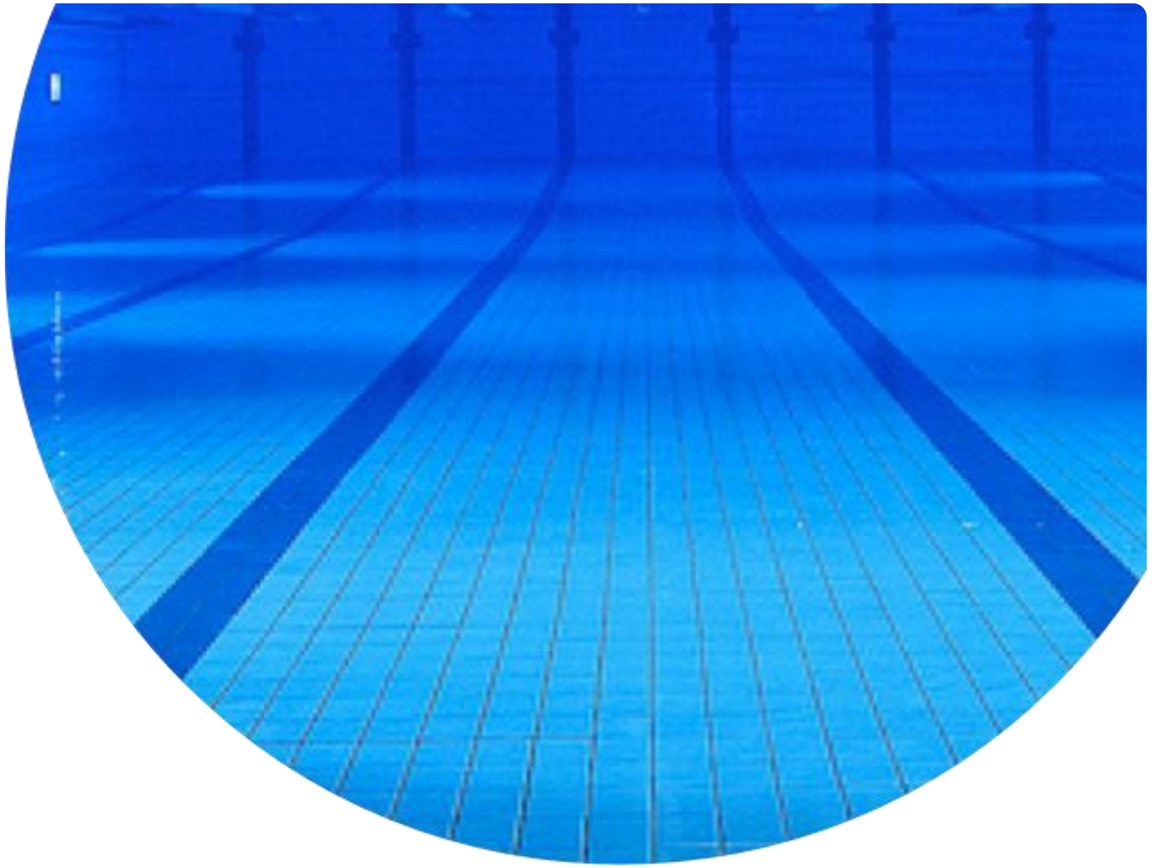
Adjustments of the *Training Heart Rate* (THR) in Water!

- *Strong* influence of water temperatures on HR
- Corrections for heart rates are needed if training is performed at/or below ***31°C or above 34°C***

- Corrections by adding (hot) and <u>subtracting</u> (cooler):

  3–4 beats/Min at 30°C

  6–7 beats/Min below 28°C



Schnitzer W, Fenzl M et al. *Phys Med Rehab Kuror* 2006;16:330-336.

To HIIT or not to HIIT also in Water?

BMJ Journals

BMJ Open Sport & Exercise Medicine

Latest content | Archive | For authors | Blog | About | Topic Collections

Home / Archive / Volume 9, Issue 4

Systematic review · 14 November 2023 · Open access

Request permissions | Cite this article | Share | Download PDF

Aquatic high-intensity interval training (HIIT) may be similarly effective to land-based HIIT in improving exercise capacity in people with chronic conditions: a systematic review and meta-analysis

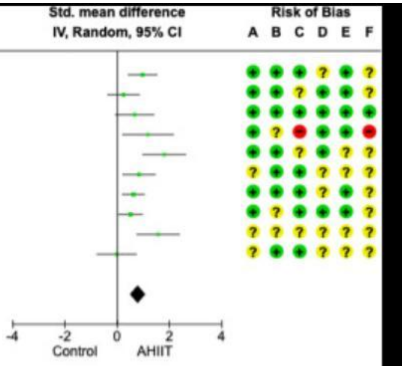
Author affiliations • Heidi Bunæs-Næss [1], Linda Aimée Hartford Kvæl [1], Birgitta Blakstad Nilsson [2], Sophie Heywood [3], Kristi Elisabeth Heiberg [1]

Study or Subgroup	AHIIT Mean	AHIIT SD	AHIIT Total	Control Mean	Control SD	Control Total	Weight	Std. mean difference IV, Random, 95% CI
Andrade 2017 (FM)	15.9	3.9	27	12.6	2.7	27	11.7%	0.97 [0.40 , 1.54]
Costa 2018 (Dyslipidemia)	28.48	2.8632	20	27.58	4.3375	20	10.8%	0.24 [-0.38 , 0.86]
Delevatti 2020 (DM2)	36.25	6.8505	13	32	5.64	16	8.8%	0.67 [-0.09 , 1.42]
Gallo-Silva 2019 (COPD)	541.3	66.7	10	442.2	93.7	9	6.3%	1.18 [0.18 , 2.17]
Kargarfard 2018 (MS)	503	57	17	418	29	15	7.8%	1.80 [0.96 , 2.64]
Mohr 2014 (HT)	692	343.7	21	454	192.3	20	10.5%	0.83 [0.19 , 1.47]
Munukka 2016 (OA)	2.4	2.0859	42	1.1	2.0859	42	14.1%	0.62 [0.18 , 1.06]
Park 2019 (PAD)	20.5	5.2	35	17.8	5.3	37	13.5%	0.51 [0.04 , 0.98]
Samadi 2019 (PCOS)	35.2	1.54	15	32.78	1.47	15	7.9%	1.56 [0.73 , 2.40]
Wadell 2004 (COPD)	18	3.32	14	18.1	5.33	12	8.6%	-0.02 [-0.79 , 0.75]
Total (95% CI)			**214**			**213**	**100.0%**	**0.78 [0.48 , 1.08]**

Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 18.81$, df = 9 (P = 0.03); $I^2 = 52\%$

Test for overall effect: Z = 5.08 (P < 0.00001)

Test for subgroup differences: Not applicable



Risk of bias legend
(A) Bias arising from the randomization process
(B) Bias due to deviations from intended interventions
(C) Bias due to missing outcome data
(D) Bias in measurement of the outcome
(E) Bias in selection of the reported result
(F) Overall bias

- **18 studies of which 16 were included into the meta-analysis**

➢ Primary outcome *Exercise Capacity (Vo2 peak, 6-12 MWT, submax physical fitness tests);*

➢ AHIIT had <u>similar effects</u> on exercise capacity as LBIT and may represent an alternative for people unable to perform LBHIIT

➢ **Studies hold severe deficiencies on reporting (Progression, Overload, Intensity)**

Bunæs-Næss et al. *BMJ Open Sport Exerc Med*. 2023 Nov 14;9(4):e001639.

To HIIT or not to HIIT also in Water?

BMJ Journals

search | Search | Advanced search

BMJ Open Sport & Exercise Medicine

Latest content Archive For authors Blog About Topic Collections

Home / Archive / Volume 9, Issue 4

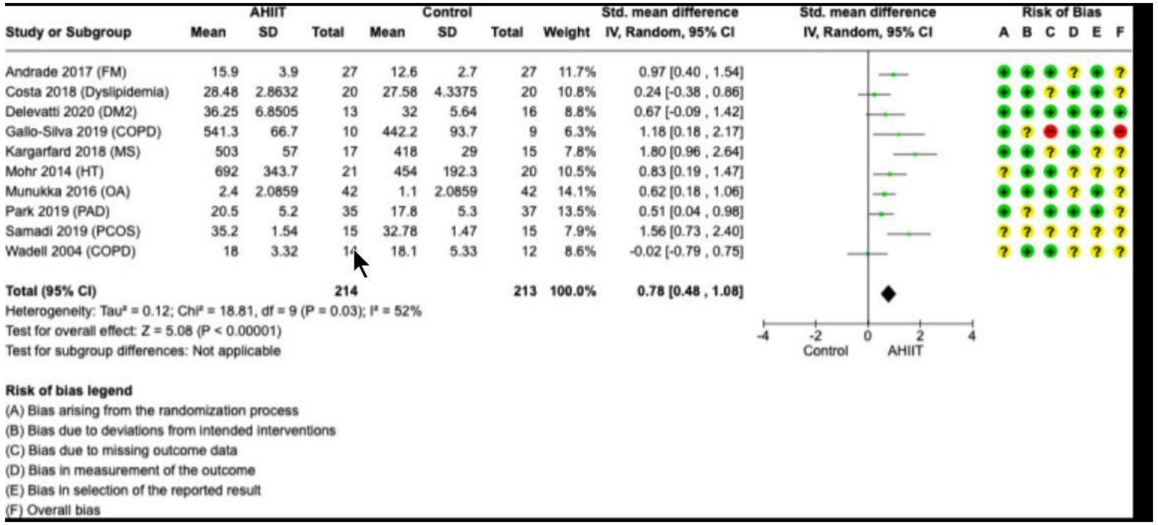
Email alerts

Systematic review · 14 November 2023 · Open access

Request permissions Cite this article Share Download PDF

Aquatic high-intensity interval training (HIIT) may be similarly effective to land-based HIIT in improving exercise capacity in people with chronic conditions: a systematic review and meta-analysis

Author affiliations · Heidi Bunæs-Næss [1], Linda Aimée Hartford Kvæl [1], Birgitta Blakstad Nilsson [2], Sophie Heywood [3], Kristi Elisabeth Heiberg [1]



Study or Subgroup	AHIIT Mean	AHIIT SD	AHIIT Total	Control Mean	Control SD	Control Total	Weight	Std. mean difference IV, Random, 95% CI
Andrade 2017 (FM)	15.9	3.9	27	12.6	2.7	27	11.7%	0.97 [0.40 , 1.54]
Costa 2018 (Dyslipidemia)	28.48	2.8632	20	27.58	4.3375	20	10.8%	0.24 [-0.38 , 0.86]
Delevatti 2020 (DM2)	36.25	6.8505	13	32	5.64	16	8.8%	0.67 [-0.09 , 1.42]
Gallo-Silva 2019 (COPD)	541.3	66.7	10	442.2	93.7	9	6.3%	1.18 [0.18 , 2.17]
Kargarfard 2018 (MS)	503	57	17	418	29	15	7.8%	1.80 [0.96 , 2.64]
Mohr 2014 (HT)	692	343.7	21	454	192.3	20	10.5%	0.83 [0.19 , 1.47]
Munukka 2016 (OA)	2.4	2.0859	42	1.1	2.0859	42	14.1%	0.62 [0.18 , 1.06]
Park 2019 (PAD)	20.5	5.2	35	17.8	5.3	37	13.5%	0.51 [0.04 , 0.98]
Samadi 2019 (PCOS)	35.2	1.54	15	32.78	1.47	15	7.9%	1.56 [0.73 , 2.40]
Wadell 2004 (COPD)	18	3.32	14	18.1	5.33	12	8.6%	-0.02 [-0.79 , 0.75]
Total (95% CI)			**214**			**213**	**100.0%**	**0.78 [0.48 , 1.08]**

Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 18.81$, $df = 9$ ($P = 0.03$); $I^2 = 52\%$

Test for overall effect: $Z = 5.08$ ($P < 0.00001$)

Test for subgroup differences: Not applicable

Risk of bias legend

(A) Bias arising from the randomization process

(B) Bias due to deviations from intended interventions

(C) Bias due to missing outcome data

(D) Bias in measurement of the outcome

(E) Bias in selection of the reported result

(F) Overall bias

- **18 studies of which 16 were included into this meta-analysis**

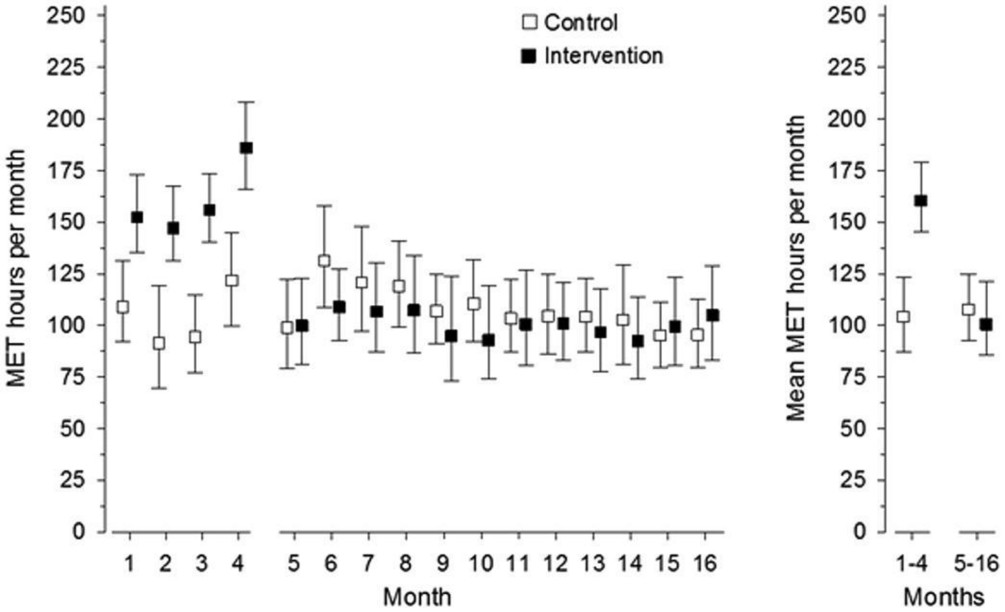
➢ The AHIIT group included four intervals of 4 min at high intensity (Borg scale 14–18).

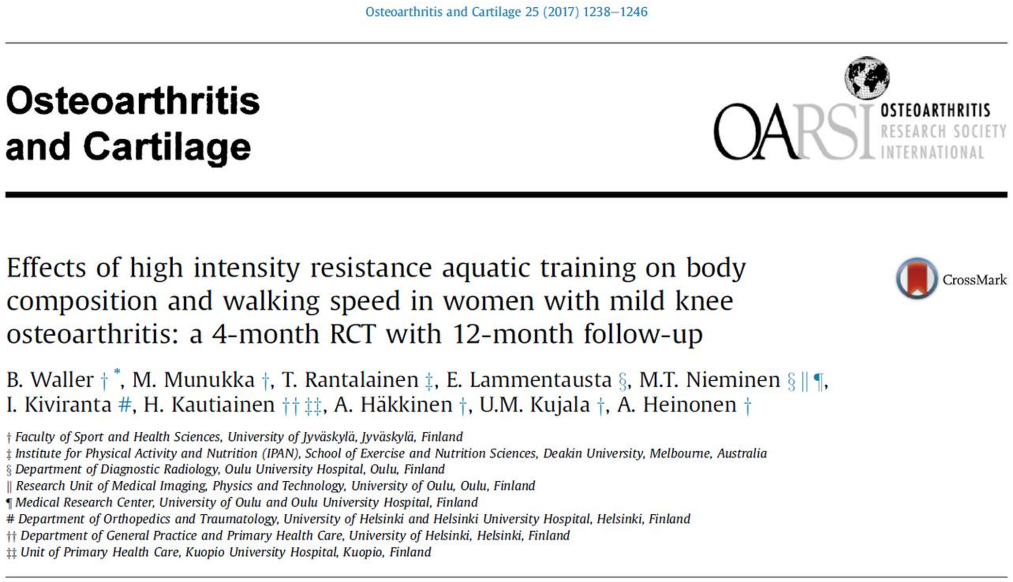
➢ Both group comprised of 5–15 participants who exercised in 32–34 °C, maintaining an immersion to a level of xiphoid process.

➢ Both groups completed training sessions lasting for 45–60 min, conducted two times per week on non-consecutive days for 12 weeks.

Bunæs-Næss et al. *BMJ Open Sport Exerc Med*. 2023 Nov 14;9(4):e001639.

High-intensive aquatic resistance training in mild knee artritis




Osteoarthritis and Cartilage 25 (2017) 1238–1246

Osteoarthritis and Cartilage

OARSI OSTEOARTHRITIS RESEARCH SOCIETY INTERNATIONAL

Effects of high intensity resistance aquatic training on body composition and walking speed in women with mild knee osteoarthritis: a 4-month RCT with 12-month follow-up

CrossMark

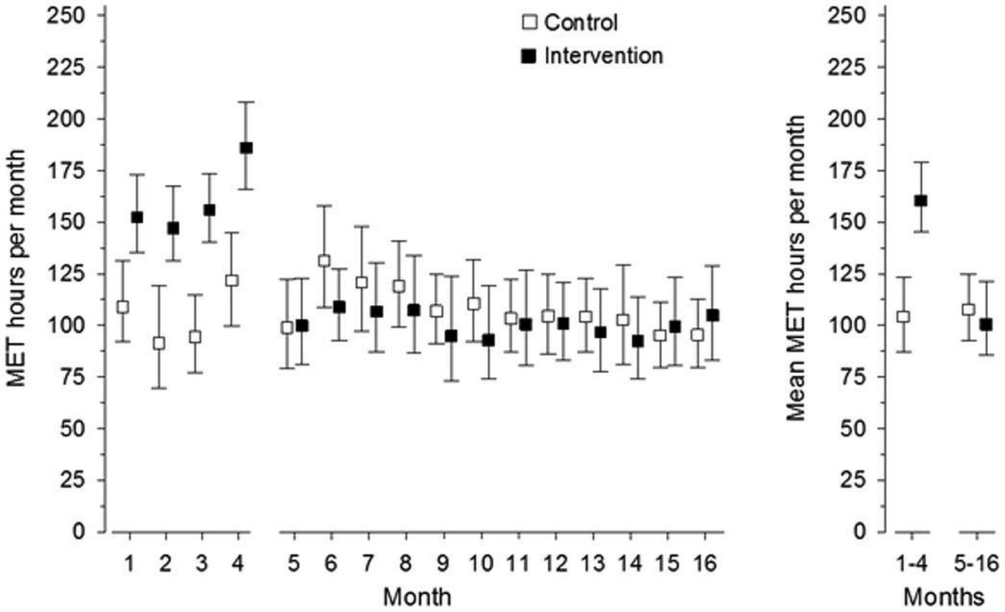
B. Waller † *, M. Munukka †, T. Rantalainen ‡, E. Lammentausta §, M.T. Nieminen § || ¶, I. Kiviranta #, H. Kautiainen †† ‡‡, A. Häkkinen †, U.M. Kujala †, A. Heinonen †

† Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
‡ Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Melbourne, Australia
§ Department of Diagnostic Radiology, Oulu University Hospital, Oulu, Finland
|| Research Unit of Medical Imaging, Physics and Technology, University of Oulu, Oulu, Finland
¶ Medical Research Center, University of Oulu and Oulu University Hospital, Finland
# Department of Orthopedics and Traumatology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
†† Department of General Practice and Primary Health Care, University of Helsinki, Helsinki, Finland
‡‡ Unit of Primary Health Care, Kuopio University Hospital, Kuopio, Finland

- HIT group (*n* = 43) participated in 48 supervised intensive aquatic resistance training sessions over 4-months while the control group (*n* = 44) maintained normal physical activity;
- 84 participants continued into the 12-months' follow-up;
- HIT decreased *fat mass* and improved *walking speed* in post-menopausal women with mild knee OA.

High-intensive aquatic resistance training in mild knee artritis

valens



Osteoarthritis and Cartilage 25 (2017) 1238–1246

Osteoarthritis and Cartilage

OARSI OSTEOARTHRITIS RESEARCH SOCIETY INTERNATIONAL

Effects of high intensity resistance aquatic training on body composition and walking speed in women with mild knee osteoarthritis: a 4-month RCT with 12-month follow-up

CrossMark

B. Waller † *, M. Munukka †, T. Rantalainen ‡, E. Lammentausta §, M.T. Nieminen § ‖ ¶, I. Kiviranta #, H. Kautiainen †† ‡‡, A. Häkkinen †, U.M. Kujala †, A. Heinonen †

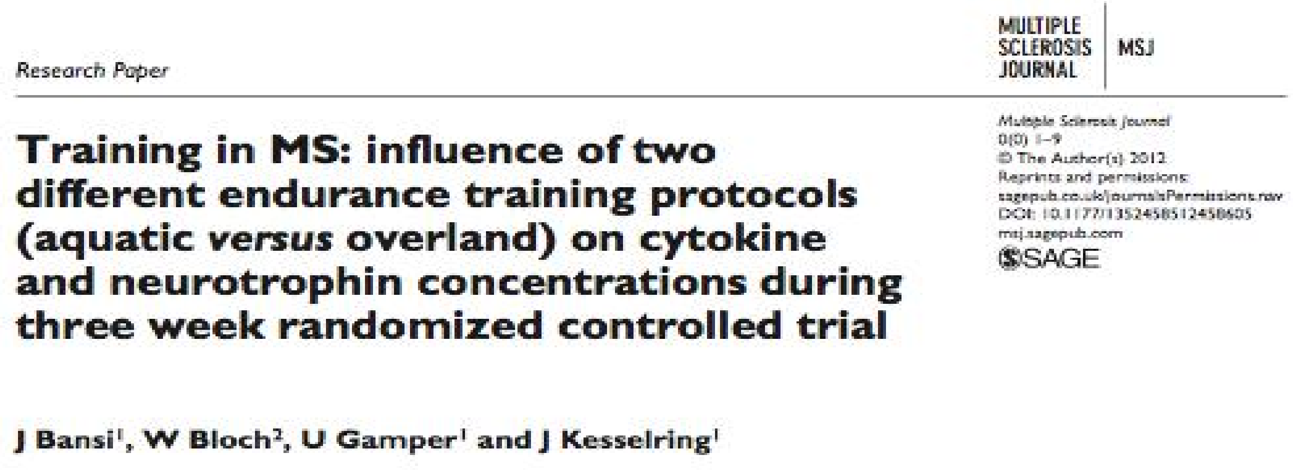
† Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
‡ Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Melbourne, Australia
§ Department of Diagnostic Radiology, Oulu University Hospital, Oulu, Finland
‖ Research Unit of Medical Imaging, Physics and Technology, University of Oulu, Oulu, Finland
¶ Medical Research Center, University of Oulu and Oulu University Hospital, Finland
# Department of Orthopedics and Traumatology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
†† Department of General Practice and Primary Health Care, University of Helsinki, Helsinki, Finland
‡‡ Unit of Primary Health Care, Kuopio University Hospital, Kuopio, Finland

- HIT sessions lasted 1 h, 3x per week for 16 weeks (48 sessions);
- HIT used variable resistance equipment to progress training intensity with three resistance levels: barefoot, small resistance fins (Theraband products USA) and large resistance boots (Hydro-boots, USA).
- Training intensity was set at as “*hard and fast as possible*”

2010 Research Paper

- **First Research** with MS: pioneers for aquatic cycling

(Thanks to Urs for making this possible!)



Research Paper

MULTIPLE SCLEROSIS JOURNAL | MSJ

Multiple Sclerosis Journal
0(0) 1–9

DOI: 10.1177/1352458512458605
msj.sagepub.com
SAGE

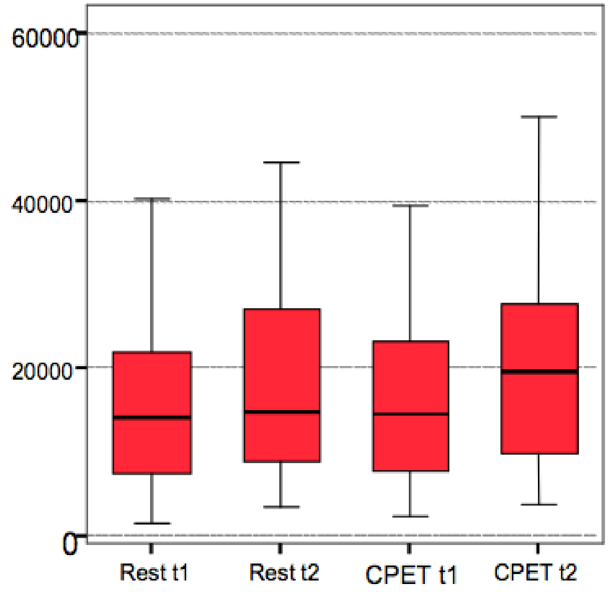
Training in MS: influence of two different endurance training protocols (aquatic *versus* overland) on cytokine and neurotrophin concentrations during three week randomized controlled trial

J Bansi[1], W Bloch[2], U Gamper[1] and J Kesselring[1]

- Aquatic cycling group showed significant BDNF increases by *3387* pg/ml (95% CI -593.4-7367.6; p=0.046) !

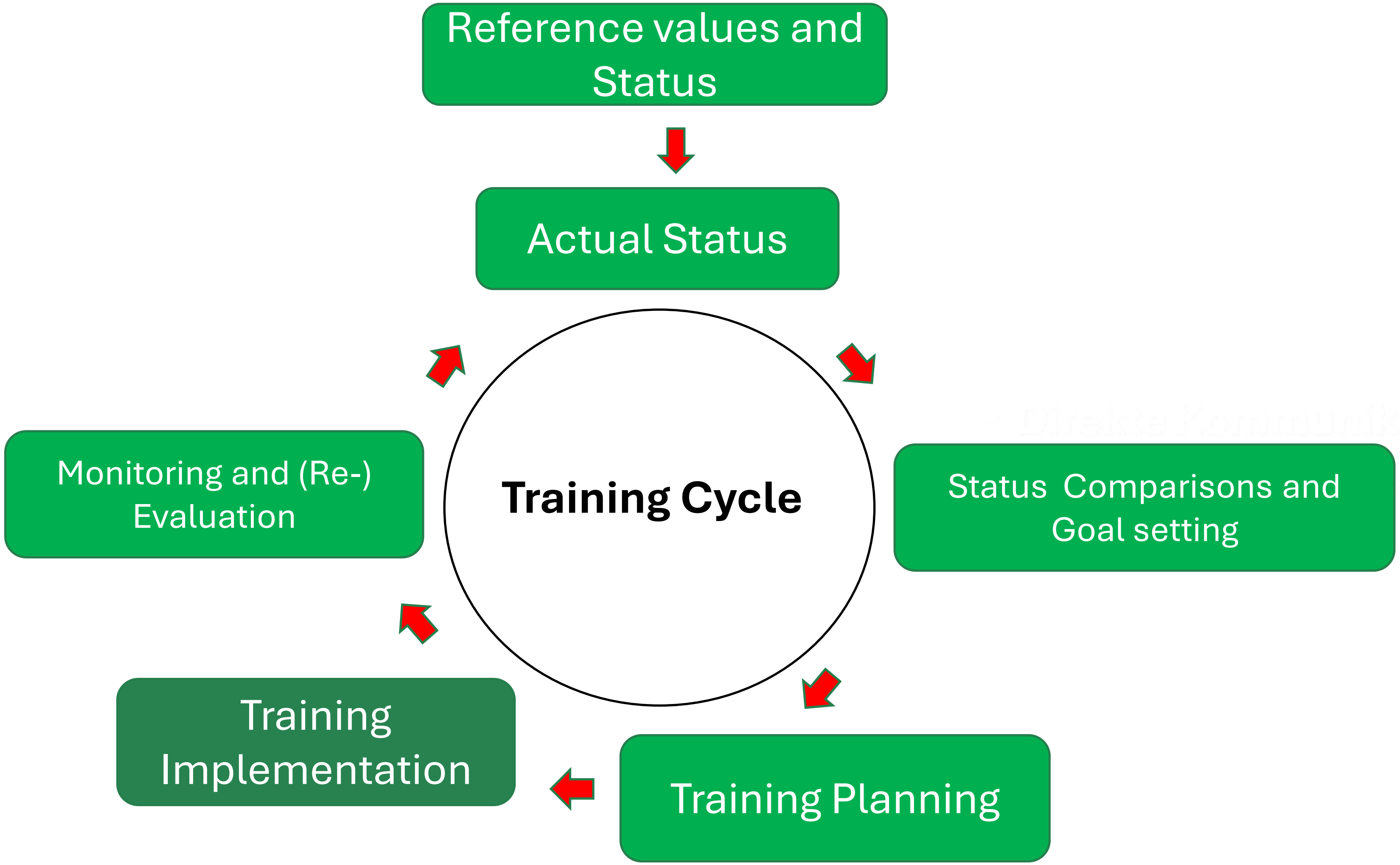
- 3-weeks aquatic cycling at 28°C with 70% HR_{peak} (– 6 beats) vs over land cycling 70% HR_{peak}

- **Training intensities moderate**



1. Future Challenges – Focus non communicable diseases
2. Clinical evidence for HIAE → Prescription and progression strategies
3. **Conlusions / Take Home**

Take Home 1 Relevance of an *Evaluation Loop*



Adapted from Bansi, de Bruin and Eggenberger OST 2024

SMART

- Specific
- Measurable
- Accepted
- Realistic
- Terminated

FITT

- *Frequency* (Volume)
- Intensity
- Type
- Terminated

Take Home 2 — Relevance of Training Principles

valens

- **Specific** – Adaptations **are** applied specifically (muscular and/or organs);

- **Progression –** Over time the body adapts to the applied intensity (*Dose-Response Relationship*, DRR) → to avoid stagnation volume and/or Intensity must be increased;

- **Overload –** To significantly increase cardiorespiratory fitness the applied training intensities must be higher than the normal activities of daily living (Out of the Box);

- **Reference Value** – Interventions must be individually taillored: a baseline value must be assessed at begin and needs to be re-evaluated over time → Adaptations are greater with low baseline fitness (DRR).

Take Home 3 Relevance of Training Principles

valens

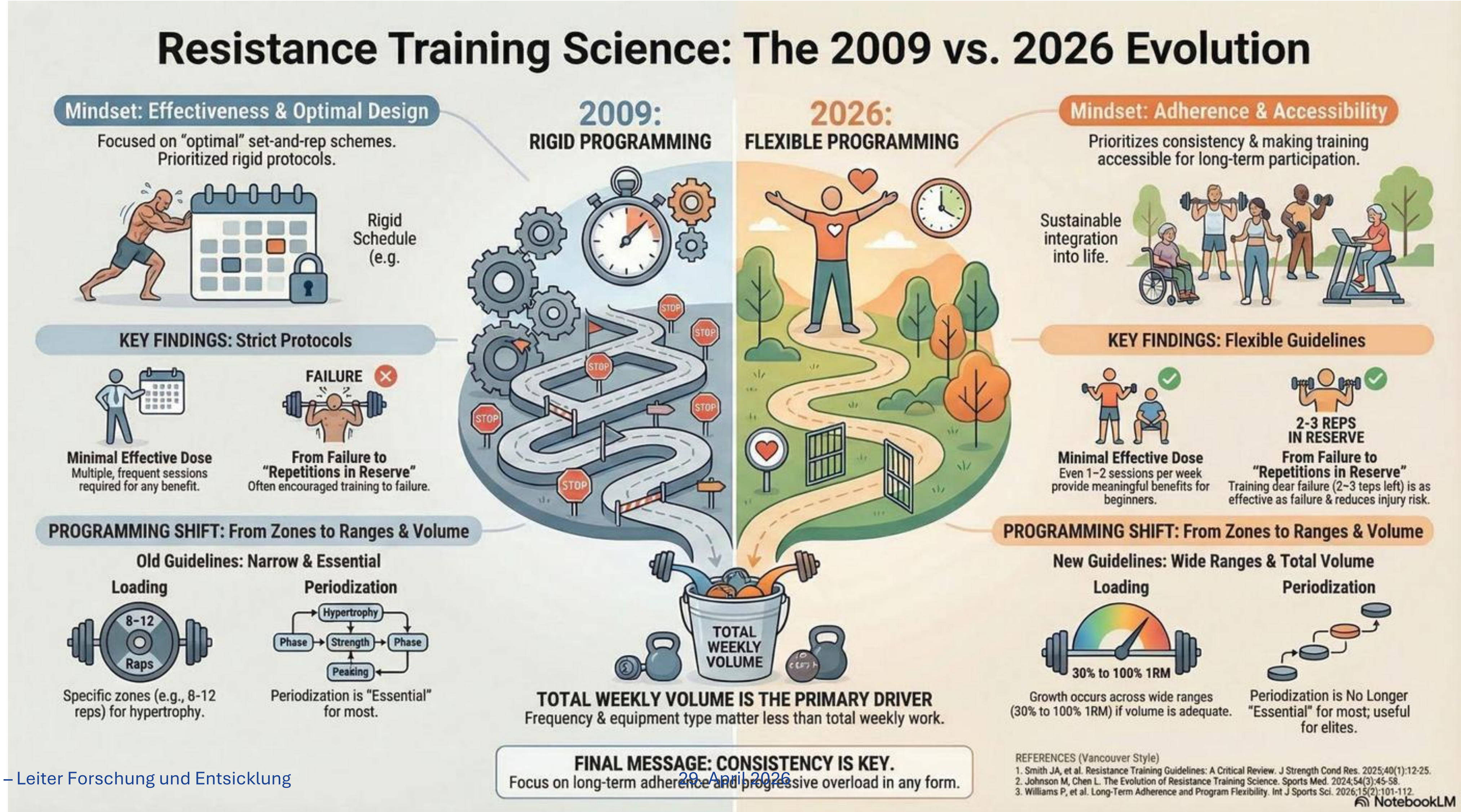
Progression – Over time the body adapts to the applied intensity (*Dose-Response Relationship*, DRR) → to avoid stagnation volume and/or Intensity must be increased;

Overload – To significantly increase cardiorespiratory fitness the applied training intensities must be higher than the normal activities of daily living (Out of the Box);

Achie Interventions must be individually taillored: a baseline value must be assessed at begin and needs to be re-evaluated over time → Adaptations are greater with low baseline fitness (DRR).

Take Home 3: *Consistency is the Key*

ACSM, Guideline shift (2009 vs 2026) on resistance training



Thank you for the Attention

valens

Rehaklinik Valens
Taminaplatz 1
7317 Valens
info.valens@kliniken-valens.ch
www.valens.ch/reha-valens

Dr Jens Bansi
Mail: jens.bansi@kliniken-valens.ch
Phone: +41 58 511 13 02

Getting the Dosage Right – Graded Exercise Testing

ICEBAT 2026, Toronto

Meet Walti

You meet Walti at your first Session.
Who would perform Exercise Testing?

- MS since 1979;
- EDSS 6.0;
- Course: relapsing-remitting, since 2010 secondary progressive

CPET
RCP (80% VO2max, 85% HFmax

- MS since 1979;
- EDSS 6.0;
- Course: Relapsing-remitting, since 2010 secondary progressive

Your Prescription for Health
ExeRcise is Medicine®

1 HOW TO USE THE ACTION GUIDE
2 PROMOTING PHYSICAL ACTIVITY IN YOUR CLINIC
3 ASSESSING PHYSICAL ACTIVITY
4 PRESCRIBING PHYSICAL ACTIVITY
5 PROVIDING PHYSICAL ACTIVITY REFERRALS
6 BEING A CHAMPION IN YOUR HEALTH SYSTEM

Appendix D - ACSM Risk Stratification Screening Questionnaire

Assess your health by marking all true statements.

<u>You have had</u>:

___ a heart attack
___ heart failure
___ cardiac arrhythmia
___ known heart murmur
___ congenital heart disease
___ any heart surgery
___ coronary angioplasty
___ heart palpitations

You have:

____ experienced chest pain with mild exertion
____ experienced dizziness, fainting, or blackouts with mild exertion
____ experienced unusual fatigue or shortness of breath during usual activities
____ been prescribed heart medications (please indicate):

Check all that apply:

____ you are a man older than 45 years
____ you smoke
____ your blood pressure is greater than 140/90
____ you take blood pressure medication
____ you are completely physically inactive
____ you currently have bone/joint problems
____ you have had a recent injury/surgery
____ you are a diabetic or take medicine to control your blood sugar
____ you have been diagnosed with high cholesterol >200 (or HDL is less than 35 mg/dL or LDL is greater than 169 mg/dL)
____ you have a close blood relative who had a heart attack before age 55 (father/brother) or age 65 (mother/sister)

____ Other (specify) ____

Use the following risk stratification scoring table (page 17) to sum the total number of risk factors present in your patient in determining their current level of cardiovascular disease risk.

You have:

___ experienced chest pain with mild exertion
___ experienced dizziness, fainting, or blackouts with mild exertion
___ experienced unusual fatigue or shortness of breath during usual activities
___ been prescribed heart medications (please indicate):

Check all that apply:

___ you are a man older than 45 years
___ you smoke
___ your blood pressure is greater than 140/90
___ you take blood pressure medication
___ you are completely physically inactive
___ you currently have bone/joint problems
___ you have had a recent injury/surgery
___ you are a diabetic or take medicine to control your blood sugar
___ you have been diagnosed with high cholesterol >200 (or HDL is less than 35 mg/dL or LDL is greater than 169 mg/dL)
___ you have a close blood relative who had a heart attack before age 55 (father/brother) or age 65 (mother/sister)

___ Other (specify) ____

Use the following risk stratification scoring table (page 17) to sum the total number of risk factors present in your patient in determining their current level of cardiovascular disease risk.

Your Prescription for Health
ExeRcise is Medicine®

HEALTHCARE PROVIDERS' ACTION GUIDE

1 HOW TO USE THE ACTION GUIDE
2 PROMOTING PHYSICAL ACTIVITY IN YOUR CLINIC
3 ASSESSING PHYSICAL ACTIVITY
4 PRESCRIBING EXERCISE
5 PROVIDING EXERCISE REFERRALS
6 BEING A CHAMPION IN YOUR HEALTH SYSTEM

Risk Stratification Scoring

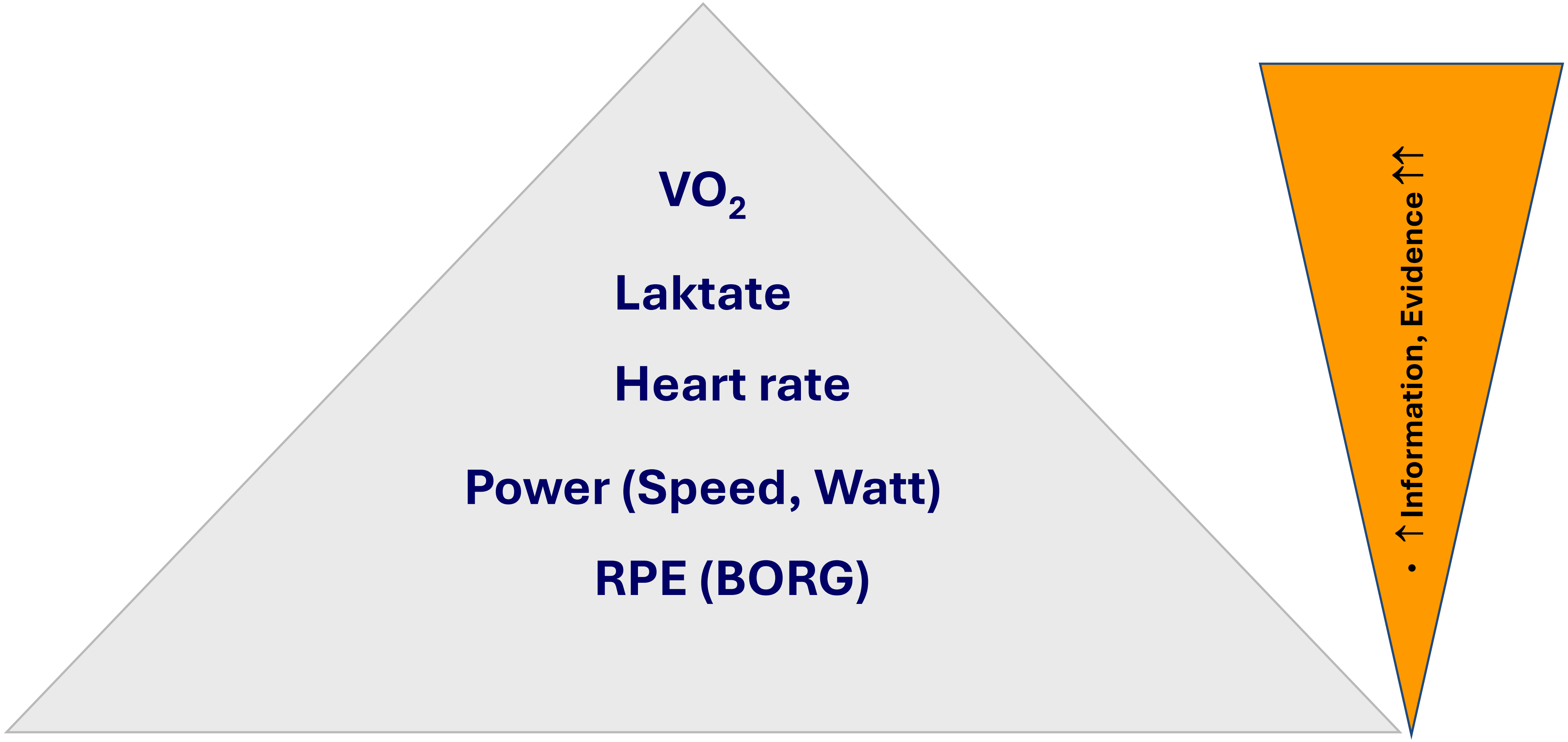
Positive Risk Factors	Defining Criteria	Points
Age	Men ≥ 45 years, Women ≥ 55 years	+1
Family History	Myocardial infarction, coronary revascularization, or sudden death before 55 years of age in father of other 1st degree male relative or before 65 years of age in mother or other 1st degree female relative	+1
Cigarette Smoking	Current cigarette smoker or those who quit within the previous six months, or exposure to environmental tobacco smoke (i.e., secondhand smoke)	+1
Sedentary Lifestyle	Not participating in at least 30 minutes of moderate-intensity physical activity on at least three days/week for at least three months	+1
Obesity	Body mass index ≥30 kg/m^2 or waist girth >102 cm (40 inches) for men >88 cm (35 inches) for men	+1
Dyslipidemia	Low-density lipoprotein (LDL) cholesterol ≥ 130mg/dL (3.37 mmol/L) or high-density lipoprotein (HDL) cholesterol <40mg/dL (1.04mmol/L) or currently on lipid-lowering medication; If total serum cholesterol is all that is available, use serum cholesterol >200 mg/dL (5.18mmol/L)	+1
Prediabetes	Fasting plasma glucose ≥100 mg/dL (5.50 mmmol/L) but <126 mg/dL (6.93 mmol/L) or impaired glucose tolerance (IGT) where a two-hour oral glucose tolerance test (OGTT) value is ≥140 mg/dL (7.70 mmol/L), but <200 mg/dL (11.00mmol/L)	+1
Negative Risk Factors	**Defining Criteria**	**Points**
High HDL Cholesterol	≥60 mg/dL (1.55 mmol/L)	-1

Total CVD Risk Score: ____________

* See Appendix E for Risk Categories and related recommendations for Screening, Clinical Testing, and Exercise Recommendations.

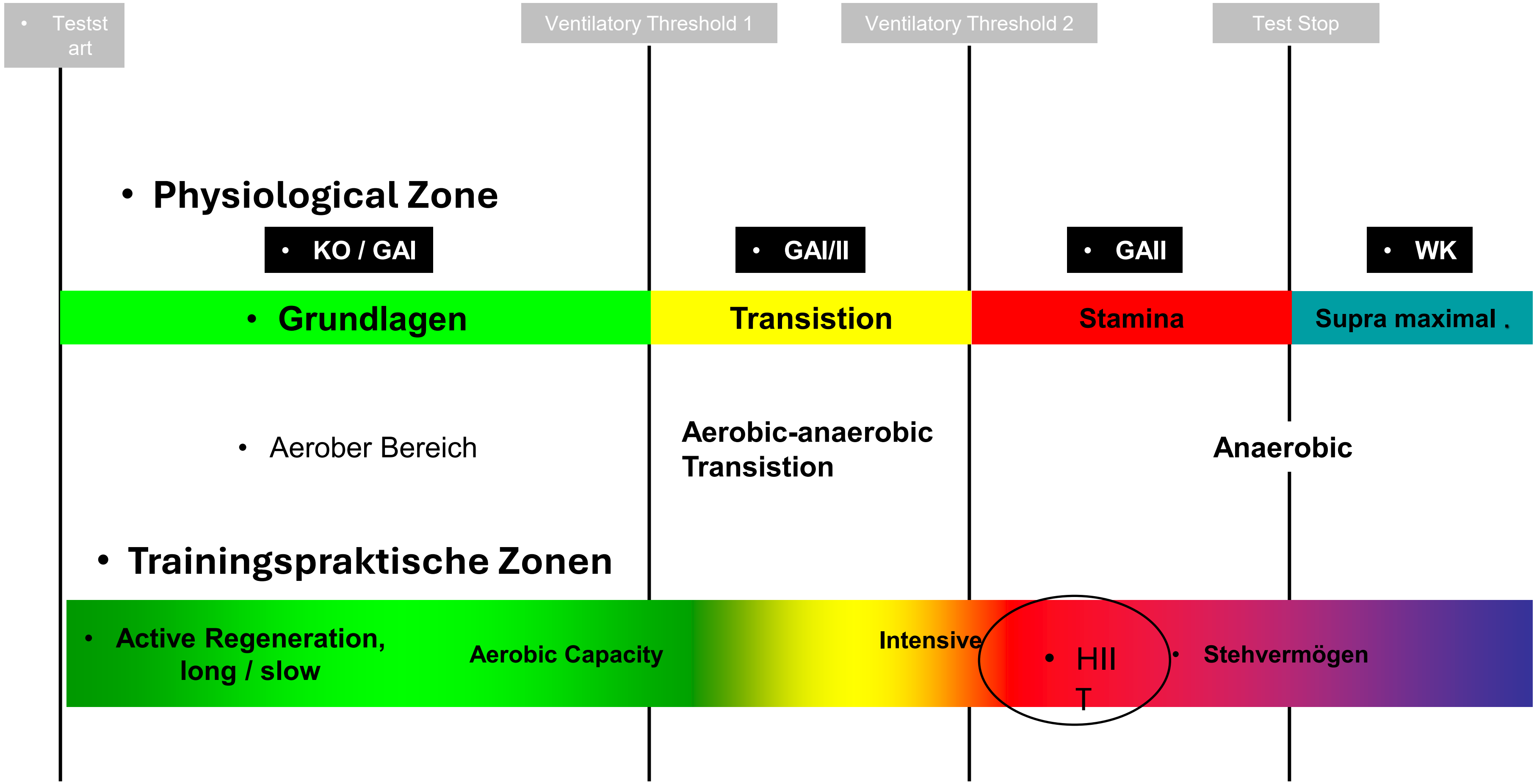
Dosing Principle

valens



Modified SWI, Magglingen, 2009

Training Zones of Endurance Training



RPE – Ratings of Percieved Exertion

Intensity	Very light	Light	Some what hard	Hard	Very hard
RPE with Borg sclaes: 6-20 or (1-10)	8-9 (1-2)	**10-12 (3-4)**	13-14 (5-6)	15-16 (7-8)	17-20 (9-10)
RPE (Speech)	Secure speech	**Converstaions**	Whole Sentences	Exchange of Words	Breathing accelerated
%HFpeak (Exercise test) %HRR Laktate(untrained)	60-70% 45-55% 2 mmol/L	**70-80%** **55-70%** **2-3 mmol/L**	80-90% 70-80% 3-4 mmol/L	90-95% 80-90% 4-7 mmol/L	95-100% >90% >7-12 mmol/L
$\%VO_2$peak	45-55%	**55-70%**	70-80%	80-90%	90-100%
Trainingsmethods	Regeneration	**Extensive Exerecise**	Intensive	HIT Baseline	HIT 2nd Week

Training Methods (HFmax)

Aerobic Capacity (65-70% of HRpeak):
- 20-30 Min continous cycling at 60-70 RPM
- (2 Min Warm-Up / Cool-Down)

RPE: 12-14

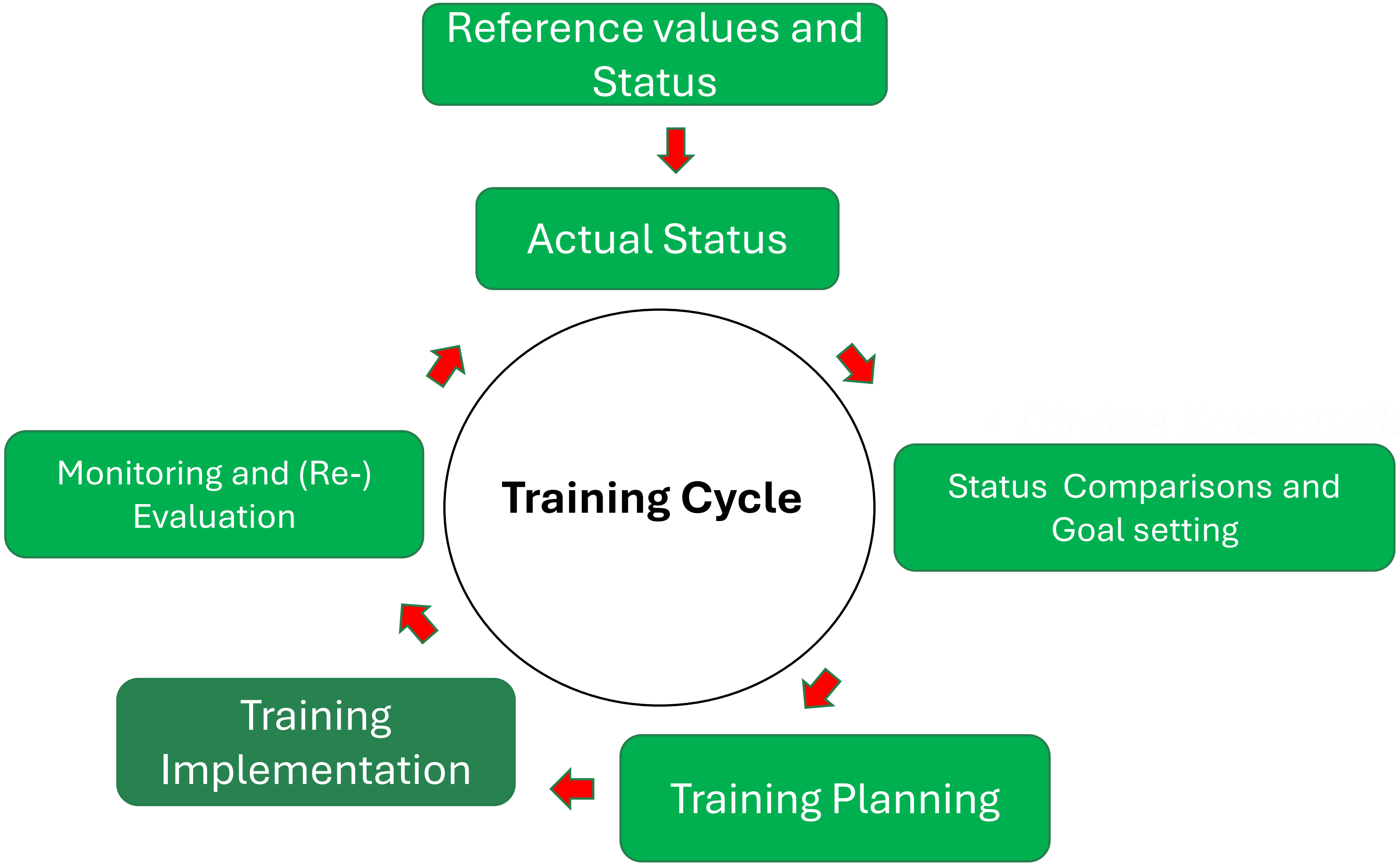
HIIT (90-95% of HRpeak):
- 5x 1Min at 95% HFmax in between Intervalls wait till HR decreases to 65%;
- Perform min 3 max 5 Intervalls

(2 Min Aufwärmen / Cool-Down)

RPE: 17-20

Take Home 1 Relevance of an *Evaluation Loop*

valens



Adapted from Bansi, de Bruin and Eggenberger OST 2024

SMART

- Specific
- Measurable
- Accepted
- Realistic
- Terminated

FITT

- *Frequency* (Volume)
- Intensity
- Type
- Terminated

Thank you for the Attention

valens

Rehaklinik Valens
Taminaplatz 1
7317 Valens
info.valens@kliniken-valens.ch
www.valens.ch/reha-valens

Dr Jens Bansi
Mail: jens.bansi@kliniken-valens.ch
Phone: +41 58 511 13 02

EFQM RECOGNISED BY EFQM 2024 ★★★★★

PME HANDELSZEITUNG BESTE ARBEITGEBER 2025 SCHWEIZ In Zusammenarbeit mit statista

FRIENDLY WORK SPACE

Folge uns auf Social-Media

CanChild
f-words for Child Development

Splashing through the F-words for Child Development: Exploring the holistic benefits of aquatics for children with developmental concerns and disabilities

Andrea Cross, PhD
Assistant Professor, Department of Pediatrics, McMaster University
Scientist, CanChild Centre for Childhood-Onset Disability Research

McMaster University Department of Pediatrics
CanChild

OBJECTIVES

- **Part I:** Structured swim program for children with autism spectrum disorder and communication delays
- **Part II:** Applying the F-words for Child Development to aquatics

CanChild

PART I

STRUCTURED SWIM PROGRAM

CanChild

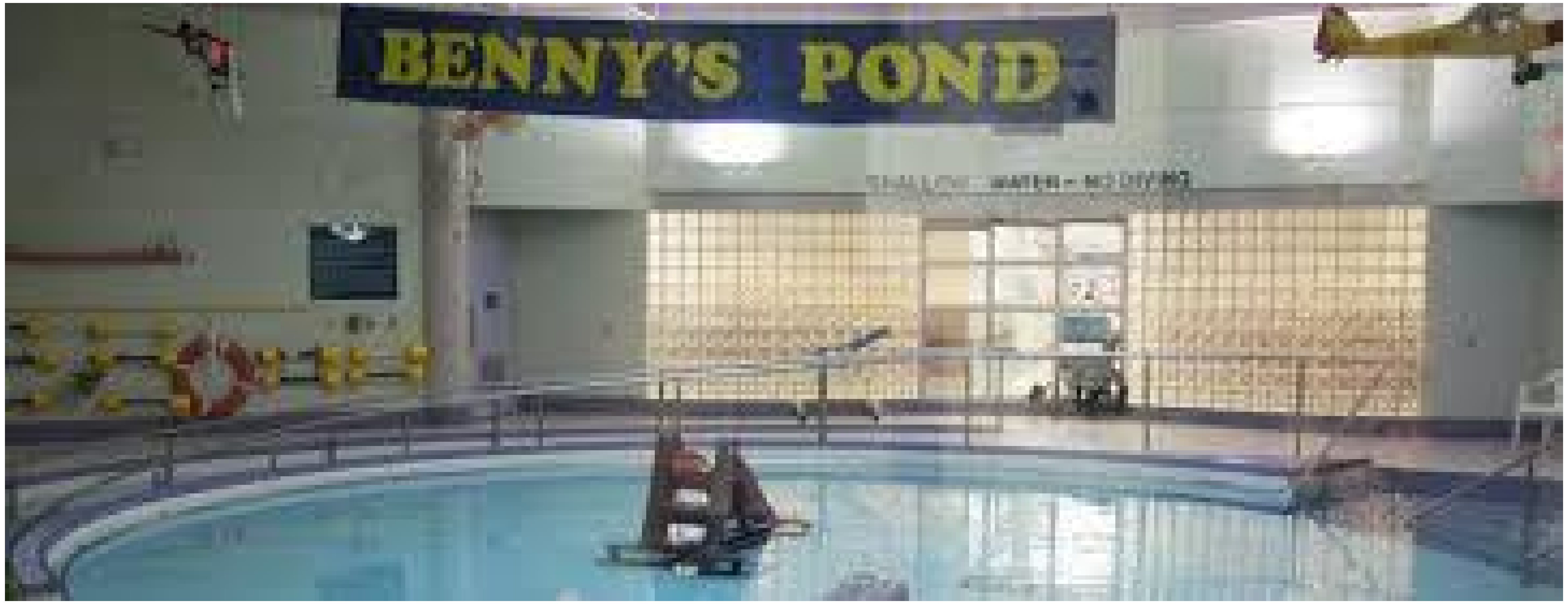
What I observed.....

- Children **love** the water
- Learning to swim is an important **life skill**
- Importance of making swimming lessons **fun** for children
- **Additional benefits** beyond the physical and safety benefits

CanChild

KidsAbility
Centre for Child Development

Wilfrid Laurier University



CanChild

Study Purpose: Explore the perceived influence of a structured swim program on children with autism spectrum disorders and communication delays.

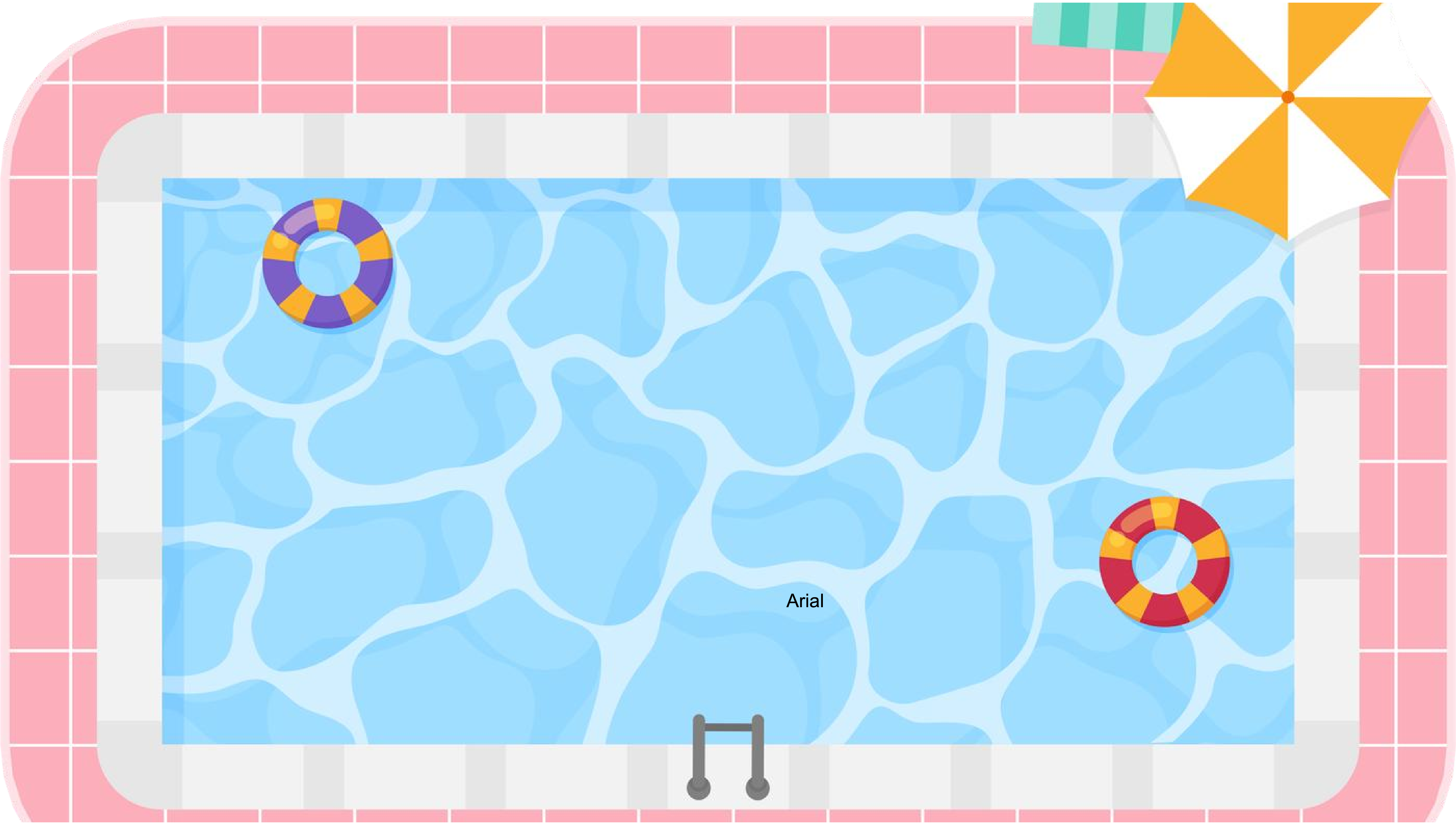
Research Questions

1. Does participating in a structured swim program influence **social interaction** of children with ASD and communication delays?
2. Does participating in a structured swim program influence **communication skills** of children with ASD and communication delays?
3. Does participating in a structured swim program decrease **sterotypical behaviours** of children with ASD?
4. Are there any **social, physical, and emotional benefits** of children with ASD and communication delays participating in a structured swim program?

CanChild

Structured Swim Program

- 10-weeks 1-hour sessions
- 2:1 or 1:1 children to volunteer ratio
- Red Cross Certified Instructor
- Program was based on:
  - Canadian Red Cross Preschool Swim Program
  - Canadian Red Cross Swim Program for Individual's who move, learn, communicate, or behave differently
  - Various teaching tools (i.e., visual cue cards, activity schedule, social story)



Setting: A warm, shallow pool used for therapy sessions, therapeutic recreation programs, and KidsAbility school swims

Children Demographics

- 15 children (3 and 4 years of age)
  - 11 male, 4 female
- Diagnoses included autism, delays in expressive and receptive language, reduced hearing, or no formal diagnosis
- 7 had taken previous swim lessons

CanChild

Swim Session Schedule

Category	Length (min)	Content	Goal
Introduction	10 min	Introductory/group songs Activity schedule Warm-up	Communication and social interaction Organized transition
2:1 or 1:1 Instruction	20 min	Safety awareness Comfort in water Breathing skills Floating skills Movement skills	Communication Water orientation and swim skills
Group Activities	10 min	Structured Game Free play time	Communication and social interaction Physical activity
Closing Activities	5 min	Circle Time Cool-down Goodbye song	Communication and social interaction Organized transition

Data Collection

Participants	N	Data Collected
Teachers	2	Semi-structured interviews
Volunteers	13	Weekly progress forms and journals, Open-Ended Questionnaire
Parents	13	Background questionnaire and semi-structured interviews
Instructor/Researcher	1	Weekly journals and field notes

Findings

- All parents, teachers, and volunteers agreed that the structured swim program had a positive influence on the children’s behaviour
- Holistic benefits were seen across domains including:
  - Social Interaction
  - Communication
  - Stereotypical behaviours
  - Quality of life (social, emotional, and physical benefits)

CanChild

Social Interaction

- Improvements in **social proximity** (relationships build with adults, group participation, eye contact) and **sociation initiation** (friendships build, cooperative play, imagination).

“I have noticed that my student has come a long way when it comes to sharing the toys during playtime. At the beginning he would get really upset even if one of his classmates would come close to one of the toys he was playing with. Now, he is able to pass around the ball and even go on the big float with his other classmates.” - Volunteer

CanChild

Communication

- Children showed varying levels of improvements in **expressive**, **receptive**, and **reciprocal** communication.

"I worked with two boys, both of which were very shy when I first met them. I introduced myself and gave them a high five, but after that all conversation was nonverbal shaking their heads yes and no. This changed as soon as we got into the pool. In the pool they were completely different children. They were energetic, happy, excited kids." - Volunteer

CanChild

Stereotypical Behaviours

- Four distinct areas: **type and frequency of stereotyped, repetitive motor mannerisms**; **resistance to change**; **stereotypical perseverations**; and **sensory responsiveness**.

"It's like having a big hug. It's like wrapping in a blanket. It's the pressure of the water and I think that it has a real calming effect for a lot of the children. " - Teacher

Stereotypical Behaviours cont.

- Four distinct areas: **type and frequency of stereotyped, repetitive motor mannerisms**; **resistance to change**; **stereotypical perseverations**; and **sensory responsiveness**.

"Everything was the same as we went into the change room and got changed; [my student] was very quiet as per usual. The second his feet hit the water it is like something changes. He becomes very chatty and rowdy when he is in the pool." - Volunteer

Social, Emotional, and Physical Benefits

- Improvements seen in all three areas that appeared to have positive influences on one another.

“It was a great experience. The visible results of children improving socially and physically over the ten weeks was incredible and it was great to form a bond with children and be able to share and live through their experience in the water.” - Volunteer

“They could hardly wait! Oh they had so much fun. They were happy, they were relaxed, they were engaged.” - Teacher

CanChild

Seven Influential Components of the Swim Program

- Fun & motivating activity
- Sensory & therapeutic benefits
- Instructor & volunteers
- Physical activity
- Toys & Games
- Program Structure
- Adapted Teaching Tools

CanChild

Take Away Message

- "The pool provides a **fun** and motivating environment where children are engaged, being **physically active**, and **socially interacting**. As long as the children's safety is insured, early expose to the aquatic environment can provide children with ASD and communication delays with a **life-long form of physical activity**."

PART II

APPLYING THE F-WORDS FOR CHILD DEVELOPMENT

CanChild

About CanChild

- **Our Focus** - children with developmental conditions - **and** their families
- **Our Mission** - to improve their quality of life
- **Our Method** - use of evidence-based clinical research to support better outcomes.
- **Our Goal** - to make a global impact in the field of childhood developmental research

CanChild

Research Themes

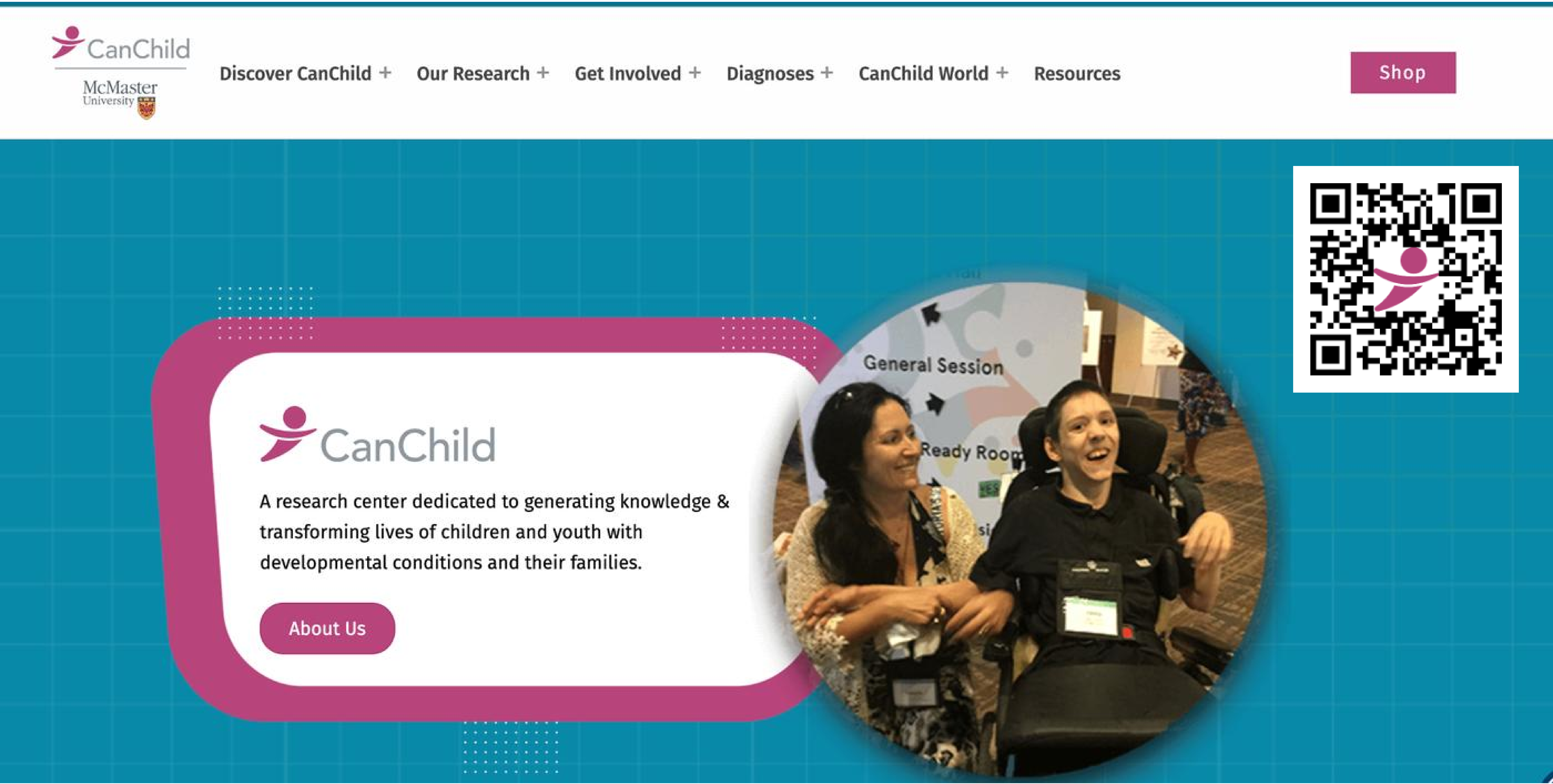
CanChild Centre for Childhood-Onset Disability Research

Our **Areas of Research** include:

- Approaches to Disability
- School & Community Services
- Focus on Family & Youth
- Participation
- Life-Course Development
- Diagnosis Informed Research
- Knowledge Translation & Implementation Science

CanChild

www.canchild.ca



> Disabil Rehabil. 2025 May;47(10):2682-2692. doi: 10.1080/09638288.2024.2394647. Epub 2024 Aug 26.

Open Access Paper

Perspectives in childhood-onset disabilities: integrating 21st-Century concepts to expand our horizons

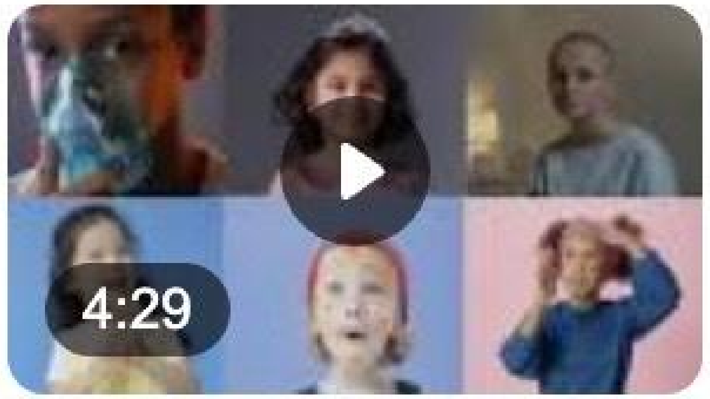
Peter L Rosenbaum [1], Christine Imms [2], Laura Miller [3], Debra Hughes [4], Andrea Cross [5]

Affiliations + expand

PMID: 39185771 DOI: 10.1080/09638288.2024.2394647

Free article

Video based on paper



Perspectives on Childhood Disability

Vimeo · CanChild

Nov 12, 2025

CanChild

The ICF Framework[1] and the F-Words[2]

Body Structure and Function

Everyone needs to stay fit and healthy both physically and mentally. Help me find ways to keep fit.

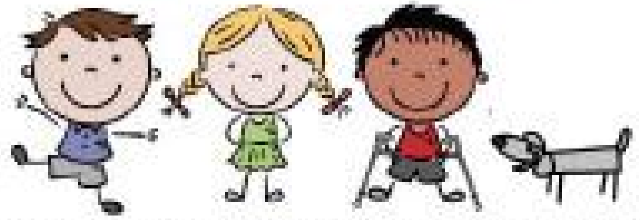
Fitness

Activity

I might do things differently but I CAN do them. How I do it is not important. Please let me try!

Functioning

Participation



Having friends is important. Please give me opportunities to make friends.

Friends

Environmental Factors

My family knows me best and I trust them. Listen to them. Talk to them. Hear them. Respect them.

Family

Personal Factors

Life is about having fun. Please help me do the activities that I find the most fun.

Fun

Future

I am growing up every day, so please find ways for me to participate and be included in my community.

For more information visit the F-words Knowledge Hub: www.canchild.ca/f-words

CanChild

1) World Health Organization. (2001) *International Classification of Functioning, Disability and Health (ICF)*

2) Rosenbaum P & Gorter JW. (2012). The 'F-words' in childhood disability: I swear this is how we should think! *Child Care Health Dev*; 38.

What do we like about the ICF?

- A framework for health for **everyone**
- The words are **“neutral”**
- Everything is **connected** to everything else
- ICF reminds us to look at – and focus on – what people **CAN DO!**

CanChild

The F-words for Child Development

Review Article

doi:10.1111/j.1365-2214.2011.01338.x

The 'F-words' in childhood disability: I swear this is how we should think!

P. Rosenbaum* and J. W. Gorter*†

**CanChild* Centre for Childhood Disability Research, McMaster University, Hamilton, ON, Canada, and
†NetChild Network for Childhood Disability Research, Utrecht, the Netherlands

FITNESS

FUNCT-
IONING

FRIENDS

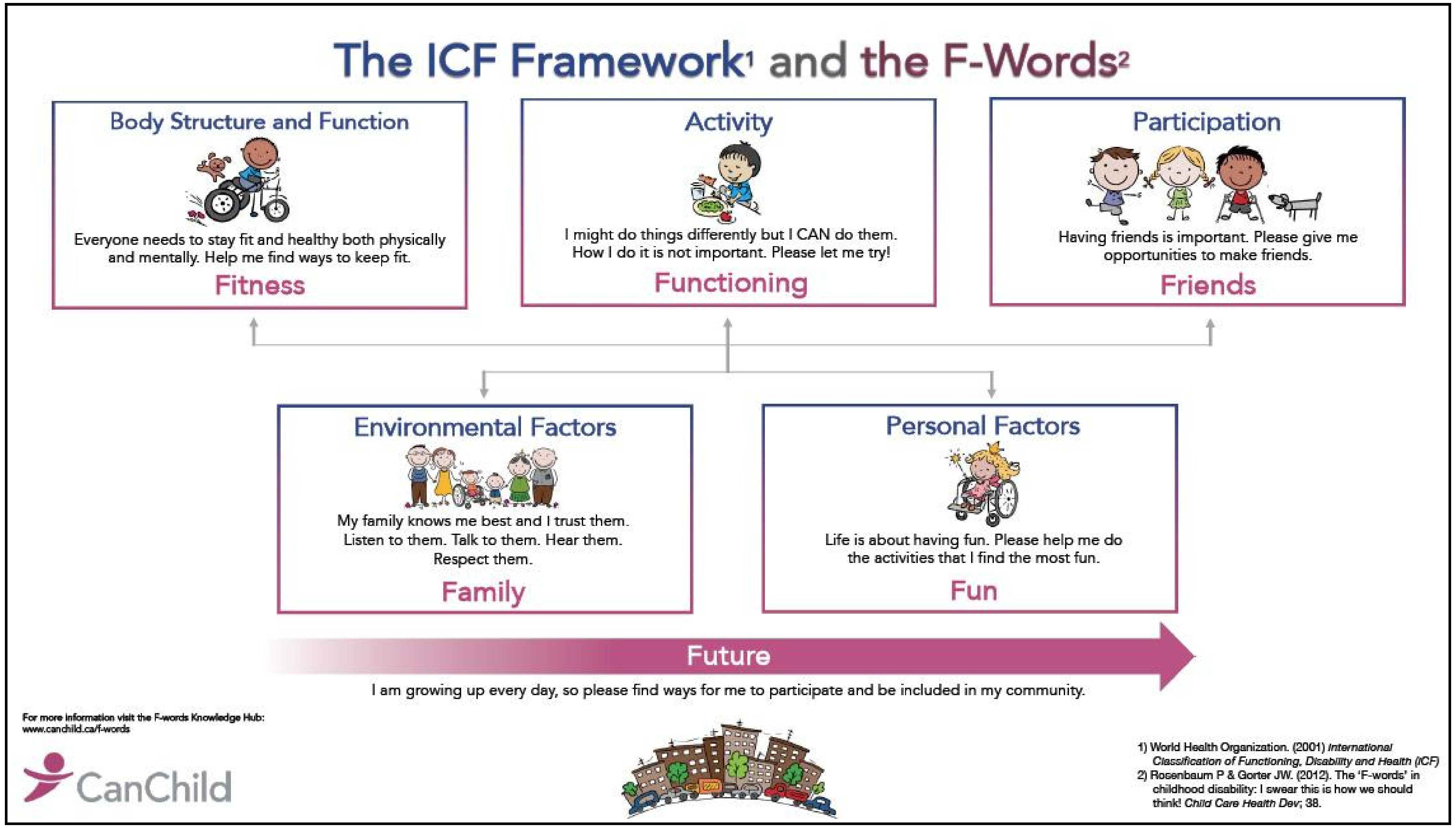
FUN

FAMILY

FUTURE

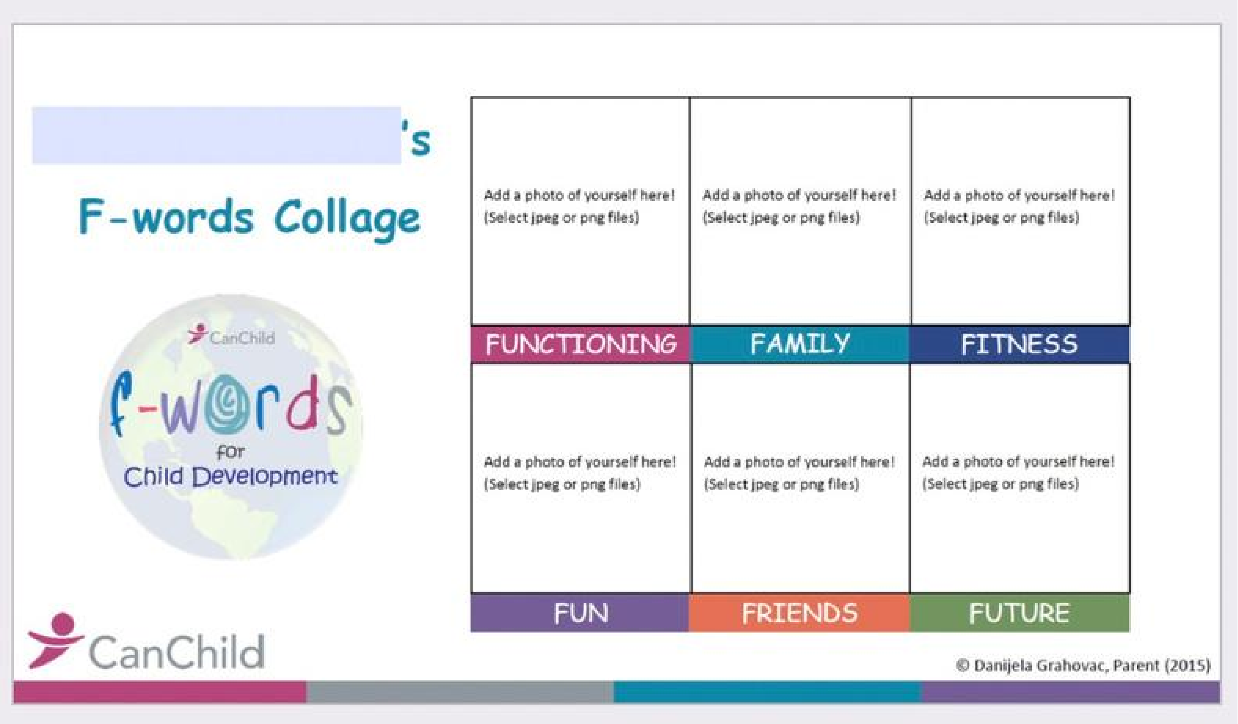
CanChild

Tools for Raising Awareness of F-words



CanChild

Parent developed tools



's

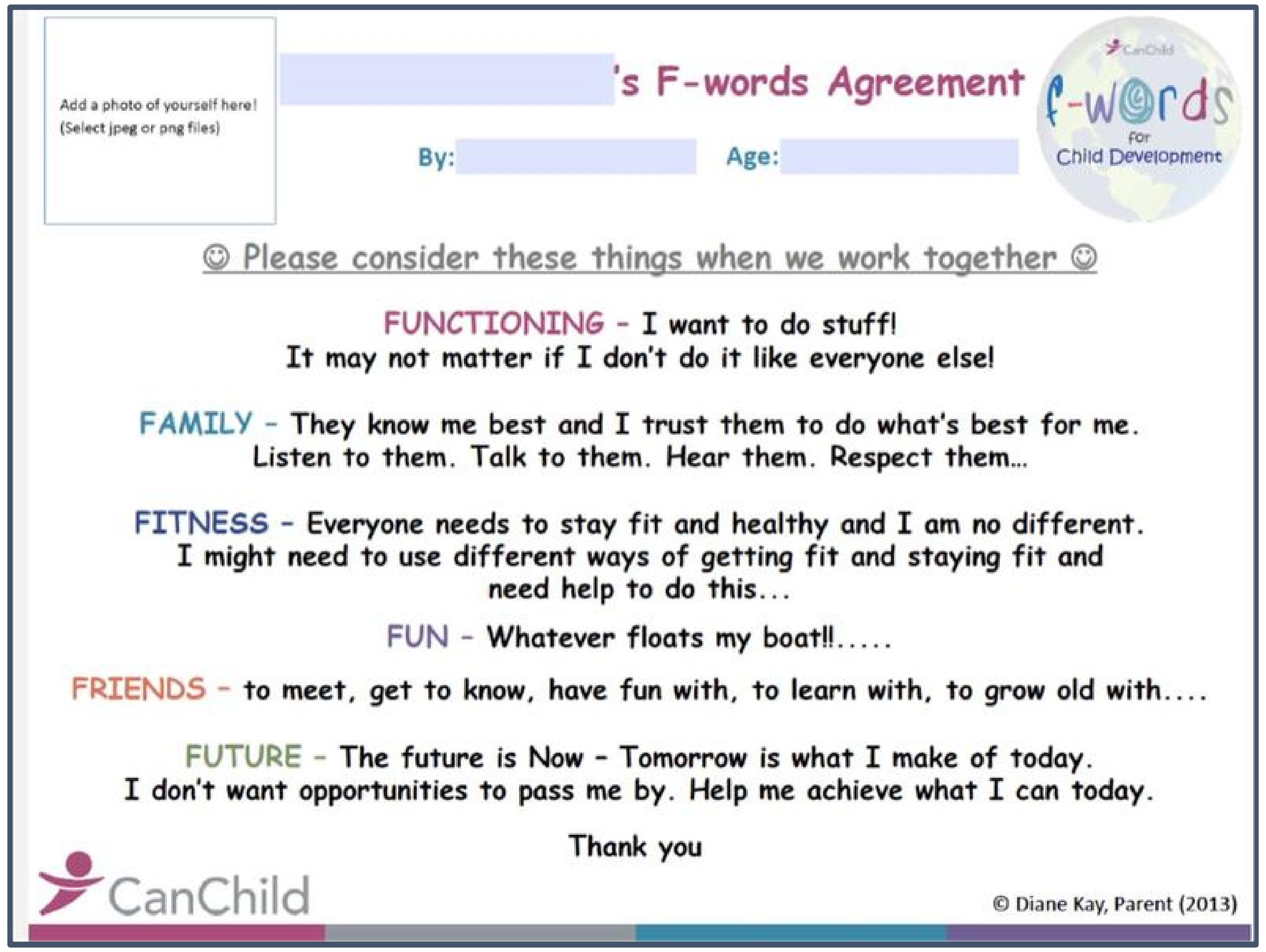
F-words Collage

CanChild f-words for Child Development

Add a photo of yourself here! (Select jpeg or png files)	Add a photo of yourself here! (Select jpeg or png files)	Add a photo of yourself here! (Select jpeg or png files)
FUNCTIONING	FAMILY	FITNESS
Add a photo of yourself here! (Select jpeg or png files)	Add a photo of yourself here! (Select jpeg or png files)	Add a photo of yourself here! (Select jpeg or png files)
FUN	FRIENDS	FUTURE

CanChild

© Danijela Grahovac, Parent (2015)



Add a photo of yourself here! (Select jpeg or png files)

's F-words Agreement

By: Age:

☺ Please consider these things when we work together ☺

FUNCTIONING - I want to do stuff! It may not matter if I don't do it like everyone else!

FAMILY - They know me best and I trust them to do what's best for me. Listen to them. Talk to them. Hear them. Respect them...

FITNESS - Everyone needs to stay fit and healthy and I am no different. I might need to use different ways of getting fit and staying fit and need help to do this...

FUN - Whatever floats my boat!!.....

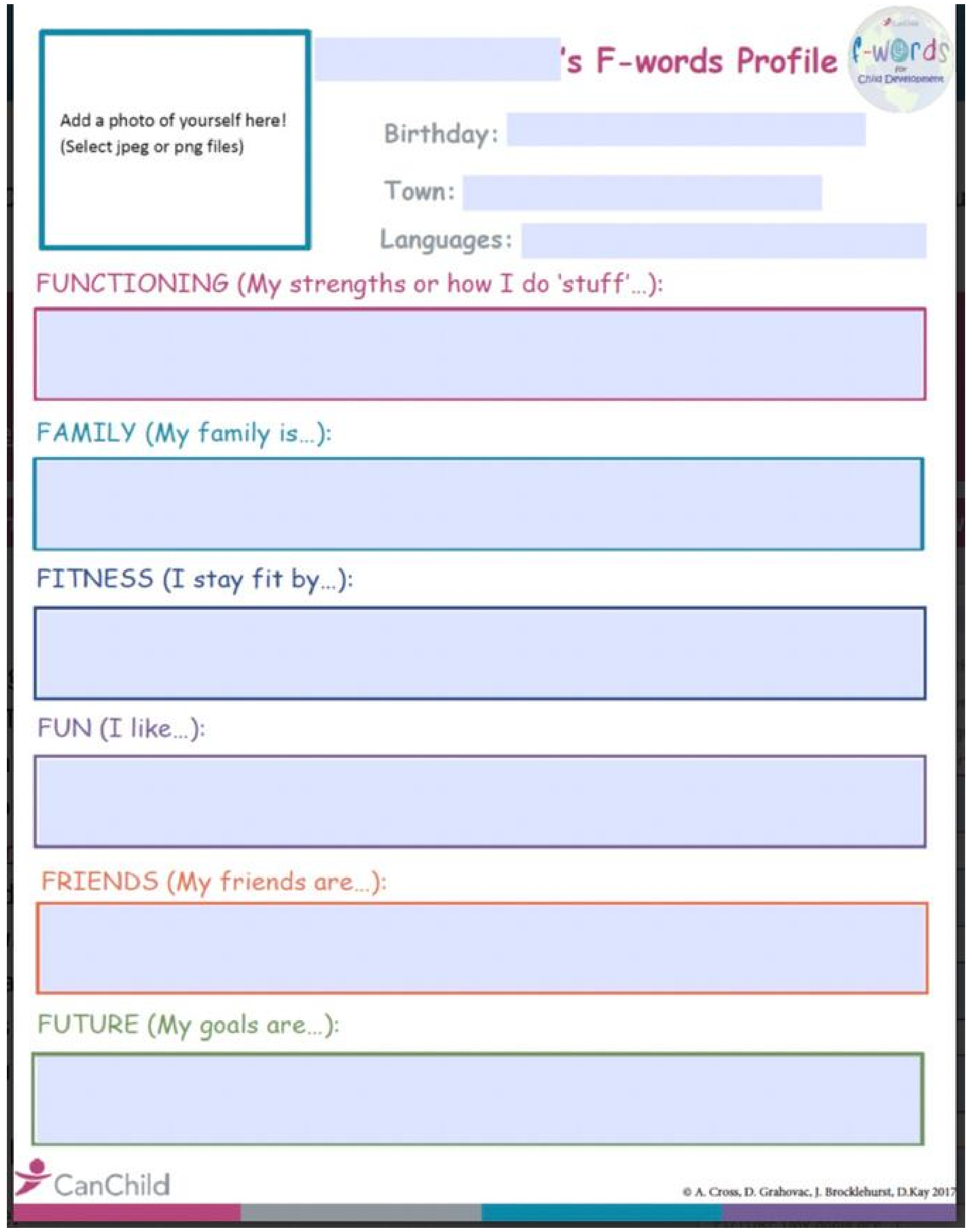
FRIENDS - to meet, get to know, have fun with, to learn with, to grow old with....

FUTURE - The future is Now - Tomorrow is what I make of today. I don't want opportunities to pass me by. Help me achieve what I can today.

Thank you

CanChild

© Diane Kay, Parent (2013)



Add a photo of yourself here! (Select jpeg or png files)

's F-words Profile

Birthday:

Town:

Languages:

FUNCTIONING (My strengths or how I do 'stuff'...):

FAMILY (My family is...):

FITNESS (I stay fit by...):

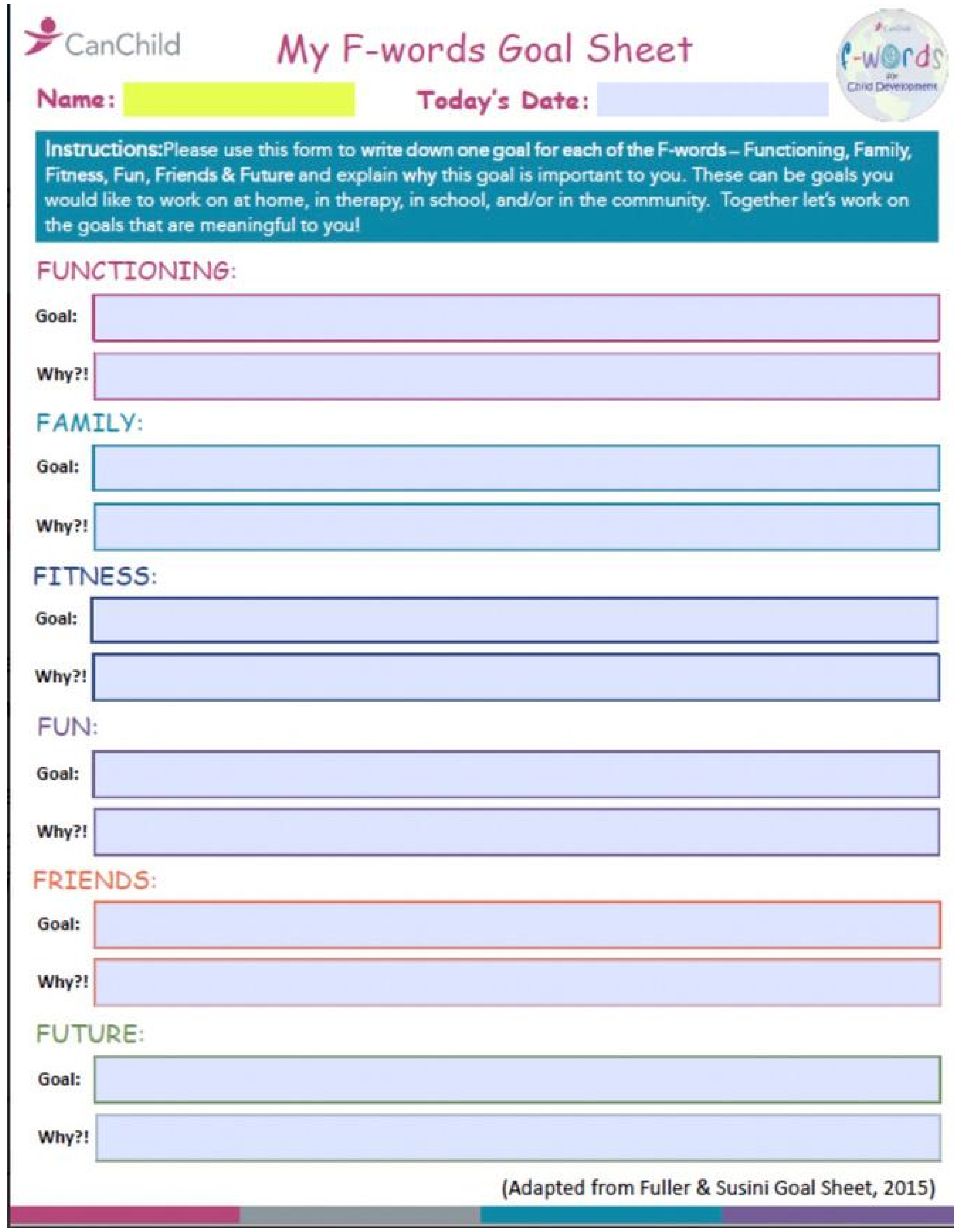
FUN (I like...):

FRIENDS (My friends are...):

FUTURE (My goals are...):

CanChild

© A. Cross, D. Grahovac, J. Brocklehurst, D.Kay 2017



CanChild

My F-words Goal Sheet

Name: Today's Date:

Instructions: Please use this form to write down one goal for each of the F-words – Functioning, Family, Fitness, Fun, Friends & Future and explain why this goal is important to you. These can be goals you would like to work on at home, in therapy, in school, and/or in the community. Together let's work on the goals that are meaningful to you!

FUNCTIONING:
Goal:
Why?!

FAMILY:
Goal:
Why?!

FITNESS:
Goal:
Why?!

FUN:
Goal:
Why?!

FRIENDS:
Goal:
Why?!

FUTURE:
Goal:
Why?!

(Adapted from Fuller & Susini Goal Sheet, 2015)

Scan for F-words Tools templates

CanChild

THE WATER IS EVERYONE'S STAGE

FUNCTION

Function refers to how your swimmer does things. It may be different than other swimmers but they can do it! As a coach, validate your swimmers abilities and strengths; invite them to share these talents during practice.

FRIENDS

Artistic swimming is very much a team sport. It is important to give your swimmers the opportunity to interact with their peers.During practice partner up swimmers to share ideas and work together. Promote positive communication amongst each other.

FUN

The most important part of artistic swimming! Every practice should ensure that the swimmers are leaving feeling happy and looking forward to the next one. Various drills or activities should be enjoyable and exciting!

FAMILY

Your swimmers families know them best! They aide in developing your swimmer to reach their goals. Include them in this process by communicating what is going on with their child during practice. Learn from eachother!

FITNESS

Help keep your swimmers fit by finding a variety of ways that challenges them to improve their fitness skills in their own unique way. Changing up the kinds of activities they perform in and out of the water aides in keeping them motivated. Develop their strength and endurance in a way that is safe for their needs and abilities.

FUTURE

Help guide your swimmers to be the best version of themselves in and out of the pool. Encourage new strategies for growth by boosting their self-esteem. Work alongside your swimmers to achieve their goals and support their future aspirations by being a mentor.

Take Away Message

- Given the distinct properties of the water it is believed that swimming not only fosters physical activity (i.e., **functioning** and **fitness**), but also provides social (i.e., **friends** and **family**) and emotional benefits (i.e., **fun**) for children with disabilities across the lifespan (i.e., **future**)

CanChild

“At first, F-words may seem obvious, but how well do we actually pay attention to these elements in children's healthcare and rehabilitation?” - Physiotherapist

.......and aquatics!

CanChild

CanChild

CanChild Home Page > Research In Practice > F-Words Knowledge Hub

ICF Resources | F-words Tools | Webinars and Podcasts | F-words Videos | F-words in Practice | F-Words Translations

Welcome to the F-words Knowledge Hub

This is the place for everyone to learn more about our favourite words for child development and beyond!

Parent quotes

"The F-words help me tell the story of my son, to paint a picture of who he is, what he likes and focus on what he CAN do!"

"The F-words help our family think about possibilities!"

CanChild

F-words for Child Development

Clinician quote

"The F-words focus on all that is possible when we think positively and work together to find solutions. They focus on an individual's unique strengths and interests."

canchild.ca/f-words

www.canchild.ca/f-words

CanChild

THE F-WORDS FOR CHILD DEVELOPMENT

F-words Training Program

Login/Sign up

Français

Interested in learning more about the F-words - enrol in our free 5-hour self-paced course

SCAN ME

HTTPS://CANCHILD-FWORDS.CA

CanChild

THANK YOU

CanChild

Generating Knowledge
Transforming Lives

CROSSAC@MCMASTER.CA

PULLING LIFESTYLE DISEASES INTO THE POOL

Aquatic Therapy as a Multisystem Clinical Model

Eugenia Hernández Ruiz PT MSc
International Aquatic Therapy Faculty (IATF)
Asociación Mexicana de Terapia Acuática (AMTA)

Why I am bringing this to you today

Observation of practice consistently showed one pattern:

Patients with pain and metabolic comorbidities moved earlier — and better — in water.

What this keynote proposes:

- A framework — not just a technique
- Aquatic therapy as a clinical entry point into systemic lifestyle intervention
- Evidence from neurophysiology, metabolism, sleep science & behaviour
- A model you can apply in your clinic on Monday

THE CHALLENGE

We are treating 21st-century diseases with 20th-century silos.

Type 2 Diabetes

Obesity & Metabolic Syndrome

Chronic Pain & Sensitisation

Depression & Neuroinflammation

Shared mechanisms: systemic inflammation · autonomic imbalance · insulin resistance · sleep disruption · HPA dysregulation

The same internal environment underlies all of them.

Chronic Low-Grade Inflammation

Elevated IL-6, TNF-α, CRP
Drives insulin resistance and neuroinflammation

Autonomic Imbalance

↓ Parasympathetic tone
HPA dysregulation, elevated cortisol

Impaired Sleep Architecture

↓ Deep sleep, fragmented cycles
Amplifies pain, ↑ appetite, ↓ recovery

Central Sensitisation

Altered descending modulation
Heightened pain perception & stress reactivity

Endothelial Dysfunction

↓ Nitric oxide bioavailability
↑ Arterial stiffness, cardiovascular risk

Behavioural Withdrawal

Fear-avoidance, low self-efficacy
Movement deprivation deepens all of the above

It is a clinically meaningful entry point into systemic dysregulation.

Persistent Pain

Central sensitisation
Descending modulation

▶

Autonomic Imbalance

HPA dysregulation
Stress reactivity

▶

Metabolic Compromise

Insulin resistance
Inflammation

▶

Sleep Disruption

Neurogenesis
Pain amplification

Woolf CJ, Pain 2011 · Finan PH et al., Sleep Med Rev 2013

Why conventional rehabilitation often struggles

Mechanical Load Intolerance

Patients with sensitisation, obesity, or fatigue cannot initially tolerate the loads required for land-based conditioning. Pain limits the very tool we use to treat pain.

Fragmented Management

Diabetes to endocrinology. Pain to physio. Sleep to GP. Each clinician addresses one node — nobody manages the whole regulatory system.

Adherence Collapse

Fear-avoidance and low self-efficacy mean patients disengage early. Without behavioural sustainability, physiological gains cannot accumulate.

A multisystem approach is not optional — it is a clinical necessity.

The Aquatic Multisystem Clinical Model

Not a modality. A clinical reasoning framework.

Environmental Modulation

- Buoyancy offloads axial compression
- Sensory richness → modulates threat
- Graded movement where land fails
- Low-threat, high-opportunity context

Physiological Regulation

- Cardiovascular conditioning
- Myokine pathways → ↓ inflammation
- BDNF & neuroplasticity
- Sleep-pain axis modulation

Behavioural Sustainability

- ↓ Fear-avoidance behaviour
- ↑ Self-efficacy
- Phased exercise snacking
- Land-based transfer

The water creates conditions land cannot replicate.

Buoyancy	Offloads axial compression and reduces peripheral nociceptive input that often makes land-based movement intolerable — addresses the mechanical threat signal, not just the load
Hydrostatic Pressure	Enhances venous return, modifies cardiovascular preload, influences baroreceptor activity ⟶ measurable changes in HRV and autonomic balance
Thermal & Sensory Input	Temperature, pressure, resistance — sensory richness that appears to modulate threat perception, enabling graded movement where it would otherwise fail
Viscosity & Drag	Slows movement, provides omnidirectional resistance ⟶ allows error correction and confident motor exploration

Carter HH et al., Exp Physiol 2014 · Torres-Ronda & Del Alcázar, J Hum Kinet 2014 · Dunlap E et al., PLoS One 2025

Why immersion enables movement that land blocks

Clinical Challenge	Land-Based Barrier	Aquatic Advantage
Sensitisation & pain	Loading triggers threat response	Buoyancy ↓ loading → ↓ threat → movement becomes possible
Obesity / deconditioning	Weight-bearing limits tolerance	Buoyancy offloads 60–90% body weight in shoulder-depth immersion
Autonomic dysregulation	Exercise stress worsens HRV acutely	Hydrostatic pressure → parasympathetic shift → ↑ HRV
Fear of falling / balance	Instability discourages participation	Water viscosity slows movement → extended time for corrections
Fatigue & low capacity	RPE too high at therapeutic load	↓ Perceived exertion at equivalent cardiovascular intensity

Physiological Regulation

Systemic targets — not secondary outcomes.

Cardiovascular

↓ Perceived exertion · ↑ Endothelial function
↓ Arterial stiffness · ↑ VO_2 capacity
(Dunlap et al., PLoS One 2025; Green et al., 2017)

Metabolic

↑ Insulin sensitivity · Myokine-mediated pathways
↓ Low-grade systemic inflammation
(Pedersen & Febbraio, 2008; Green et al., 2017)

Neurocognitive

↑ BDNF → synaptic plasticity
Neuroprotection through fitness
Cognitive-motor performance
(Tari et al., Lancet 2025; Szuhany et al., 2015)

Sleep & Pain

A therapeutic target — not merely an outcome
Descending pain modulation · Neurogenesis
Inflammatory tone · Fear-avoidance cycle
(Finan et al., Sleep Med Rev 2013)

How aquatic exercise works on three systems

Myokines · Parasympathetic tone · Systemic inflammation

Aquatic exercise
Movement + hydrostatic pressure

Muscles contract
Release myokines (IL-6, IL-10, BDNF)

Anti-inflammatory signal
↓ TNF-α, ↑ IL-10 in bloodstream

Hydrostatic pressure
Acts on chest + blood vessels

Parasympathetic shift
↑ HRV, ↓ cortisol, calmer stress response

Lower perceived exertion
Same work, less stress response

More exercise possible
Same metabolic cost, more movement

Patient tolerates more movement
Lifestyle change becomes sustainable

The sleep-pain bidirectional axis

Sleep is not an outcome. It is a treatment target.

Poor Sleep

↓ Descending pain inhibition
↑ Central sensitisation
↑ Inflammatory cytokines
↓ Neurogenesis

↔ **BIDIRECTIONAL** ↔

More Pain

↑ Hyperarousal at night
↑ Sleep fragmentation
↓ Slow-wave sleep depth
↑ Fatigue → ↓ activity

How aquatic therapy addresses this cycle:

Graded movement exposure → ↓ fear → ↑ tolerance → ↓ pain → better sleep → ↓ central sensitisation → more movement possible

Finan PH et al., Sleep Med Rev 2013

DOMAIN 3

Behavioural Sustainability

This is where many rehabilitation approaches lose ground.

PHASED EXERCISE SNACKING MODEL

PHASE 1	PHASE 2	PHASE 3
Aquatic Micro-Sessions	**Transition & Transfer**	**Land-Based Micro-Sessions**
Short structured sessions Graded exposure ↓ Fear-avoidance ↑ Self-efficacy	Improved movement tolerance Confidence established Clinical reasoning checkpoint	Distributed daily activity Community integration Long-term adherence

Stamatakis E et al., Exerc Sport Sci Rev 2022 · WHO Global Action Plan on Physical Activity 2018–2030

Small doses. Real physiological signal.

Exercise snacking = brief, repeated bouts distributed throughout the day

Aquatic Phase 10–20 min sessions	Initiates cardiovascular and anti-inflammatory response with minimal mechanical threat
Transition Phase Mixed aquatic + short land bouts	Builds movement confidence across environments; clinician monitors load tolerance
Land Phase 3–5 min micro-sessions × 3–5/day	Cumulative glycaemic, cardiovascular and neuromuscular benefit equivalent to single longer sessions

Stamatakis E et al., Exerc Sport Sci Rev 2022

When & How to Apply the Model

Early-Stage Intervention

When land-based loading is initially not tolerated. Restore movement confidence, reduce sensitisation, initiate systemic adaptation.

Parallel Strategy

Run alongside land-based care. Address autonomic and metabolic dimensions while progressing mechanical loading on land.

Transitional Pathway

Bridge from aquatic rehabilitation toward progressive land-based loading. Exercise snacking closes the gap sustainably.

Target population: persistent pain + metabolic or inflammatory comorbidities

Outcome measures: how do we know it's working?

A multidomain approach requires multidomain measurement

TSK-11
Fear-avoidance

Tampa Scale of Kinesiophobia

11 items, rated 1–4. Score >37 = clinically significant fear of movement. Tracks threat perception over time.

FABQ
Fear-avoidance

Fear-Avoidance Beliefs Questionnaire

Two subscales: physical activity (FABQ-PA) and work (FABQ-W). Captures beliefs driving avoidance behaviour.

NRS
Pain

Numeric Rating Scale

0–10 pain scale. Measure during movement, not only at rest — this reveals threat perception, not just tissue state.

PSQI
Sleep

Pittsburgh Sleep Quality Index

19 items across 7 components. Score ≥ 5 = poor quality sleep. Sleep is a treatment target in this model.

HRV
Autonomic balance

Heart Rate Variability

Higher HRV = better parasympathetic tone. Captured via wearables. Tracks the autonomic response to immersion.

HbA1c
Metabolic

Glycated Haemoglobin

Reflects average blood glucose over 2–3 months. Normal <5.7%. Target for T2D <7%. Tracks myokine-driven insulin sensitivity gains.

No single outcome tells the full story — use the combination to demonstrate multisystem change

A clinical vignette

Patient Profile

52-year-old woman

- Chronic low back pain (4 years)
- Type 2 diabetes, BMI 34
- Disrupted sleep, persistent fatigue
- Two failed attempts at gym-based rehab
- High fear-avoidance, low self-efficacy
- Referred with note: 'non-compliant'

Applying the Model

Wks 1–4	Aquatic sessions 3×/week. Focus: graded movement, autonomic regulation, reduced threat perception. Sleep diary introduced.
Wks 5–8	Pain ↓, sleep improving. Short land walks added. Exercise snacking introduced: 5 min × 3/day.
Wks 9–12	HbA1c improving. Fear-avoidance score ↓. Aquatic to 1×/week maintenance. Land-based routine sustained independently.

This is a composite clinical vignette for illustrative purposes.

What the evidence supports — and what it does not yet

Strong Mechanistic Evidence

- Aquatic immersion modulates autonomic balance and reduces arterial stiffness (Carter et al., 2014; Dunlap et al., 2025)
- Movement activates myokine-mediated pathways → ↓ inflammation, ↑ insulin sensitivity (Pedersen & Febbraio, 2008; Green et al., 2017)
- Exercise-induced BDNF supports synaptic plasticity and neural adaptation (Szuhany et al., 2015; Tari et al., Lancet 2025)
- Sleep disruption amplifies pain sensitisation and inflammatory tone (Finan et al., 2013)
- Exercise snacking produces cumulative metabolic and cardiovascular benefit (Stamatakis et al., 2022)

Where Evidence is Still Emerging

- Aquatic-specific RCTs on multimorbid lifestyle disease populations are limited
- Optimal aquatic dosing parameters for metabolic outcomes are not yet defined
- The model itself is derived from clinical observation + convergent mechanistic evidence — not a validated protocol
- Long-term follow-up data on exercise snacking in aquatic contexts is sparse

Clinical reasoning requires transparency about what we know, what we infer, and what we still need to study.

CONCLUSION

The complexity of lifestyle-related disease demands multidimensional clinical strategies.

- Aquatic therapy as a clinical entry point — not a last resort
- Three interacting domains: environment · physiology · behaviour
- Pain as the gateway to systemic intervention
- Exercise snacking as a bridge to lifestyle change
- Honest framework: convergent evidence, evolving research

This is not a new modality.

References

- Bae S, Masaki H. Front Hum Neurosci. 2019;13:260.
- Becker BE. PM&R. 2009.
- Carter HH et al. Exp Physiol. 2014.
- Dunlap E et al. PLoS One. 2025;20(12):e0338929.
- Finan PH et al. Sleep Med Rev. 2013.
- Green DJ et al. J Physiol. 2017.
- Herold F et al. Front Aging Neurosci. 2018;10:228.
- Krakauer JW, Cortés JC. NeuroRehabilitation. 2018;43(1):31–40.
- Pedersen BK, Febbraio MA. Physiol Rev. 2008.
- Stamatakis E et al. Exerc Sport Sci Rev. 2022.
- Szuhany KL et al. Neurosci Biobehav Rev. 2015.
- Tari AR et al. Lancet. 2025;405(10475):1093–1118.
- Torres-Ronda L, Del Alcázar XS. J Hum Kinet. 2014.
- Woolf CJ. Pain. 2011.
- World Health Organization. Global Action Plan on Physical Activity 2018–2030. Geneva: WHO; 2018.
- Zhu M et al. Front Aging Neurosci. 2025;17:1514271.

Immersion in Evidence-Based Practice: Physiological Insights for Optimizing Aquatic Exercise Dosage in Health Promotion

Cristine Lima Alberton, PhD


UNIVERSIDADE FEDERAL DE PELOTAS
RS-BRASIL
LabNeuro
LABORATÓRIO DE AVALIAÇÃO NEUROMUSCULAR

Review

Perceptual and Motor Skills
2021, Vol. 128(5) 2166–2185

DOI: 10.1177/00315125211032159
journals.sagepub.com/home/pms
SAGE

Aquatic Exercise for Health Promotion: A 31-Year Bibliometric Analysis

Wen-Sheng Zhou[1,2], Fei-Fei Ren[3,4], Yong Yang[4,5], and Kuei-Yu Chien[2]

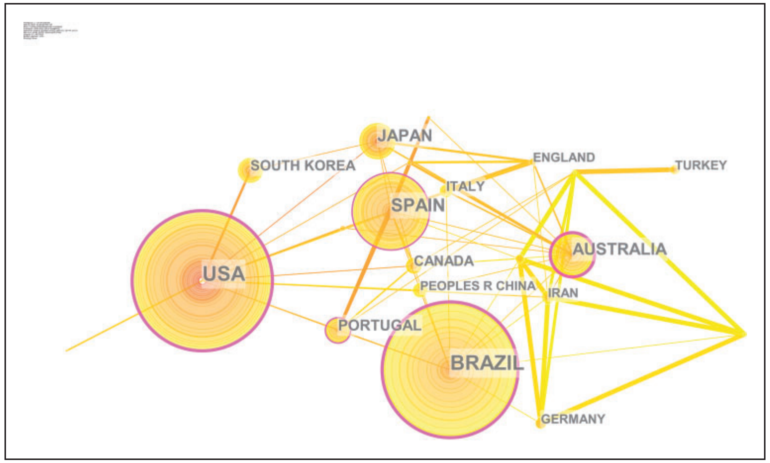


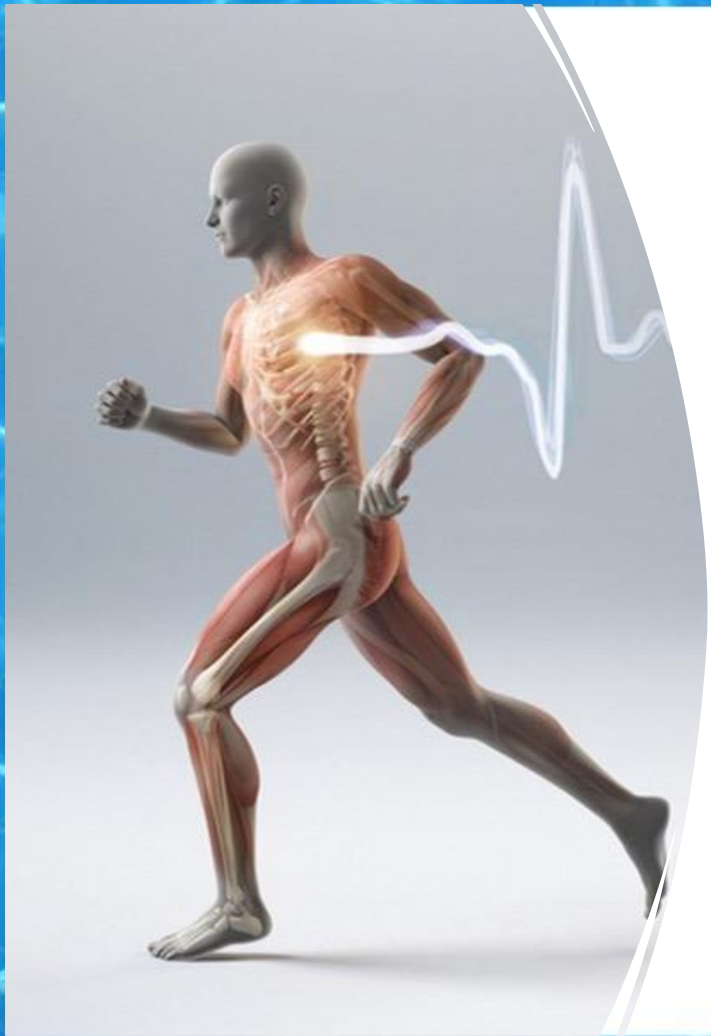
Figure 2. Analysis of Countries in International Scientific Cooperation. Note: Each node stands for one country with its ring size representing its frequency and its thickness of the fuchsia ring representing its centrality.

Main purpose:

- Highlight the importance of aquatic aerobic exercise for health promotion and to discuss key considerations for its safe and effective prescription in aquatic therapy.

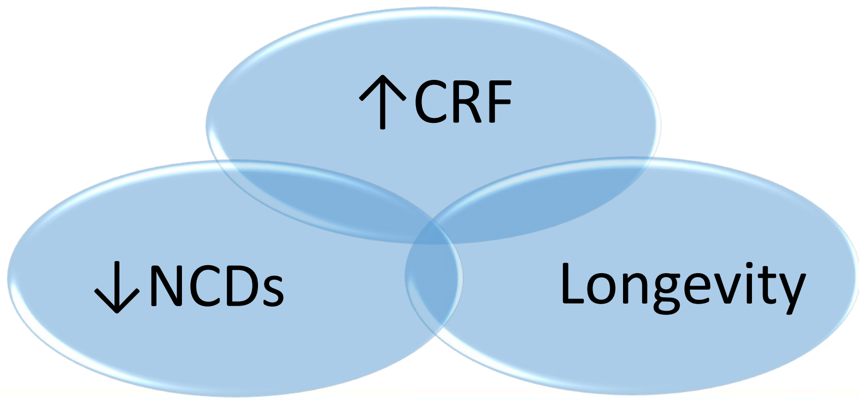
Outline

- Exercise, Cardiorespiratory Fitness and Cardiometabolic Health
- Exercise Dosage: The FITT Principle
- Water Properties: Physical and Physiological Responses
- How to Control Intensity in Water: HR and RPE Key considerations
- Real-World Applications: Aquatic Programs
- Take-Home Messages



Exercise and Health

- Regular exercise: one of the most powerful tools to improve health;
- Cardiorespiratory fitness → strong predictor of reduced all-cause and cardiovascular mortality;



Exercise and Health

Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events in Healthy Men and Women
A Meta-analysis

JAMA, May 20, 2009—Vol 301, No. 19

JAMA The Journal of the American Medical Association

Satoru Kodama, MD, PhD
Kazumi Saito, MD, PhD
Shiro Tanaka, PhD
Miho Maki, MS
Yoko Yachi, RD, MS
Mihoko Asumi, MS
Ayumi Sugawara, RD
Kumiko Totsuka, RD
Hitoshi Shimano, MD, PhD
Yasuo Ohashi, PhD
Nobuhiro Yamada, MD, PhD
Hirohito Sone, MD, PhD

Small gains in CRF:
→ Substantial health benefits
→ Aquatic exercise can play an important role

- 102 980 participants;
- ↑ 1MET in CRF: **↑ 3.5 ml.kg^{-1}.min^{-1}**

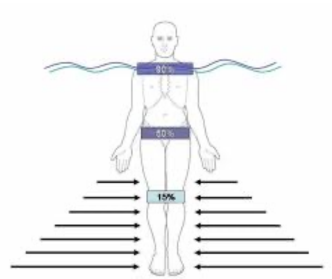
- **All-cause mortality**
  - Pooled RR: 0.87
  - ↓ 13% risk
- **Cardiovascular events**
  - Pooled RR: 0.85
  - ↓ 15% risk

Why Aquatic Exercise for Health?

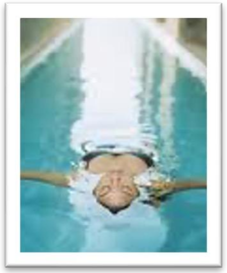
- Alternative for individuals who face functional limitations or barriers to land-based exercises;
- Unique Properties of water → safety, comfort, and adherence to exercise.

DRAG FORCE

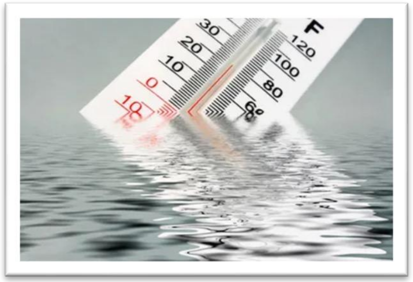
HYDROSTATIC PRESSURE



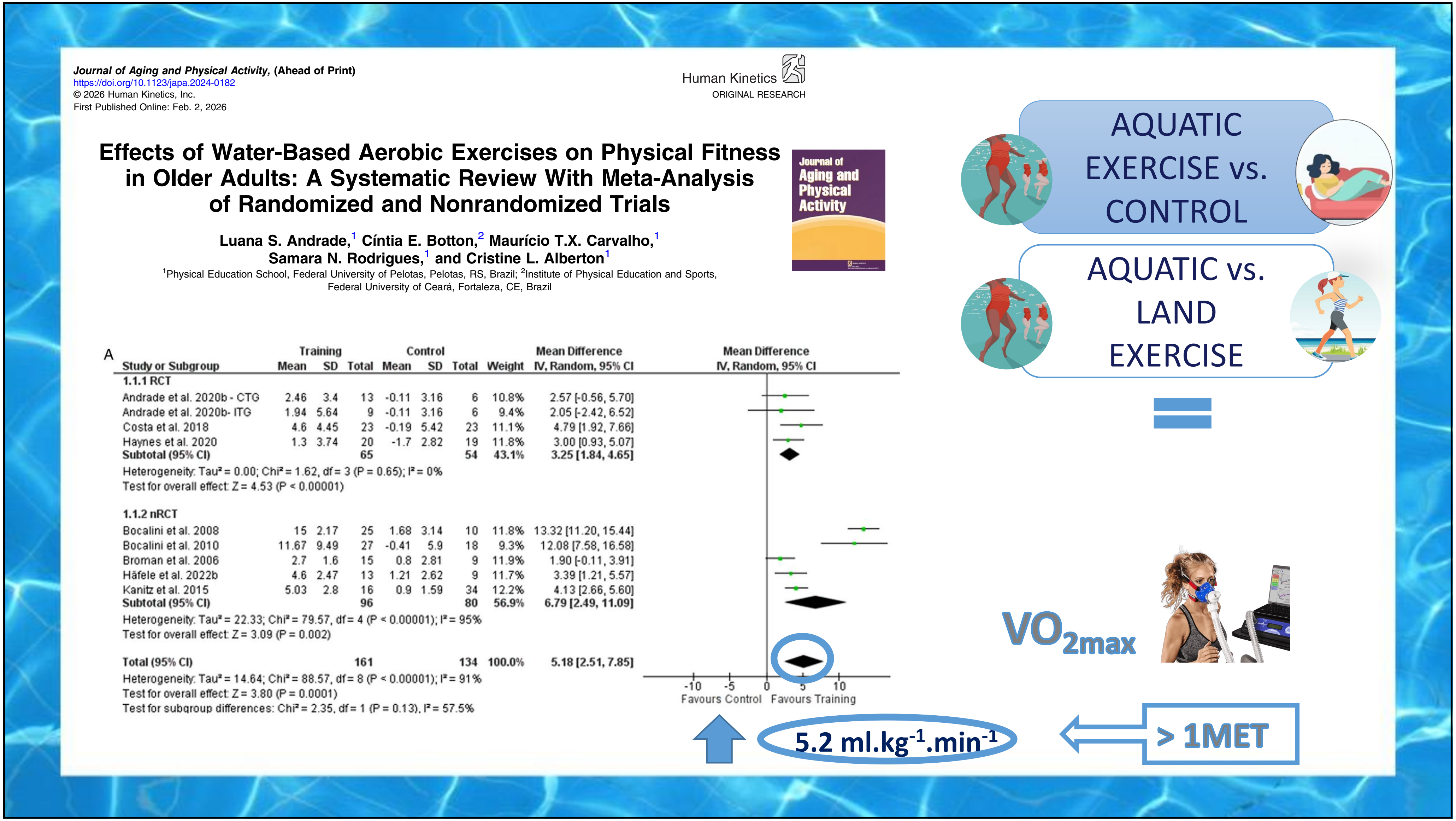
BUOYANCY



THERMAL CONDUCTIVITY



But is aquatic aerobic exercise effective for health?

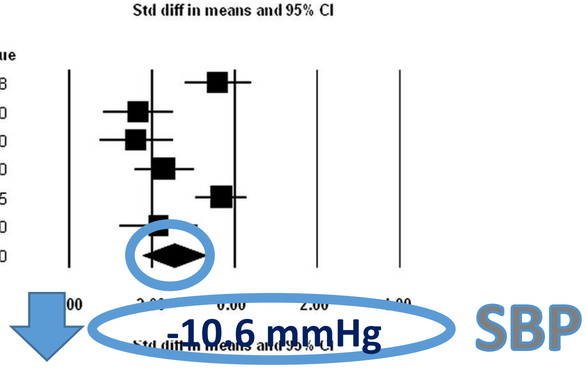

Journal of Aging and Physical Activity, (Ahead of Print)
https://doi.org/10.1123/japa.2024-0182
© 2026 Human Kinetics, Inc.
First Published Online: Feb. 2, 2026
Human Kinetics
ORIGINAL RESEARCH
Effects of Water-Based Aerobic Exercises on Physical Fitness in Older Adults: A Systematic Review With Meta-Analysis of Randomized and Nonrandomized Trials
Luana S. Andrade,[1] Cíntia E. Botton,[2] Maurício T.X. Carvalho,[1] Samara N. Rodrigues,[1] and Cristine L. Alberton[1]
[1]Physical Education School, Federal University of Pelotas, Pelotas, RS, Brazil; [2]Institute of Physical Education and Sports, Federal University of Ceará, Fortaleza, CE, Brazil
Journal of Aging and Physical Activity
A
Study or Subgroup | Training Mean | SD | Total | Control Mean | SD | Total | Weight | Mean Difference IV, Random, 95% CI
1.1.1 RCT
Andrade et al. 2020b - CTG | 2.46 | 3.4 | 13 | -0.11 | 3.16 | 6 | 10.8% | 2.57 [-0.56, 5.70]
Andrade et al. 2020b- ITG | 1.94 | 5.64 | 9 | -0.11 | 3.16 | 6 | 9.4% | 2.05 [-2.42, 6.52]
Costa et al. 2018 | 4.6 | 4.45 | 23 | -0.19 | 5.42 | 23 | 11.1% | 4.79 [1.92, 7.66]
Haynes et al. 2020 | 1.3 | 3.74 | 20 | -1.7 | 2.82 | 19 | 11.8% | 3.00 [0.93, 5.07]
Subtotal (95% CI) | 65 | 54 | 43.1% | 3.25 [1.84, 4.65]
Heterogeneity: Tau² = 0.00; Chi² = 1.62, df = 3 (P = 0.65); I² = 0%
Test for overall effect: Z = 4.53 (P < 0.00001)
1.1.2 nRCT
Bocalini et al. 2008 | 15 | 2.17 | 25 | 1.68 | 3.14 | 10 | 11.8% | 13.32 [11.20, 15.44]
Bocalini et al. 2010 | 11.67 | 9.49 | 27 | -0.41 | 5.9 | 18 | 9.3% | 12.08 [7.58, 16.58]
Broman et al. 2006 | 2.7 | 1.6 | 15 | 0.8 | 2.81 | 9 | 11.9% | 1.90 [-0.11, 3.91]
Häfele et al. 2022b | 4.6 | 2.47 | 13 | 1.21 | 2.62 | 9 | 11.7% | 3.39 [1.21, 5.57]
Kanitz et al. 2015 | 5.03 | 2.8 | 16 | 0.9 | 1.59 | 34 | 12.2% | 4.13 [2.66, 5.60]
Subtotal (95% CI) | 96 | 80 | 56.9% | 6.79 [2.49, 11.09]
Heterogeneity: Tau² = 22.33; Chi² = 79.57, df = 4 (P < 0.00001); I² = 95%
Test for overall effect: Z = 3.09 (P = 0.002)
Total (95% CI) | 161 | 134 | 100.0% | 5.18 [2.51, 7.85]
Heterogeneity: Tau² = 14.64; Chi² = 88.57, df = 8 (P < 0.00001); I² = 91%
Test for overall effect: Z = 3.80 (P = 0.0001)
Test for subgroup differences: Chi² = 2.35, df = 1 (P = 0.13), I² = 57.5%
Mean Difference IV, Random, 95% CI
-10 -5 0 5 10
Favours Control Favours Training
AQUATIC EXERCISE vs. CONTROL
AQUATIC vs. LAND EXERCISE
=
VO2max
5.2 ml.kg-1.min-1
> 1MET

Aquatic Training in Upright Position as an Alternative to Improve Blood Pressure in Adults and Elderly: A Systematic Review and Meta-Analysis

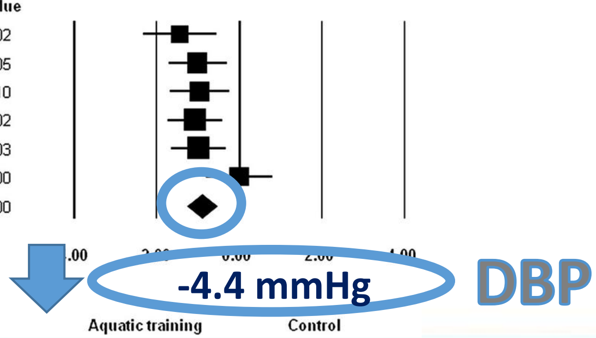
Thaís Reichert[1,3] · Rochelle Rocha Costa[1] · Bruna Machado Barroso[1] · Vitória de Mello Bones da Rocha[1] · Rodrigo Sudatti Delevatti[1,2] · Luiz Fernando Martins Kruel[1]

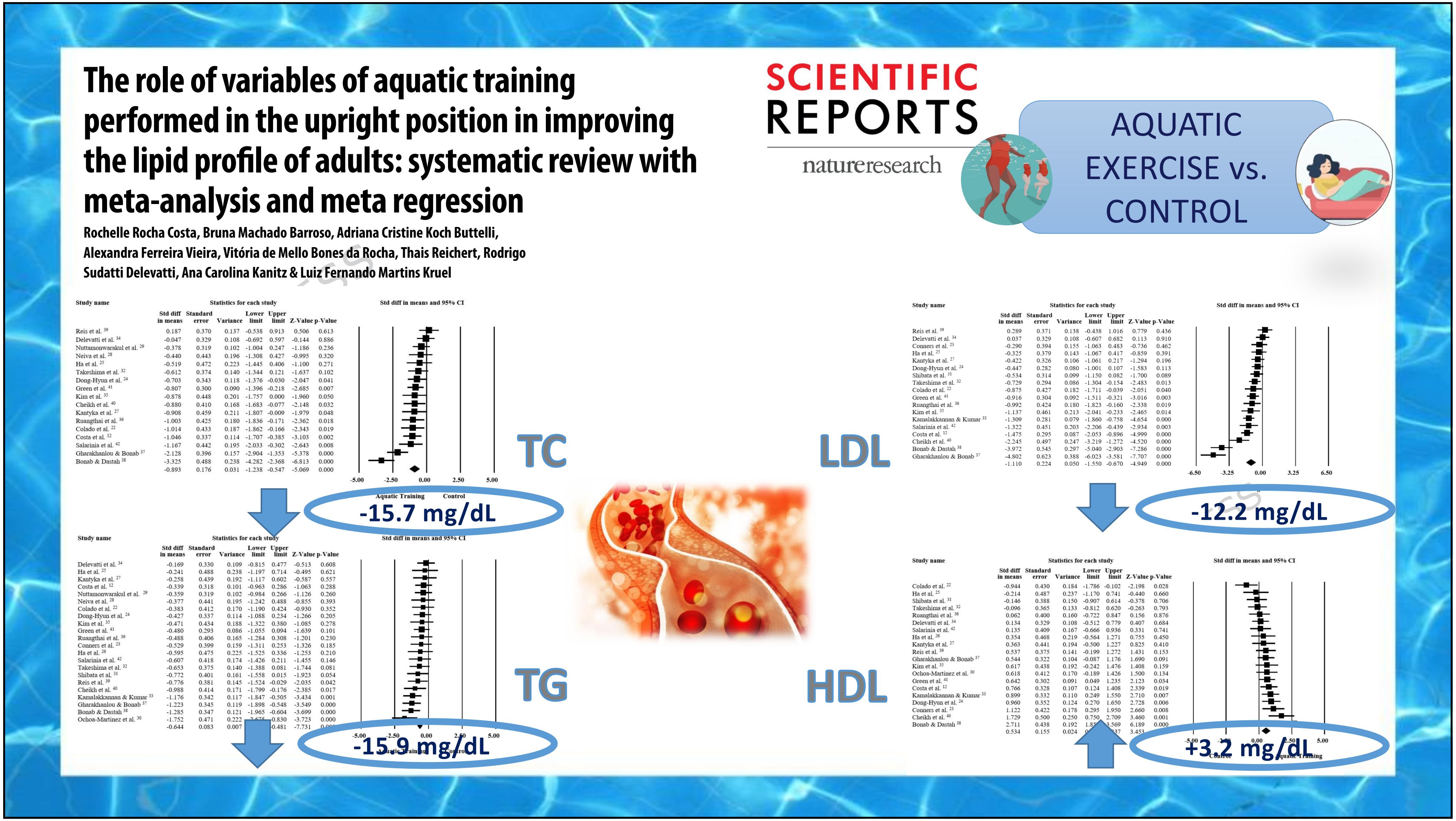
Sports Med (2018) 48:1727–1737
https://doi.org/10.1007/s40279-018-0918-0

Study	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Colado et al. [22]	-0.403	0.412	0.170	-1.211	0.405	-0.978	0.328
Farahani et al. [29]	-2.335	0.433	0.187	-3.183	-1.487	-5.396	0.000
Guimarães et al. [30]	-2.381	0.462	0.214	-3.287	-1.475	-5.152	0.000
Kamalakkannan et al. [32]	-1.695	0.369	0.136	-2.417	-0.972	-4.597	0.000
Nuttamonwarakul et al. [25]	-0.327	0.318	0.101	-0.951	0.297	-1.026	0.305
Pechter et al. [33]	-1.840	0.485	0.235	-2.791	-0.890	-3.796	0.000
Overall	-1.469	0.390	0.152	-2.233	-0.705	-3.768	0.000



Study	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Colado et al. [22]	-1.447	0.457	0.209	-2.342	-0.552	-3.169	0.002
Farahani et al. [29]	-1.019	0.363	0.132	-1.731	-0.307	-2.804	0.005
Guimarães et al. [30]	-0.968	0.374	0.140	-1.700	-0.235	-2.590	0.010
Kamalakkannan et al. [32]	-1.072	0.338	0.114	-1.735	-0.409	-3.170	0.002
Nuttamonwarakul et al. [25]	-0.990	0.335	0.112	-1.646	-0.333	-2.954	0.003
Pechter et al. [33]	0.000	0.412	0.170	-0.808	0.808	0.000	1.000
Overall	-0.920	0.177	0.031	-1.266	-0.574	-5.211	0.000




The role of variables of aquatic training performed in the upright position in improving the lipid profile of adults: systematic review with meta-analysis and meta regression
Rochelle Rocha Costa, Bruna Machado Barroso, Adriana Cristine Koch Buttelli, Alexandra Ferreira Vieira, Vitória de Mello Bones da Rocha, Thais Reichert, Rodrigo Sudatti Delevatti, Ana Carolina Kanitz & Luiz Fernando Martins Kruel
SCIENTIFIC REPORTS
natureresearch
AQUATIC EXERCISE vs. CONTROL
TC
-15.7 mg/dL
LDL
-12.2 mg/dL
TG
-15.9 mg/dL
HDL
+3.2 mg/dL

Aquatic exercise effectiveness

Collectively, these findings support the cardiorespiratory fitness and cardiometabolic benefits of aquatic exercise programs.

Key factor: Exercise Dosage

How should we prescribe and monitor aquatic exercise to maximize these benefits?

Exercise Dosage: The FITT Principle

- **F**requency
- **I**ntensity
- **T**ime
- **T**ype

Controlling these variables is the foundation of effective exercise prescription

AMERICAN COLLEGE of SPORTS MEDICINE

POSITION STAND

0195-9131/11/4307-1334/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0b013e318213fefb

Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise

This pronouncement was written for the American College of Sports Medicine by Carol Ewing Garber, Ph.D., FACSM, (Chair); Bryan Blissmer, Ph.D.; Michael R. Deschenes, Ph.D., FACSM; Barry A. Franklin, Ph.D., FACSM; Michael J. Lamonte, Ph.D., FACSM; I-Min Lee, M.D., Sc.D., FACSM; David C. Nieman, Ph.D., FACSM; and David P. Swain, Ph.D., FACSM.

Exercise Dosage: The FITT Principle

AEROBIC EXERCISES

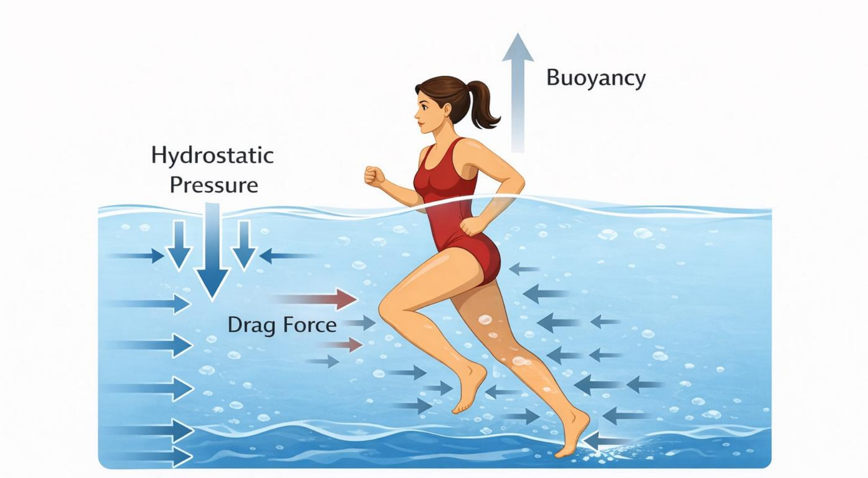
- **F**requency
  - ≈ 3 sessions per week;
- **T**ime
  - Minimum of 20-30 minutes per session;
- **T**ype
  - Aerobic exercises involving large muscle groups, performed continuously or intermittently.

Exercise Dosage: The FITT Principle

AEROBIC EXERCISES

- Intensity:
  - Moderate: 40–59% HRR
  - Vigorous: 60–89% HRR

Intensity	%HRR or %$\dot{V}O_2R$	%HR_{max}	%$\dot{V}O_{2max}$
Very light	<30	<57	<37
Light	30–39	57–63	37–45
Moderate	40–59	64–76	46–63
Vigorous	60–89	77–95	64–90
Near–maximal to maximal	≥90	≥96	≥91



HR control is a bit more complex in water due to the effects of water properties on the body

What makes aquatic exercise unique?

Drag force

$$F_d = \frac{1}{2} C_d \, \rho \, A \, V^2$$

→ **Fluid dynamics Principles**

MULTIDIRECTIONAL RESISTANCE

→ **Role in determining exercise load during aquatic activities**

What makes aquatic exercise unique?

Buoyancy

Population	% reduction in apparent weight	
Young adults - ♂ ♀	71% -	Harrisson et al., Physioterapy, 1992
Post menop (57y) ♀	75% -	Alberton et al., Eur J Sport Sci, 2021
Older adults (69y) ♀	80% -	Alberton et al., Res Q Exerc Sport, 2019
Obesity (24y) ♀	81% -	Alberton et al., Sports Biomech, 2024

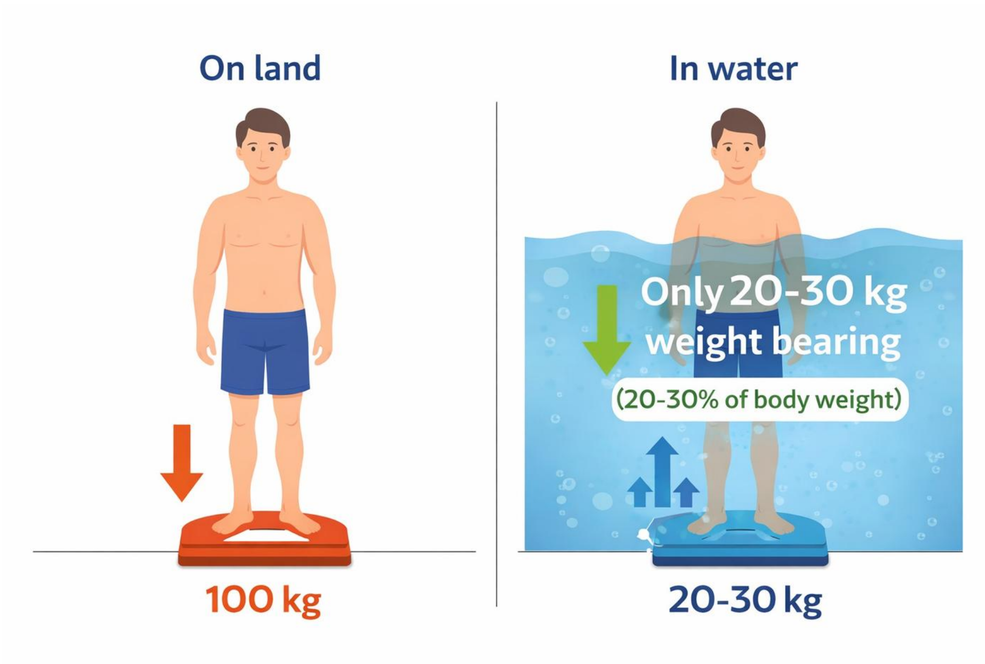
NOTE: xyphoid process depth immersion

UPWARD FORCE AGAINST GRAVITY → **Allows the body to float**

What makes aquatic exercise unique?

Buoyancy

UPWARD FORCE
AGAINST GRAVITY

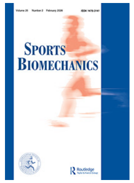


What makes aquatic exercise unique?

SPORTS BIOMECHANICS
2024, VOL. 23, NO. 4, 470–483
https://doi.org/10.1080/14763141.2021.1872690

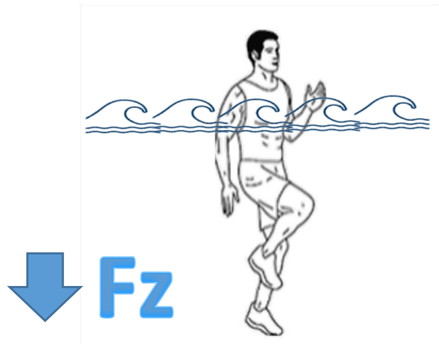
Routledge
Taylor & Francis Group

Check for updates

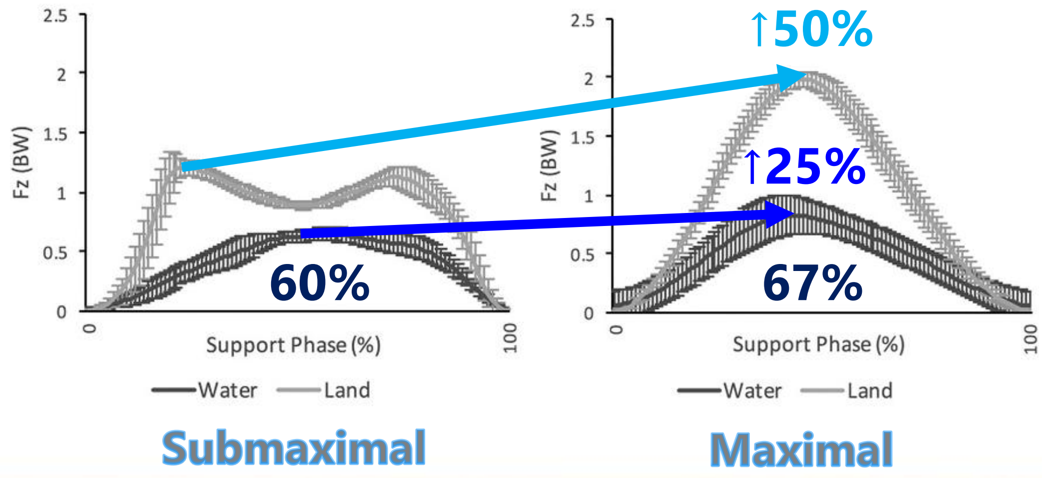


Magnitude of vertical ground reaction force during water-based exercises in women with obesity

Cristine Lima Alberton[a], Bruna Amaral Fonseca[a], Gabriela Neves Nunes[a], Marco Bergamin[b] and Stephanie Santana Pinto[a]



↑ physiological intensities can be achieved in the aquatic environment with lower mechanical loads



What makes aquatic exercise unique?

Hydrostatic Pressure

1 atm: ≈760 mmHg
1m water: 73.6 mmHg

- ↓ pressure
  Upper body

- ↑ pressure
  Lower limbs

GREATER ACTION AS DEPTH INCREASES

Pressure gradient:
Body fluids are redistributed from the lower limbs toward the upper body

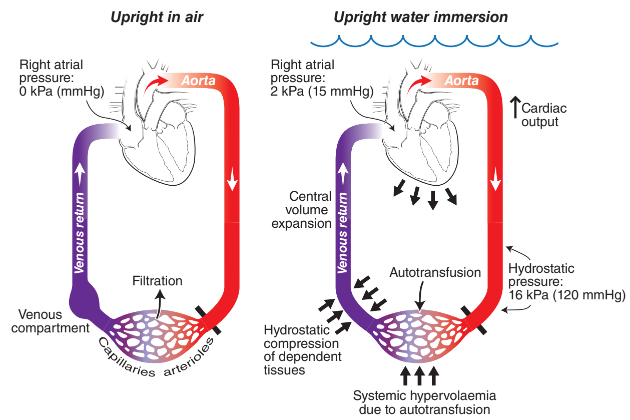
↑ VR

Cardiovascular changes

Human Physiology in an Aquatic Environment

*David R. Pendergast,[*1,2] Richard E. Moon,[3] John J. Krasney,[2] Heather E. Held,[4] and Paola Zamparo[5]*

COMPREHENSIVE PHYSIOLOGY Volume 5, October 2015



↑ VR

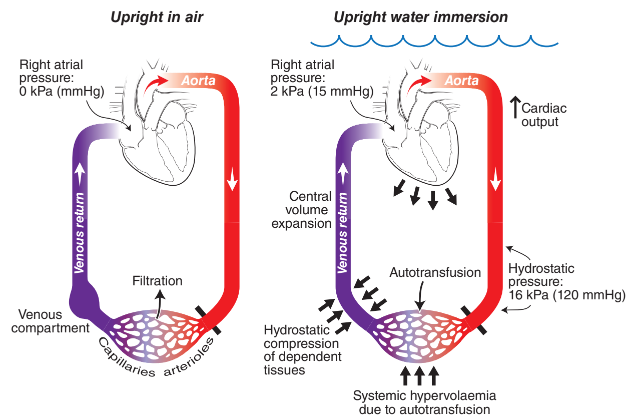
- ↑ central blood volume;
- ↑ stroke volume (Frank-Starling);
- ↑ cardiac output;
- ↓ compensatory HR.

Neuroendocrine changes

Human Physiology in an Aquatic Environment

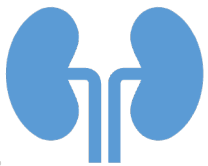
David R. Pendergast,[*1,2] *Richard E. Moon,*[3] *John J. Krasney,*[2] *Heather E. Held,*[4] *and Paola Zamparo*[5]

COMPREHENSIVE PHYSIOLOGY Volume 5, October 2015



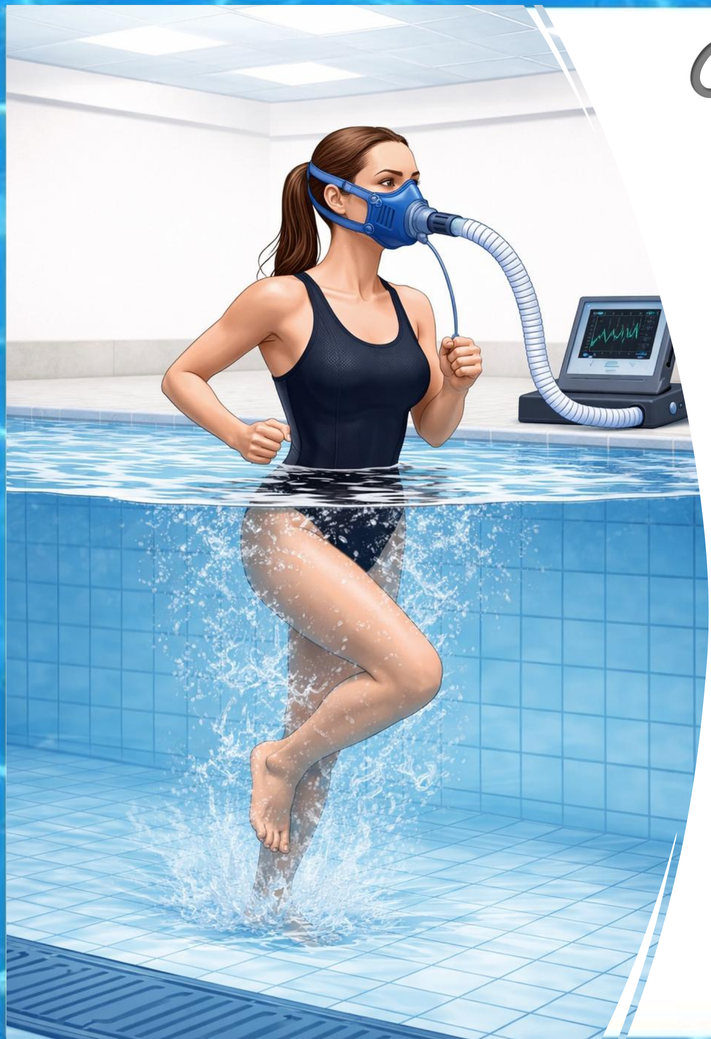
↑ VR

- ↑ central blood volume;
- ↑ stroke volume (Frank-Starling);



But do these adjustments persist during exercise?
How do they influence exercise prescription?

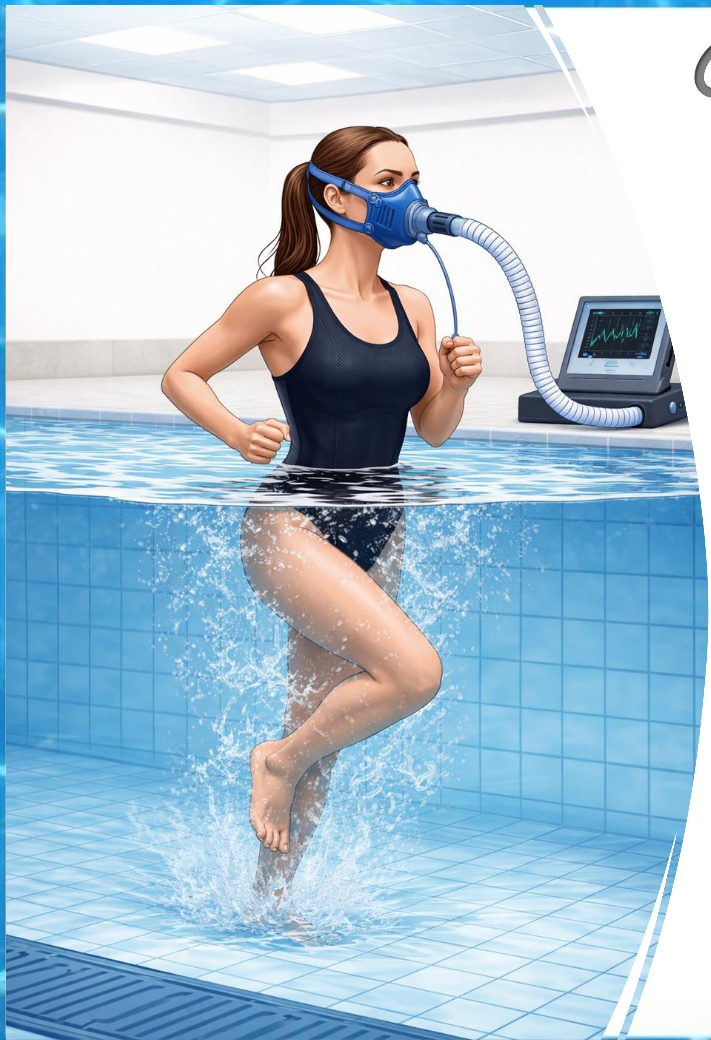
- Atrial stretching;
- ↑ atrial natriuretic peptide secretion;
- ↓ antidiuretic hormone;
- ↓ renine-angiotensin-aldosterone system;
- ↓ SNS activity;
- ↓ systemic vascular resistance;
- ↑ diuresis + natriuresis.



Connection: Exercise intensity prescription in water

HR = 130 bpm

How can this intensity be classified?
What is its clinical significance?

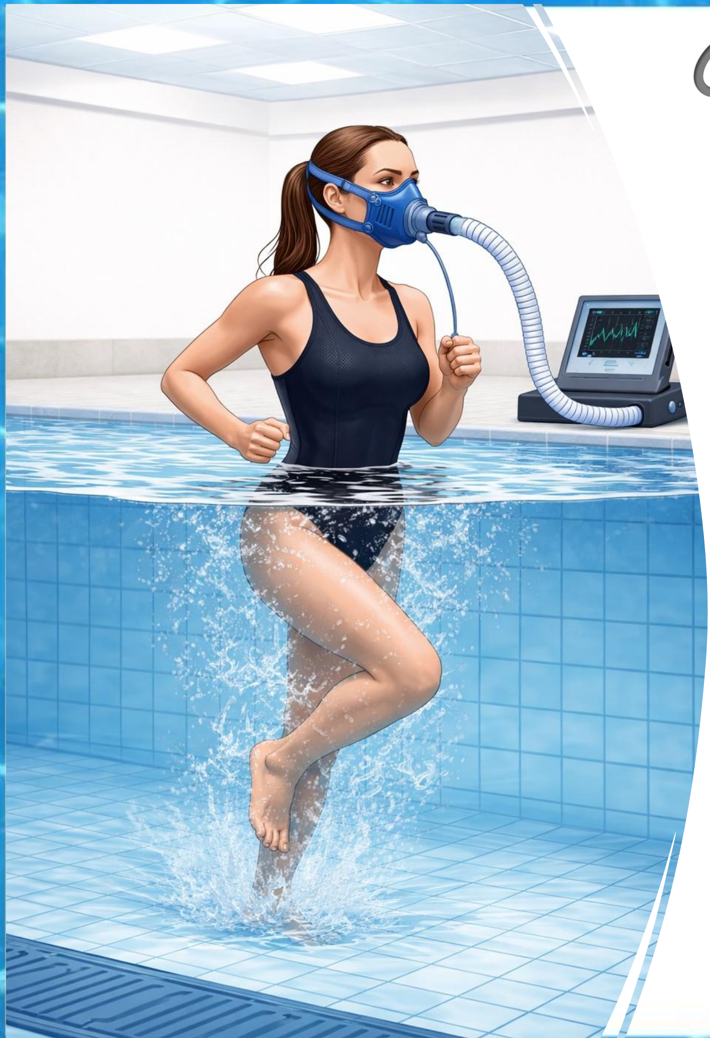


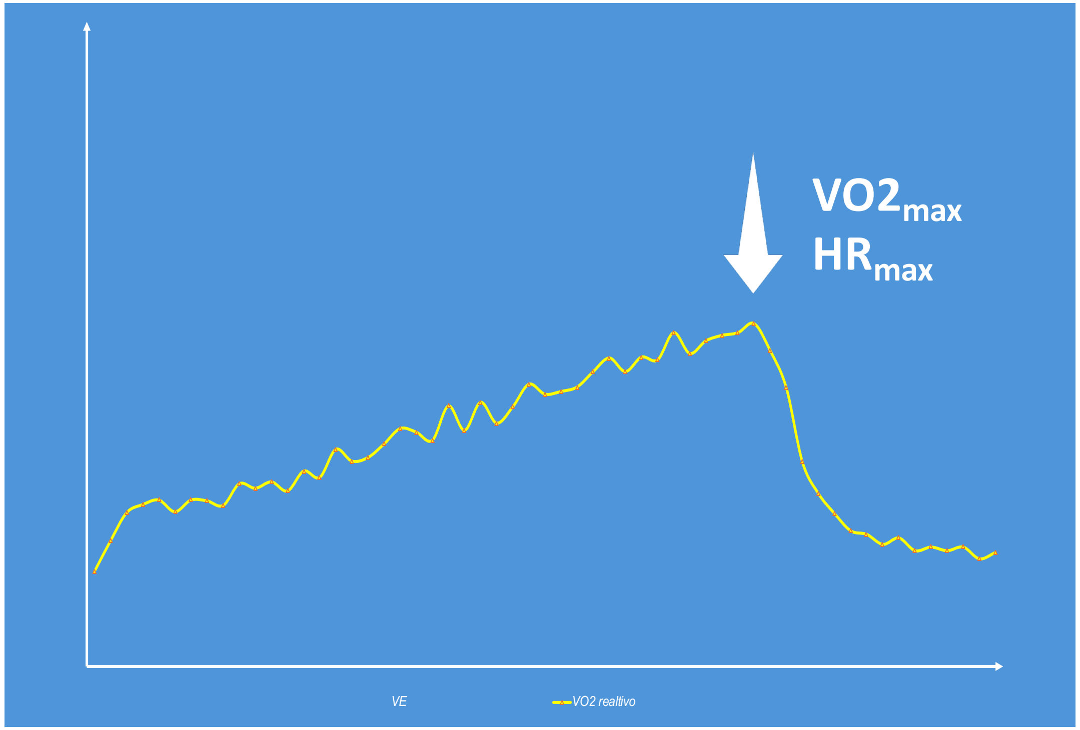
Cardiorrespiratory responses: Graded Maximal Test

HR_{max}

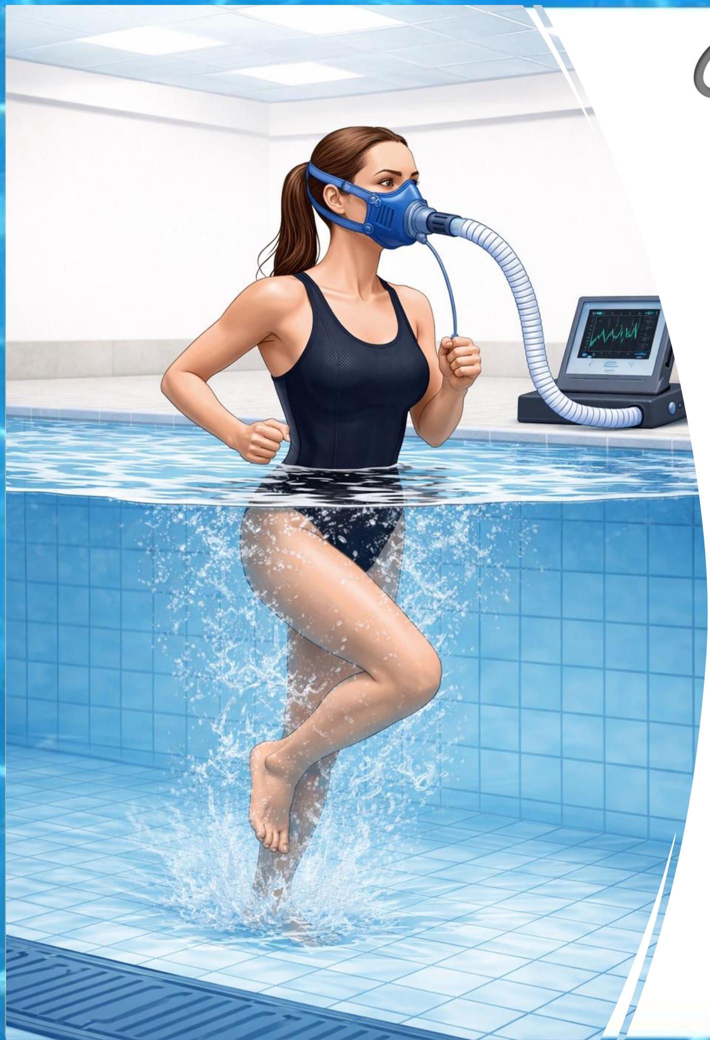
- Estimated from equations
- Graded maximal test

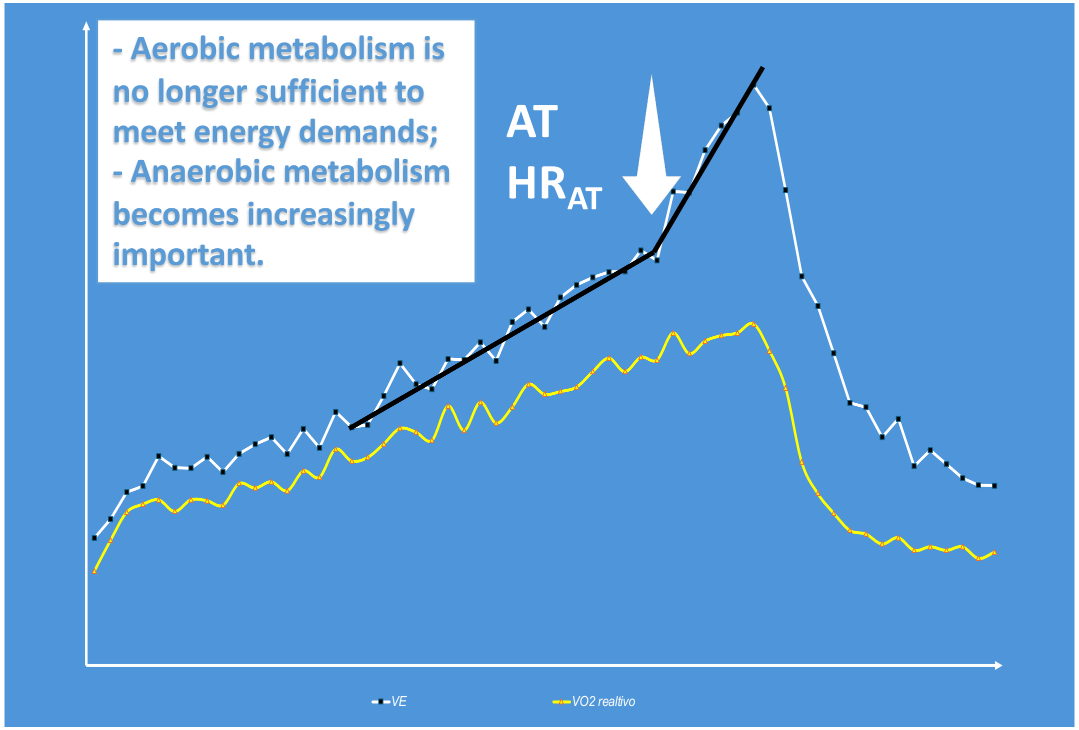
Cardiorrespiratory responses: Graded Maximal Test

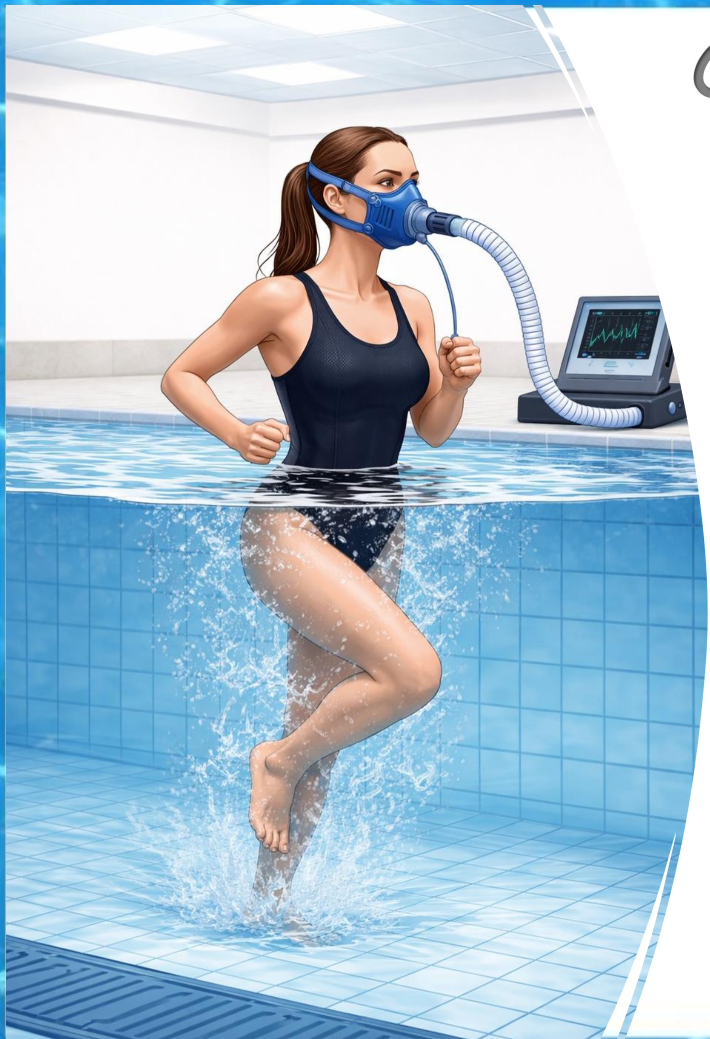




Cardiorrespiratory responses: Graded Maximal Test

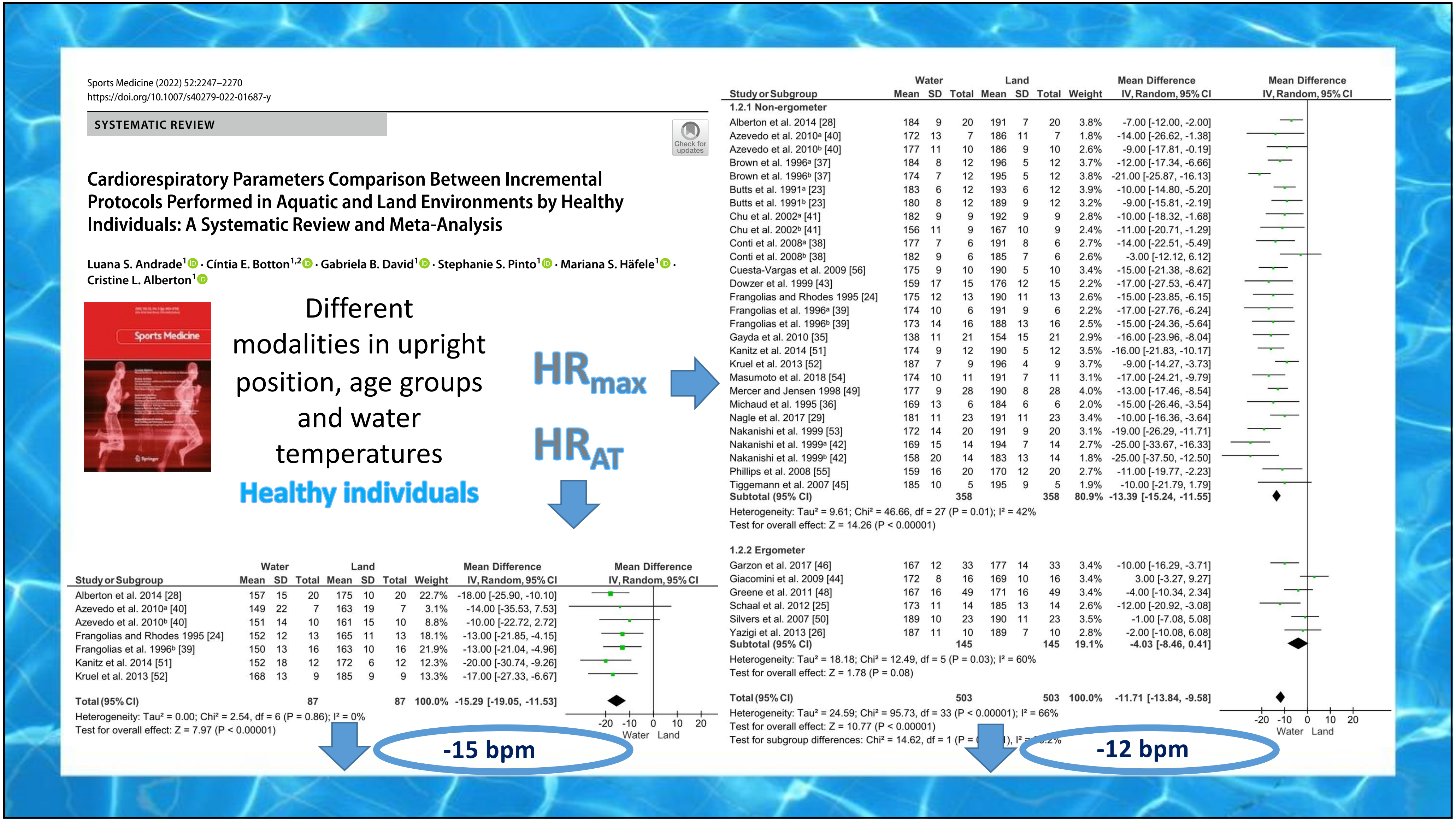






Cardiorrespiratory responses: Graded Maximal Test

Understanding how HR behaves at this metabolic threshold and at maximal intensity in water is essential to determine whether the physiological responses observed at rest persist during exercise.



Sports Medicine (2022) 52:2247–2270
https://doi.org/10.1007/s40279-022-01687-y

SYSTEMATIC REVIEW

Cardiorespiratory Parameters Comparison Between Incremental Protocols Performed in Aquatic and Land Environments by Healthy Individuals: A Systematic Review and Meta-Analysis

Luana S. Andrade[1] · Cíntia E. Botton[1,2] · Gabriela B. David[1] · Stephanie S. Pinto[1] · Mariana S. Häfele[1] · Cristine L. Alberton[1]

Study or Subgroup	Water Mean	Water SD	Water Total	Land Mean	Land SD	Land Total	Weight	Mean Difference IV, Random, 95% CI
Alberton et al. 2014 [28]	157	15	20	175	10	20	22.7%	-18.00 [-25.90, -10.10]
Azevedo et al. 2010ª [40]	149	22	7	163	19	7	3.1%	-14.00 [-35.53, 7.53]
Azevedo et al. 2010ᵇ [40]	151	14	10	161	15	10	8.8%	-10.00 [-22.72, 2.72]
Frangolias and Rhodes 1995 [24]	152	12	13	165	11	13	18.1%	-13.00 [-21.85, -4.15]
Frangolias et al. 1996ᵇ [39]	150	13	16	163	10	16	21.9%	-13.00 [-21.04, -4.96]
Kanitz et al. 2014 [51]	152	18	12	172	6	12	12.3%	-20.00 [-30.74, -9.26]
Kruel et al. 2013 [52]	168	13	9	185	9	9	13.3%	-17.00 [-27.33, -6.67]
Total (95% CI)			**87**			**87**	**100.0%**	**-15.29 [-19.05, -11.53]**

Heterogeneity: Tau² = 0.00; Chi² = 2.54, df = 6 (P = 0.86); I² = 0%
Test for overall effect: Z = 7.97 (P < 0.00001)

Study or Subgroup	Water Mean	Water SD	Water Total	Land Mean	Land SD	Land Total	Weight	Mean Difference IV, Random, 95% CI
1.2.1 Non-ergometer								
Alberton et al. 2014 [28]	184	9	20	191	7	20	3.8%	-7.00 [-12.00, -2.00]
Azevedo et al. 2010ª [40]	172	13	7	186	11	7	1.8%	-14.00 [-26.62, -1.38]
Azevedo et al. 2010ᵇ [40]	177	11	10	186	9	10	2.6%	-9.00 [-17.81, -0.19]
Brown et al. 1996ª [37]	184	8	12	196	5	12	3.7%	-12.00 [-17.34, -6.66]
Brown et al. 1996ᵇ [37]	174	7	12	195	5	12	3.8%	-21.00 [-25.87, -16.13]
Butts et al. 1991ª [23]	183	6	12	193	6	12	3.9%	-10.00 [-14.80, -5.20]
Butts et al. 1991ᵇ [23]	180	8	12	189	9	12	3.2%	-9.00 [-15.81, -2.19]
Chu et al. 2002ª [41]	182	9	9	192	9	9	2.8%	-10.00 [-18.32, -1.68]
Chu et al. 2002ᵇ [41]	156	11	9	167	10	9	2.4%	-11.00 [-20.71, -1.29]
Conti et al. 2008ª [38]	177	7	6	191	8	6	2.7%	-14.00 [-22.51, -5.49]
Conti et al. 2008ᵇ [38]	182	9	6	185	7	6	2.6%	-3.00 [-12.12, 6.12]
Cuesta-Vargas et al. 2009 [56]	175	9	10	190	5	10	3.4%	-15.00 [-21.38, -8.62]
Dowzer et al. 1999 [43]	159	17	15	176	12	15	2.2%	-17.00 [-27.53, -6.47]
Frangolias and Rhodes 1995 [24]	175	12	13	190	11	13	2.6%	-15.00 [-23.85, -6.15]
Frangolias et al. 1996ª [39]	174	10	6	191	9	6	2.2%	-17.00 [-27.76, -6.24]
Frangolias et al. 1996ᵇ [39]	173	14	16	188	13	16	2.5%	-15.00 [-24.36, -5.64]
Gayda et al. 2010 [35]	138	11	21	154	15	21	2.9%	-16.00 [-23.96, -8.04]
Kanitz et al. 2014 [51]	174	9	12	190	5	12	3.5%	-16.00 [-21.83, -10.17]
Kruel et al. 2013 [52]	187	7	9	196	4	9	3.7%	-9.00 [-14.27, -3.73]
Masumoto et al. 2018 [54]	174	10	11	191	7	11	3.1%	-17.00 [-24.21, -9.79]
Mercer and Jensen 1998 [49]	177	9	28	190	8	28	4.0%	-13.00 [-17.46, -8.54]
Michaud et al. 1995 [36]	169	13	6	184	6	6	2.0%	-15.00 [-26.46, -3.54]
Nagle et al. 2017 [29]	181	11	23	191	11	23	3.4%	-10.00 [-16.36, -3.64]
Nakanishi et al. 1999 [53]	172	14	20	191	9	20	3.1%	-19.00 [-26.29, -11.71]
Nakanishi et al. 1999ª [42]	169	15	14	194	7	14	2.7%	-25.00 [-33.67, -16.33]
Nakanishi et al. 1999ᵇ [42]	158	20	14	183	13	14	1.8%	-25.00 [-37.50, -12.50]
Phillips et al. 2008 [55]	159	16	20	170	12	20	2.7%	-11.00 [-19.77, -2.23]
Tiggemann et al. 2007 [45]	185	10	5	195	9	5	1.9%	-10.00 [-21.79, 1.79]
Subtotal (95% CI)			**358**			**358**	**80.9%**	**-13.39 [-15.24, -11.55]**
Heterogeneity: Tau² = 9.61; Chi² = 46.66, df = 27 (P = 0.01); I² = 42%								
Test for overall effect: Z = 14.26 (P < 0.00001)								
1.2.2 Ergometer								
Garzon et al. 2017 [46]	167	12	33	177	14	33	3.4%	-10.00 [-16.29, -3.71]
Giacomini et al. 2009 [44]	172	8	16	169	10	16	3.4%	3.00 [-3.27, 9.27]
Greene et al. 2011 [48]	167	16	49	171	16	49	3.4%	-4.00 [-10.34, 2.34]
Schaal et al. 2012 [25]	173	11	14	185	13	14	2.6%	-12.00 [-20.92, -3.08]
Silvers et al. 2007 [50]	189	10	23	190	11	23	3.5%	-1.00 [-7.08, 5.08]
Yazigi et al. 2013 [26]	187	11	10	189	7	10	2.8%	-2.00 [-10.08, 6.08]
Subtotal (95% CI)			**145**			**145**	**19.1%**	**-4.03 [-8.46, 0.41]**
Heterogeneity: Tau² = 18.18; Chi² = 12.49, df = 5 (P = 0.03); I² = 60%								
Test for overall effect: Z = 1.78 (P = 0.08)								
Total (95% CI)			**503**			**503**	**100.0%**	**-11.71 [-13.84, -9.58]**

Heterogeneity: Tau² = 24.59; Chi² = 95.73, df = 33 (P < 0.00001); I² = 66%
Test for overall effect: Z = 10.77 (P < 0.00001)
Test for subgroup differences: Chi² = 14.62, df = 1 (P = [illegible]), I² = [illegible]

Exercise intensity prescription in water

Intensity	%HRR or %$\dot{V}O_2R$	%HR_{max}	%$\dot{V}O_{2max}$
Very light	<30	<57	<37
Light	30–39	57–63	37–45
Moderate	40–59	64–76	46–63
Vigorous	60–89	77–95	64–90
Near–maximal to maximal	≥90	≥96	≥91

Clinical Practice → HRReserve:

$$\%HRR = [(HR_{max} - HR_{rest}) \times \%target] + HR_{rest}$$

HR for intensity control in water

Using HR values obtained on land → misclassify exercise intensity in water → usually overestimating it.

HR is influenced by water temperature, immersion depth, and body position → land-based HR → innacurate prescription.

Aquatic exercise intensity control is not simply "land exercise performed in water”

Andrade LS, Alberton CL. Aquatic aerobic exercise and physical fitness: from scientific foundations to practical applications. Rev Bras Ativ Fis Saúde. 2025;30:e0390.

How should we actually use HR in water?

- Use aquatic-specific testing
- If testing is not feasible → adjust estimated HR
- Medical treatment → HR may be inaccurate

Alternative ways of intensity control may be necessary depending on the clinical case.

RPE - Rating of Perceived Exertion

- RPE is a practical and valid tool for monitoring intensity during aquatic exercise.

Borg RPE Scale®

Use this scale to tell how strenuous and tiring the work feels to you. The exertion is mainly felt as fatigue in your muscles and as breathlessness or possibly aches. When the exercise is hard it also becomes difficult to talk. It is your own feeling of exertion that is important. Don't underestimate it, but don't overestimate it either. For common exercise, such as cycling, running or walking, 11-15 is a good level. For strength and high-intensity interval training (HIIT), 15-19 is good. If you are sick follow your doctor's advice. Look at the scale and the descriptions and then choose a number. Use whatever numbers you want, even numbers between the descriptions.

6	**No exertion at all**	No muscle fatigue, breathlessness or difficulty in breathing.
7	**Extremely light**	Very, very light.
8		
9	**Very light**	Like walking slowly for a short while. Very easy to talk.
10		
11	**Light**	Like a light exercise at your own pace.
12	**Moderate**	
13	**Somewhat hard**	Fairly strenuous and breathless. Not so easy to talk.
14		
15	**Hard**	Heavy and strenuous. An upper limit for fitness training, as when running or walking fast.
16		
17	**Very hard**	Very strenuous. You are very tired and breathless. Very difficult to talk.
18		
19	**Extremely hard**	The most strenuous effort you have ever experienced.
20	**Maximal exertion**	Maximal heaviness.

0	Nothing at all	
0.3		
0.5	Extremely weak	Just noticeable
0.7		
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	"Maximal"
11		
⊰		
●	Absolute maximum	Highest possible

0	**Nothing at all**	
0,5	**Minimal**	
1	**Very weak**	
1,5		
2	**Weak**	**Light**
2,5		
3	**Moderate**	
4		
5	**Strong**	**Heavy**
6		
7	**Very strong**	
8		
9		
10	**Extremely strong** **"Maximal"**	
11		
⊰		
●	**Absolute maximum** **Highest possible**	

●	Absolute maximum	
120		
110		
100	"Maximal"	
95		
90	Extremely strong	
85		
80		
75		
70	Very strong	
65		
60		
55		
50	Strong	Heavy
45		
40		
35	Somewhat strong	
30		
25		
	Moderate	
20		
15		
12	Weak	Light
10		
7	Very weak	
5		
3	Extremely weak	
2	"Minimal"	
1	Absolute minimum	
0	Nothing at all	

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	Moderate
13	Somewhat hard
14	**HR = 130 bpm**
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

INSTRUCTION:

Individuals are asked to rate how hard they feel they are working, considering sensations such as breathing, fatigue, and overall effort

Borg RPE Scale®
Ratings (R) of Perceived (P) Exertion (E).

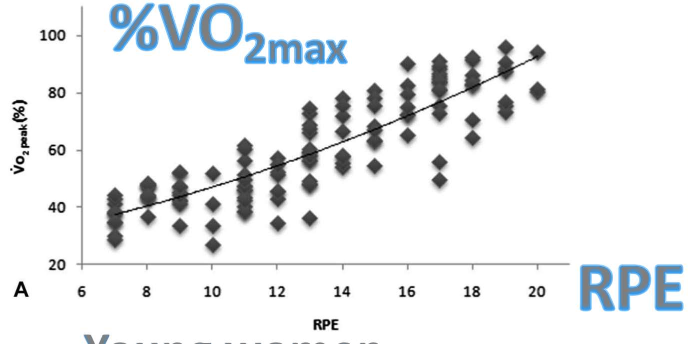
English

Relationship between RPE and VO_2

HR, $\dot{V}O_2$, AND RPE RELATIONSHIPS IN AN AQUATIC INCREMENTAL MAXIMUM TEST PERFORMED BY YOUNG WOMEN

GABRIELA B. DAVID, LUANA S. ANDRADE, GUSTAVO Z. SCHAUN, AND CRISTINE L. ALBERTON
Department of Sports, Physical Education School, Federal University of Pelotas, Pelotas, Brazil

J Strength Cond Res 31(10): 2852–2858, 2017-

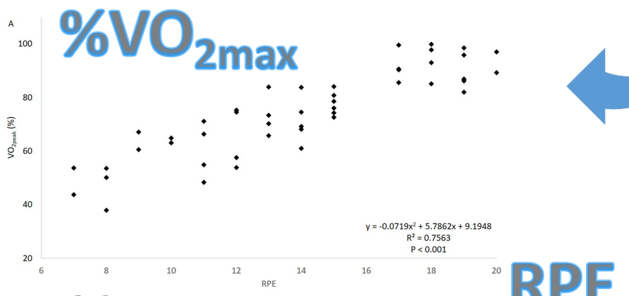


International Journal of
Environmental Research and Public Health
MDPI

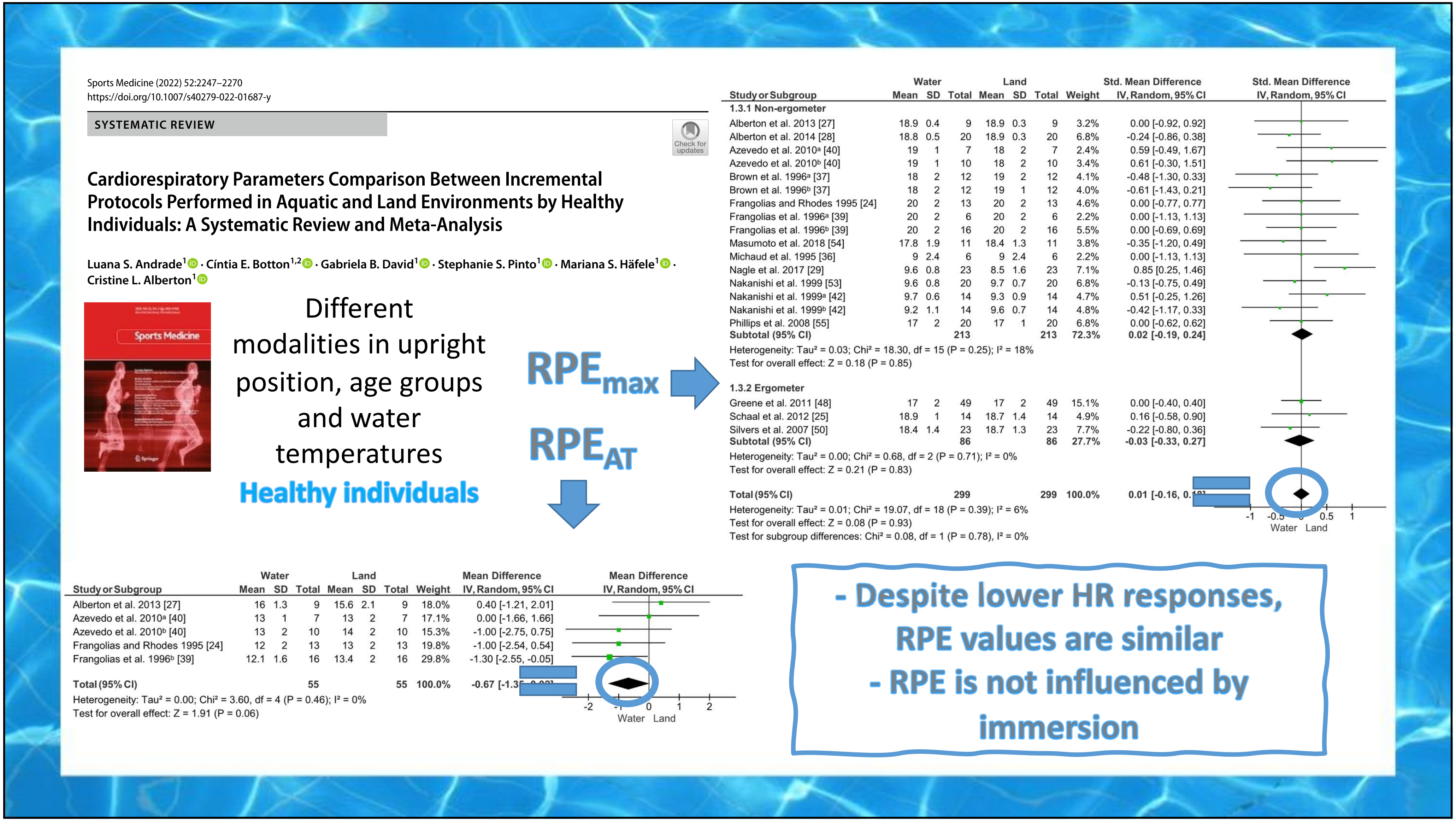
Article

Relationship between Oxygen Uptake, Heart Rate, and Perceived Effort in an Aquatic Incremental Test in Older Women

Luana Siqueira Andrade [1], Ana Carolina Kanitz [2], Mariana Silva Häfele [1], Gustavo Zaccaria Schaun [1,3], Stephanie Santana Pinto [1] and Cristine Lima Alberton [1,*]



VO2: gold-standard parameter for physiological exercise intensity



Sports Medicine (2022) 52:2247–2270
https://doi.org/10.1007/s40279-022-01687-y
SYSTEMATIC REVIEW
Check for updates
Cardiorespiratory Parameters Comparison Between Incremental Protocols Performed in Aquatic and Land Environments by Healthy Individuals: A Systematic Review and Meta-Analysis
Luana S. Andrade[1] · Cíntia E. Botton[1,2] · Gabriela B. David[1] · Stephanie S. Pinto[1] · Mariana S. Häfele[1] · Cristine L. Alberton[1]
Sports Medicine
Different modalities in upright position, age groups and water temperatures
Healthy individuals
RPEmax
RPEAT
Study or Subgroup | Water Mean SD Total | Land Mean SD Total | Weight | Std. Mean Difference IV, Random, 95% CI
1.3.1 Non-ergometer
Alberton et al. 2013 [27] 18.9 0.4 9 18.9 0.3 9 3.2% 0.00 [-0.92, 0.92]
Alberton et al. 2014 [28] 18.8 0.5 20 18.9 0.3 20 6.8% -0.24 [-0.86, 0.38]
Azevedo et al. 2010a [40] 19 1 7 18 2 7 2.4% 0.59 [-0.49, 1.67]
Azevedo et al. 2010b [40] 19 1 10 18 2 10 3.4% 0.61 [-0.30, 1.51]
Brown et al. 1996a [37] 18 2 12 19 2 12 4.1% -0.48 [-1.30, 0.33]
Brown et al. 1996b [37] 18 2 12 19 1 12 4.0% -0.61 [-1.43, 0.21]
Frangolias and Rhodes 1995 [24] 20 2 13 20 2 13 4.6% 0.00 [-0.77, 0.77]
Frangolias et al. 1996a [39] 20 2 6 20 2 6 2.2% 0.00 [-1.13, 1.13]
Frangolias et al. 1996b [39] 20 2 16 20 2 16 5.5% 0.00 [-0.69, 0.69]
Masumoto et al. 2018 [54] 17.8 1.9 11 18.4 1.3 11 3.8% -0.35 [-1.20, 0.49]
Michaud et al. 1995 [36] 9 2.4 6 9 2.4 6 2.2% 0.00 [-1.13, 1.13]
Nagle et al. 2017 [29] 9.6 0.8 23 8.5 1.6 23 7.1% 0.85 [0.25, 1.46]
Nakanishi et al. 1999 [53] 9.6 0.8 20 9.7 0.7 20 6.8% -0.13 [-0.75, 0.49]
Nakanishi et al. 1999a [42] 9.7 0.6 14 9.3 0.9 14 4.7% 0.51 [-0.25, 1.26]
Nakanishi et al. 1999b [42] 9.2 1.1 14 9.6 0.7 14 4.8% -0.42 [-1.17, 0.33]
Phillips et al. 2008 [55] 17 2 20 17 1 20 6.8% 0.00 [-0.62, 0.62]
Subtotal (95% CI) 213 213 72.3% 0.02 [-0.19, 0.24]
Heterogeneity: Tau² = 0.03; Chi² = 18.30, df = 15 (P = 0.25); I² = 18%
Test for overall effect: Z = 0.18 (P = 0.85)
1.3.2 Ergometer
Greene et al. 2011 [48] 17 2 49 17 2 49 15.1% 0.00 [-0.40, 0.40]
Schaal et al. 2012 [25] 18.9 1 14 18.7 1.4 14 4.9% 0.16 [-0.58, 0.90]
Silvers et al. 2007 [50] 18.4 1.4 23 18.7 1.3 23 7.7% -0.22 [-0.80, 0.36]
Subtotal (95% CI) 86 86 27.7% -0.03 [-0.33, 0.27]
Heterogeneity: Tau² = 0.00; Chi² = 0.68, df = 2 (P = 0.71); I² = 0%
Test for overall effect: Z = 0.21 (P = 0.83)
Total (95% CI) 299 299 100.0% 0.01 [-0.16, 0.1
Heterogeneity: Tau² = 0.01; Chi² = 19.07, df = 18 (P = 0.39); I² = 6%
Test for overall effect: Z = 0.08 (P = 0.93)
Test for subgroup differences: Chi² = 0.08, df = 1 (P = 0.78), I² = 0%
Std. Mean Difference IV, Random, 95% CI
-1 -0.5 0 0.5 1
Water Land
Study or Subgroup | Water Mean SD Total | Land Mean SD Total | Weight | Mean Difference IV, Random, 95% CI
Alberton et al. 2013 [27] 16 1.3 9 15.6 2.1 9 18.0% 0.40 [-1.21, 2.01]
Azevedo et al. 2010a [40] 13 1 7 13 2 7 17.1% 0.00 [-1.66, 1.66]
Azevedo et al. 2010b [40] 13 2 10 14 2 10 15.3% -1.00 [-2.75, 0.75]
Frangolias and Rhodes 1995 [24] 12 2 13 13 2 13 19.8% -1.00 [-2.54, 0.54]
Frangolias et al. 1996b [39] 12.1 1.6 16 13.4 2 16 29.8% -1.30 [-2.55, -0.05]
Total (95% CI) 55 55 100.0% -0.67 [-1.3
Heterogeneity: Tau² = 0.00; Chi² = 3.60, df = 4 (P = 0.46); I² = 0%
Test for overall effect: Z = 1.91 (P = 0.06)
Mean Difference IV, Random, 95% CI
-2 -1 0 1 2
Water Land
- Despite lower HR responses, RPE values are similar
- RPE is not influenced by immersion

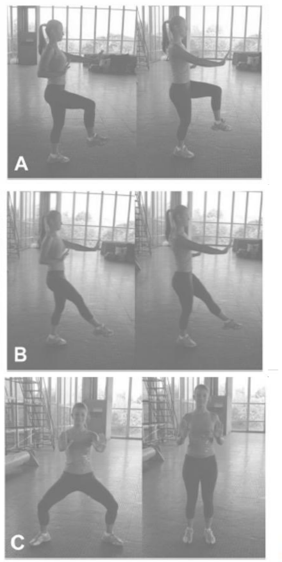
RPE and Metabolic Thresholds

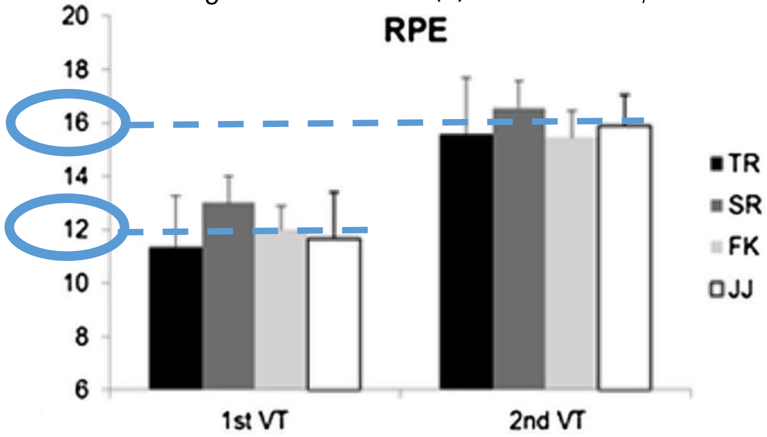
Maximal and Ventilatory Thresholds of Oxygen Uptake and Rating of Perceived Exertion Responses to Water Aerobic Exercises

Cristine L. Alberton, Amanda H. Antunes, Débora D. Beilke, Stephanie S. Pinto, Ana C. Kanitz, Marcus P. Tartaruga, and Luiz F. Martins Kruel
Exercise Research Laboratory, School of Physical Education, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

J Strength Cond Res 27(7): 1897–1903, 2013-

Young women





ACSM Guidelines: moderate-to-vigorous intensity limits

6	No exertion at all	
7	Extremely light	
8		
9	Very light	
10		
11	Light	
12	Moderate	VT1
13	Somewhat hard	
14		
15	Hard	
16		VT2
17	Very hard	
18		
19	Extremely hard	
20	Maximal exertion	

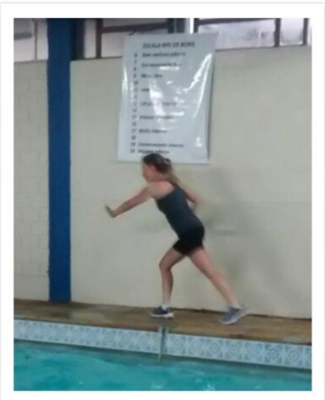
Psicophysiological responses: intensity prescription in water

Intensity	Relative Intensity: %HRR or $\%\dot{V}O_2R$	$\%HR_{max}$	$\%\dot{V}O_{2max}$	Perceived Exertion (Rating on 6–20 RPE Scale)
Very light	<30	<57	<37	<Very light (RPE < 9)
Light	30–39	57–63	37–45	Very light–fairly light (RPE 9–11)
Moderate	40–59	64–76	46–63	Fairly light to somewhat hard (RPE 12–13)
Vigorous	60–89	77–95	64–90	Somewhat hard to very hard (RPE 14–17)
Near–maximal to maximal	≥90	≥96	≥91	≥Very hard (RPE ≥ 18)

RPE may be used to individualize exercise dosage during aquatic aerobic exercise based on these physiological reference parameters

RPE considerations

- Tool validity and usefulness:
  - ✓ Appropriate instruction
  - ✓ Contextual adaptation
  - ✓ Patient familiarization
- Scale needs to be clearly visible



A license for use can be obtained from:
BorgPerception.se [Internet]. About RPE scales; [cited 2026 Feb 25]. Available from: https://borgperception.se/

Borg RPE Scale®

Use this scale to tell how strenuous and tiring the work feels to you. The exertion is mainly felt as fatigue in your muscles and as breathlessness or possibly aches. When the exercise is hard it also becomes difficult to talk. It is your own feeling of exertion that is important. Don't underestimate it, but don't overestimate it either. For common exercise, such as cycling, running or walking, 11-15 is a good level. For strength and high-intensity interval training (HIIT), 15-19 is good. If you are sick follow your doctor's advice. Look at the scale and the descriptions and then choose a number. Use whatever numbers you want, even numbers between the descriptions.

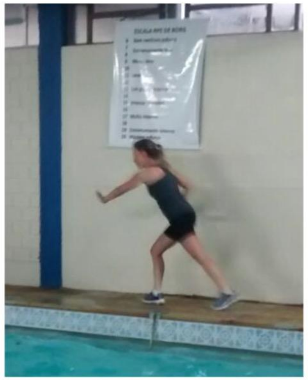
6	**No exertion at all**	No muscle fatigue, breathlessness or difficulty in breathing.
7	**Extremely light**	Very, very light.
8		
9	**Very light**	Like walking slowly for a short while. Very easy to talk.
10		
11	**Light**	Like a light exercise at your own pace.
12	**Moderate**	
13	**Somewhat hard**	Fairly strenuous and breathless. Not so easy to talk.
14		
15	**Hard**	Heavy and strenuous. An upper limit for fitness training, as when running or walking fast.
16		
17	**Very hard**	Very strenuous. You are very tired and breathless. Very difficult to talk.
18		
19	**Extremely hard**	The most strenuous effort you have ever experienced.
20	**Maximal exertion**	Maximal heaviness.

Practical Pool Session

Pool Session 2
Chair: Caio Castro
Theme: Emphasis on Intensity

Saturday April 25th, 2026

15:50-16:30 P4	Rhythm and Music as Therapeutic Tools: Enhancing Motor Control and Modulating Intensity in Aquatic Rehabilitation	Emily Dunlap
16:30-17:10 P5	Mastering Intensity Control: Practical Strategies for Aquatic Aerobic Exercise	Cristine Alberton



FIITT Principle: Real-world applications

STUDY PROTOCOL Open Access

Land- and water-based aerobic exercise program on health-related outcomes in breast cancer survivors (WaterMama): study protocol for a randomized clinical trial

Cristine Lima Alberton[1], Luana Siqueira Andrade[1*], Bruno Ezequiel Botelho Xavier[1], Victor Hugo Guesser Pinheiro[1], Antonio Ignacio Cuesta-Vargas[2] and Stephanie Santana Pinto[1]

Trials

Alberton *et al. Trials* (2024) 25:536
https://doi.org/10.1186/s13063-024-08389-y

WaterMama Trial

STUDY PROTOCOL | Open Access

Land- and water-based aerobic exercise program on health-related outcomes in breast cancer survivors (WaterMama): study protocol for a randomized clinical trial

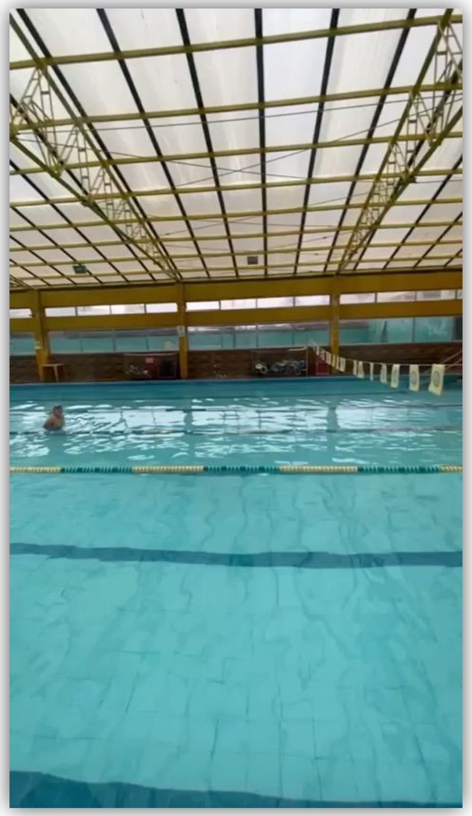
Cristine Lima Alberton[1], Luana Siqueira Andrade[1*], Bruno Ezequiel Botelho Xavier[1], Victor Hugo Guesser Pinheiro[1], Antonio Ignacio Cuesta-Vargas[2] and Stephanie Santana Pinto[1]

Table 2 12-week aerobic exercises duration

Weeks	Sets	Intensity	Duration
1–3	7	4 min RPE 13 + 1 min RPE 11	35 min
4–6	7	4 min RPE 14 + 1 min RPE 11	35 min
7–9	7	4 min RPE 15 + 1 min RPE 11	35 min
10–12	7	4 min RPE 16 + 1 min RPE 11	35 min

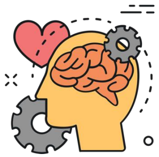
RPE rating of perceived exertion

2x/week



LabNeuro LABORATÓRIO DE AVALIAÇÃO NEUROMUSCULAR · CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico · CAPES · FAPERGS

WaterCog Trial



LabNeuro
LABORATÓRIO DE AVALIAÇÃO NEUROMUSCULAR

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

CAPES

Table 1 Periodization of the 12-week aquatic aerobic exercise program

Weeks	Sets	Exercises	Duration	Intensity	Total Duration
1–4	7	Butt Kick	4 min	RPE 13	35 min
		Frontal Kick			
		Cross-Country Skiing			
		Stationary Running			
		Stationary Running	1 min	RPE ≤ 11	
5–8	7	Butt Kick	4 min	RPE 14	35 min
		Frontal Kick			
		Cross-Country Skiing			
		Stationary Running			
		Stationary Running	1 min	RPE ≤ 11	
9–12	7	Butt Kick	4 min	RPE 15	35 min
		Frontal Kick			
		Cross-Country Skiing			
		Stationary Running			
		Stationary Running	1 min	RPE ≤ 11	

RPE rating of perceived exertion

Take home message

Aquatic aerobic exercise is an effective and safe strategy to improve CRF and cardiometabolic health.

The unique properties of water allow a high physiological stimulus with lower mechanical load, while also altering physiological responses.

Exercise prescription should follow the FITT principle.

Exercise intensity in water requires specific considerations due to immersion, particularly when using HR.

Alternatively, RPE is a valid, practical, and reliable tool to guide exercise intensity in aquatic settings.

UNIVERSIDADE FEDERAL DE PELOTAS
RS-BRASIL

ESCOLA SUPERIOR DE
EDUCAÇÃO FÍSICA
E FISIOTERAPIA
UFPEL

Canada 2026
ICEBAT
GLOBAL TRENDS
IN AQUATIC THERAPY

Thank you!

@cristine.alberton
@labneuroufpel
cristine.alberton@ufpel.edu.br

LabNeuro
LABORATÓRIO DE AVALIAÇÃO NEUROMUSCULAR

Chronic Pain: Where to Start?!!!

ICEBAT 2026

Oliver Krouwel, MSc Clinical Specialist in Pain Management, MSK & Aquatic Physiotherapy Research Officer & ATACP Foundation Course Tutor UK

Email: sussexhydrotherapy@gmail.com

WHY THIS QUESTION MATTERS

- Pain >3 months = disease entity
- Chronic pain is not a niche problem
- Leading cause of Years Lived with Disability (YLDs)
- Increasing complexity: multimorbidity, social stress, Psychological implications
- Chronic pain: a global health priority
- Growing clinical and socioeconomic burden

‘Gold’ standard land exercise?

- Land-based exercise works — but not always and not on its own!
- Barriers:
- High pain sensitisation
- Obesity / not fit / load intolerance
- Anxiety related to movement / Fear of causing more damage!
- Low confidence with failure history

“Many of the people we see in chronic pain services present with high levels of pain sensitisation, significant deconditioning, or limited load tolerance. For some, even very small amounts of weight-bearing or impact are enough to provoke flare-ups that reinforce fear and avoidance.”
“Add to that obesity, cardiorespiratory deconditioning, anxiety around movement, or a strong belief that pain equals damage — and suddenly our so-called ‘gold standard’ interventions become incredibly difficult to access.”
“What often gets missed here is the issue of *history*, people with chronic pain don’t arrive as new learners — they arrive with a backlog of failed attempts at exercise. Each unsuccessful experience quietly erodes confidence and increases the sense that their body is fragile or unreliable.”
“So when we re-prescribe land-based exercise without addressing readiness, we sometimes unknowingly repeat the same cycle: good intent, poor tolerance, flare-up, withdrawal.”

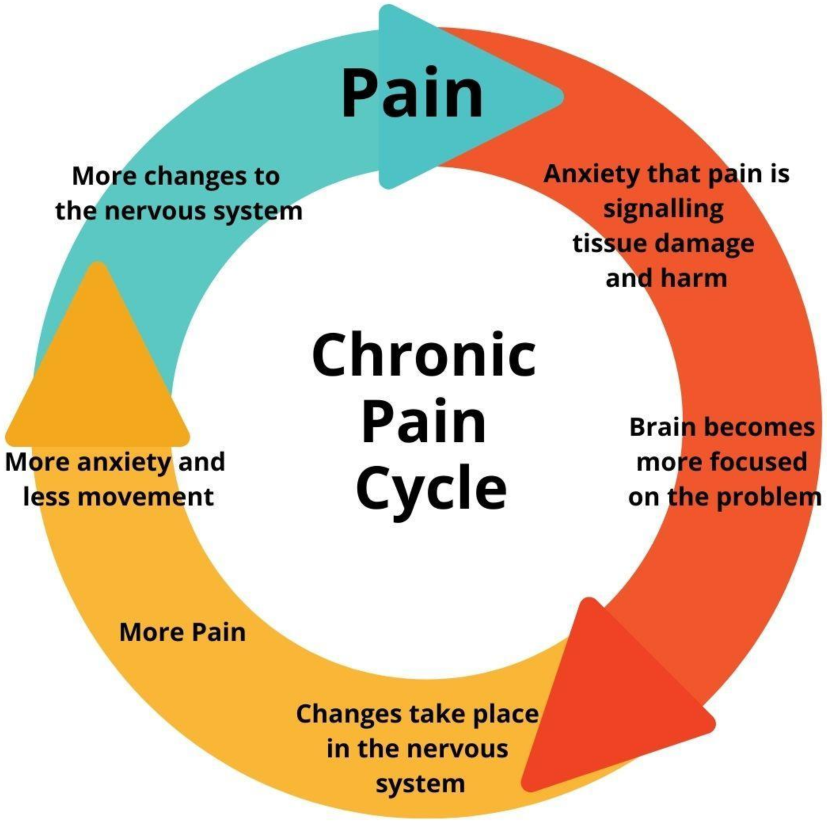
The reality in clinic

- People with chronic pain don't arrive as blank slates
- Previous failed treatments
- Fear of movement (kinesiophobia)
- Competing life demands
- Mixed readiness for change

Association happens with experience. Initially protective then can become maladaptive. This can happen quickly!!!

The belief we meet every day

- “Exercise hurts me — so it can’t be good for me.”
- A logical point of view from lived experience
- Reinforced by flare-ups
- Avoidance becomes protective… then maladaptive



“What’s crucial here is that this is not a knowledge deficit. Most people with chronic pain already know that exercise is ‘good for them’. The issue isn’t education — it’s experience. Their body has taught them that effort equals danger.”
“And if we ignore that belief — or try to override it with reassurance alone — we often end up reinforcing it through failed attempts at exercise that provoke pain or flare-ups.”
“This is the pivot point for aquatic therapy. Not because water magically fixes pain, but because it allows us to change the *context* in which movement is experienced.
In the right conditions, movement in water can feel less threatening, more supported, and more controllable — which gives us a rare therapeutic window where people can move *without immediately confirming their fear.”*

Why water changes the equation

- Potentially less perceived threat in the water
- Warm water can feel safe and therapeutic
- Buoyancy alters loading
- Hydrostatic pressure supports the body
- Aquatic Therapy creates a therapeutic window

That matters, because threat perception is one of the strongest drivers of pain and avoidance.”
“What’s important is that this isn’t just physiology or psychology — it’s both at the same time. The changed environment allows meaningful movement, and meaningful movement begins to update beliefs about what the body can tolerate.”
“So aquatic therapy isn’t about avoiding challenge — it’s about changing the conditions under which challenge occurs. And once we have that window, we can begin to introduce volume, intensity, and progression in a way that wouldn’t have been possible on land.”

Water is not “easier exercise”

- It allows different workouts
- Higher movement volume
- Earlier intensity
- Different sensory input
- **Altered threat perception**
- Still able to apply the FITT principles when appropriate for the patient.

Evidence overview (2016–2026)

- What was reviewed
- **21** Systematic Reviews / meta-analysis
- **10** fully published **RCTs** that involve active rehabilitation! And 2 pilot/study protocol RCT’s
- Conditions: Fibromyalgia, CLBP, OA.

What the evidence tells us:

Details of research is in the conference handbook

Fibromyalgia (FM):

- Consistent analgesic effects
- Improvements in QoL & sleep
- Warm water enhances short-term analgesia

Osteoarthritis (OA):

- Pain & function similar to land exercise
- More tolerable than land-based exercises
- Fewer post-exercise flare-ups
- Better uptake in Grade III–IV OA

Chronic Low Back Pain (CLBP):

- Water based therapy + general care is the most effective.
- 3-month aquatic programme
- Disability reduction maintained at 12 months - not just short-term
- Suggests neuromuscular + behavioural carry over

Adherence

"Adherence isn't just a behavioural footnote — it's a clinical signal. It tells us that the environment matters. That reducing threat, increasing confidence, and supporting early success can dramatically influence whether someone continues to move at all. I**n chronic pain, *any* sustained movement is far more valuable than a theoretically perfect programme that someone abandons."**

Condition	Study Title	Adherence
Fibromyalgia	Fernandes et al 2013 --- Swimming vs Walking RCT	Swimming **77.8%**, Walking **72.2%**
Fibromyalgia	Rivas-Neira et al., 2024 — Aquatic vs Land-Based Therapy	**93% attendance**, minimal dropout (≈90% retained)
Osteoarthritis	Sirousazizi et al., 2019 — Aquatic Exercise for Knee OA	**31/32 completed** (~97%)
Osteoarthritis	Slouma et al., 2024 — Aquatic vs Land-Based Exercise	**No dropouts** in aquatic group
Osteoarthritis	Rezasoltani et al., 2020 — Aquatic Cycling for Knee OA	**94% completion**
Osteoarthritis	Mahfouz et al., 2025 — Aquatic Exercise vs Standard Care	**High adherence**, strong retention
CLBP	Hend et al., 2021 — Aquatic vs Land-Based Exercise	**Not reported**
CLBP	Peng et al., 2022 — Aquatic Exercise vs PT Modalities	**≥75% required**; >2-week absence = dropout
CLBP	Rosenstein et al., 2025 — Aquatic Exercise vs Standard Care	**88%** (17.56/20 sessions)

Interventions:

	Study Title	Intervention Description	Duration + Frequency
Fibro	Fernandes et al 2013 --- Swimming vs Walking RCT	Swimming: front-crawl at anaerobic threshold HR −10 bpm. Walking: at anaerobic threshold HR. Supervised aerobic training.	**50 min, 3×/week, 12 weeks**
Fibro	Rivas-Neira et al., 2024 — Aquatic vs Land-Based Therapy	4-block structure: 15-min warm-up, 25-min proprioception, 8-min stretching, 12-min relaxation. Aquatic in 30 °C water; land in lab.	**60 min, 3×/week, 12 weeks**
OA	Sirousazizi et al., 2019 — Aquatic Exercise for Knee OA	Warm-up 10–15 min, 35-min strengthening, 10-min cool-down. Water depth 1.2 m, temp ~32 °C.	**~60 min, 3×/week, 8 weeks**
OA	Slouma et al., 2024 — Aquatic vs Land-Based Exercise	Warm-up, aerobic movements, strengthening, balance, cool-down. Land group matched.	**60 min, 3×/week, 8 weeks**
OA	Rezasoltani et al., 2020 — Aquatic Cycling	10-min warm-up, 30-min aquatic cycling, 10-min cool-down. Water depth 1.2 m, temp ~32 °C.	**50 min, 3×/week, 4 weeks**
OA	Mahfouz et al., 2025 — Aquatic vs Standard Care	Aquatic programme targeting strength, balance, gait, mobility. Standard care: stretching, strengthening, manual therapy, aerobic conditioning.	**~60 min, 2–3×/week, 8 weeks**
CLBP	Hend et al., 2021 — Aquatic vs Land-Based Exercise	Warm-up 2-min walking, stretching, strengthening (core, glutes, trunk rotators, limbs), balance, functional tasks. Water depth 130 cm, temp 32–34 °C.	**50 min, 3×/week, 6 weeks**
CLBP	Peng et al., 2022 — Aquatic Exercise vs PT Modalities	10-min warm-up, 40-min aquatic exercise, 10-min cool-down. Control: TENS, heat, ultrasound.	**60 min, 2×/week, 12 weeks**
CLBP	Rosenstein et al., 2025 — Aquatic Exercise vs Standard Care	SwimEx pool: trunk stabilisation, gluteal strengthening, functional tasks. Progression via reps, resistance, turbulence, complexity.	**~60 min, 2×/week, 10 weeks**

Intensity

Condition	Stud		Intensity
Fibromyalgia	Fern		**Anaerobic threshold HR** (swimming adjusted −10 bpm)
Fibromyalgia	Riva The		**Modified Borg 3–4**, not exceeding **5**
Osteoarthritis	Sirc		**Not quantified**
Osteoarthritis	Slo		**Not quantified**
Osteoarthritis	Re		**40–60% of the reserve HR**
Osteoarthritis	Ma Ca		**Not quantified**
CLBP	H		**Not quantified**
CLBP	P		**Borg ≈13** (≈60–80% HRmax)
CLBP	P Care	rd	**Borg RPE – didn't state target level!**

"A weakness in the evidence from a research perspective. Reading between the lines I think it highlights something important. Because before we ask how hard someone should work, we need to ask what we're trying to achieve with this group of patients. **In some cases, the goal may be physiological adaptation — improved strength, cardiovascular fitness, or endurance. In others, particularly early in chronic pain rehabilitation, the priority may be confidence, desensitisation, and re-establishing trust in movement."**

"Those two aims require very different interpretations of intensity. A Borg score of 4 or 5 might be a meaningful challenge for someone with pain sensitisation, even if it looks modest on paper."

The research to practice gap

- Why translation lags
- Specialised centres vs community pools
- Research uses different protocols ? Which is best!
- Blinding paradox in physiotherapy trials

"When you look across trials, you'll see differences in water depth, temperature, exercise selection, intensity, and progression. That **often leads clinicians to ask: *which is the correct programme?* But that question assumes there should be one best protocol — *and that's* probably the wrong way to think about it."**

"we also have the blinding paradox in physiotherapy research. Aquatic therapy trials are often downgraded methodologically, not because they're ineffective, but because you simply cannot blind a participant to being in water. **That methodological limitation can unfairly dilute confidence in clinically meaningful results."**

"What *is* reassuring, though, is the consistency across conditions. We repeatedly see similar signals: reduced pain, improved function, better adherence, and greater tolerance for movement. That tells us something important — **maybe it isn't the *exact* protocol that matters most, but *how the environment is used. In many cases with this patient group to change threat, confidence, and capacity for movement."***

moving away from rigid protocols, and toward phenotype-based clinical reasoning: clinically reasoning based based on the person in front of us.

Sensory Modulation Phenotype *(Fibromyalgia, CRPS, high kinesiophobia)*

- Focus on Movement confidence and Desensitisation
- Relaxation → graded resistance
- Dosage: 30–45 min, 2× / week

Sensory modulation

- Clinical goal:
  Reduce threat before increasing load.

Examples

- Buoyancy related ROM
- Ai Chi-inspired movement
- Water Specific Therapy
- Halliwick principles
- Mindful / rhythmic movement

RPE Scale (Rate of Perceived Exertion)	
1	**Very Light Activity** Hardly any exertion, but more than sleeping, watching TV, Etc.
2-3	**Light Activity** Feels like you can maintain for hours, easy to breathe and carry on a conversation
4-6	**Moderate Activity** Breathing Heavily but you can still hold a short conversation, Still somewhat comfortable, but becoming noticable more challenging
7-8	**Vigorous Activity** Borderline uncomfortable, short of breath, can speak a sentence
9	**Very Hard Activity** Very difficult to maintain exercise intensity, can barely breathe and speak only a few words
10	**Maximal Effort** Feels almost impossible to keep going, completely out of breathe, unable to talk, cannot maintain for more than a very short amount of time

Neuromuscular Loading Phenotype *(CLBP, post-op, deconditioned OA)*

- Focus: Strength through range, CV fitness and Neuromuscular control.

- Dosage: ~45 min, up to 3× / week

Neuromuscular Loading

- Clinical goal:
  improve tolerance to movement through biomechanical principles (Strength, control/balance, general fitness, mobility/suppleness).

- Examples of Loading in water
- Using drag & turbulence - Paddles / fins
- BRRM
- HIIT in water
- Metacentric control work
- Key point:
  You can load meaningfully in water.

Borg Rating of Perceived Exertion		
Green	6	Zero Exertion
	7	Extremely light
	8	Minimal effort
Yellow	9	Very light exertion (comfortable)
	10	Just start to hear breathing
	11	Conversation is easy
	12	Light exertion
Orange	13	Somewhat hard
	14	Breathing hard but not struggling
	15	Can converse but not full sentences
	16	Hard work
Red	17	Very hard - getting uncomfortable
	18	Can no longer converse
	19	Extremely hard - body is screaming
	20	Maximal exertion

Three practical rules

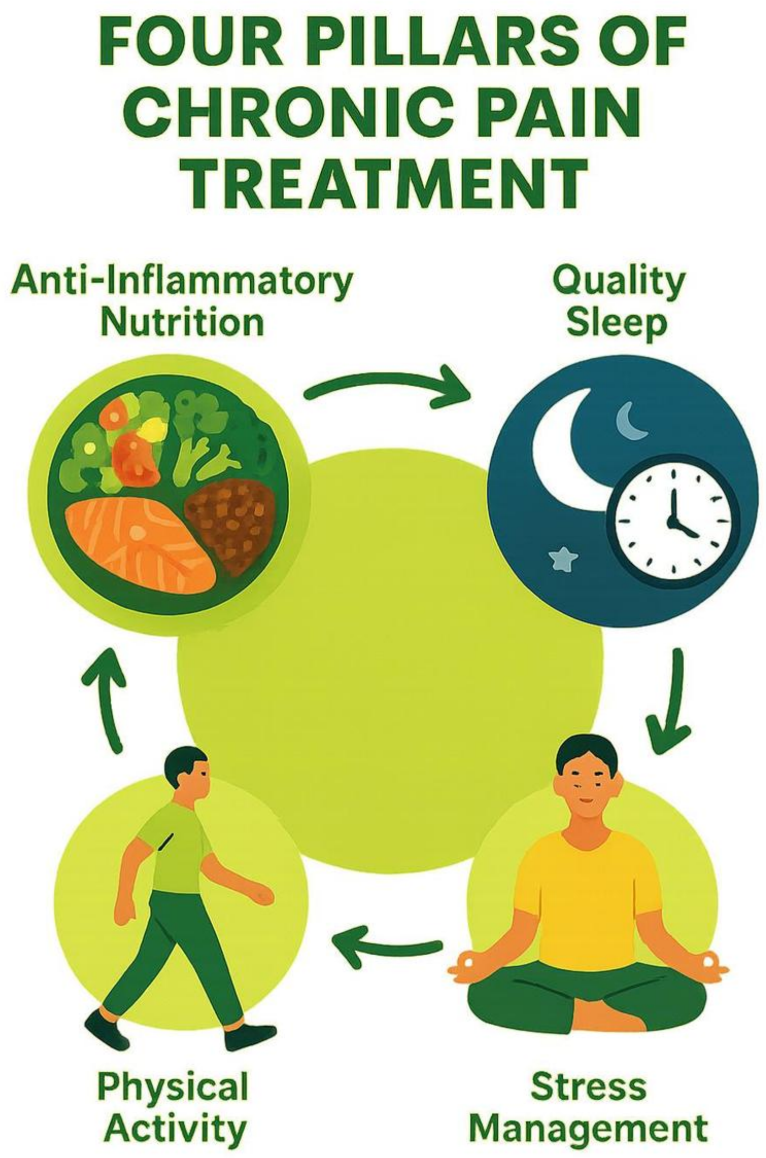
- consider kinesiophobia (Tampa scale 11, > 37 = high)
- NB: = 51!
- Prioritise adherence. Any exercise > no exercise
- Bridge to land deliberately

		Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1	I'm afraid that I might injury myself if I exercise	1	2	3	4
2	If I were to try to overcome it, my pain would increase	1	2	3	4
3	My body is telling me I have something dangerously wrong	1	2	3	4
4	My pain would probably be relieved if I were to exercise	4	3	2	1
5	People aren't taking my medical condition seriously enough	1	2	3	4
6	My accident has put my body at risk for the rest of my life	1	2	3	4
7	Pain always means I have injured my body	1	2	3	4
8	Just because something aggravates my pain does not mean it is dangerous	4	3	2	1
9	I am afraid that I might injure myself accidentally	1	2	3	4
10	Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening	1	2	3	4
11	I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	1	2	3	4
12	Although my condition is painful, I would be better off if I were physically active	4	3	2	1
13	Pain lets me know when to stop exercising so that I don't injure	1	2	3	4
14	It's really not safe for a person with a condition like mine to be physically active	1	2	3	4
15	I can't do all the things normal people do because it's too easy for me to get injured	1	2	3	4
16	Even though something is causing me a lot of pain, I don't think it's actually dangerous	4	3	2	1
17	No one should have to exercise when he/she is in pain	1	2	3	4

"The ACSM. *Guidelines for Exercise Testing and Prescription*, 12th edition, 2026. explicitly states **Adherence and Implementation are key to improving health and fitness.**
They considered:
Behavioural, social, and environmental fac tors as critical. With tailored programs to improve patient engagement"

Remember management is not just about exercise!

- As Chronic pain is a complex multifactorial problem, we must understand the role of the MDT to help the overall management contributing to patient care.



Take-home message

- Where to start with chronic pain?
- Start with what people can tolerate
- Start with confidence, not compliance
- The aim is to facilitate an enthusiasm for exercise!
- Use water to change the story, then change the load
- Reframing aquatic therapy
- Full reference list and details of the literature is available in the Conference Book.

"We as health professionals need to consider the psychology of the patient, it has a huge impact on everything we do and has a direct impact on the success of our interventions. **Enthusiasm drives behaviour change which in turn will improve physiological gains.**"

Rhythm and Music as Therapeutic Tools: Enhancing Motor Control and Modulating Intensity in Aquatic Rehabilitation

Emily Dunlap, PT, PhD
ICEBAT Canada 2026

1

Feel the rhythm
Let it take you higher

Follow my lead and We'll
set it on fire

2

Why Rhythm is such a Powerful Motor Cue?

Auditory Cortex
Detects rhythm and timing

↓

Premotor Cortex + Suppl. Motor Area
Links auditory timing cues to motor planning

↓

Basal Ganglia
Internal beat generation and timing prediction

↓

Cerebellum
Fine timing adjustment and error correction

↓

Primary Motor Cortex
Execution of synchronized movement

The brain does not just react to rhythm…

it predicts the next beat

Thaut et al, *Front in Psychology*, 2015

3

Entrainment

Entrainment:

Synchronization that happens when system are coupled or connected.

Auditory-motor entrainment:

Firing rates of auditory neurons (triggered by auditory rhythm/music) entrain the firing patterns of motor neurons.

Thaut et al, *Front in Psychology*, 2015

4

Rhythmic auditory cueing (RAC)

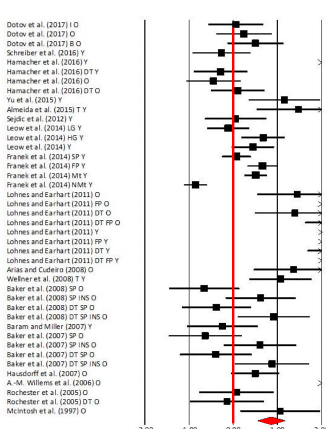
Using external rhythmic sounds (like metronome or music) to help guide and improve movement patterns, especially gait.

Goal:
Improve **temporal organization**, **gait consistency**, and **motor timing**

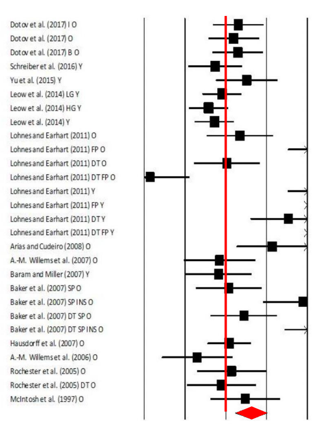
5

RAC and Older adults (Land-based)

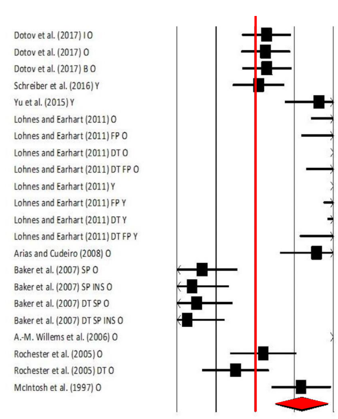
Gait Velocity



Stride Length



Cadence

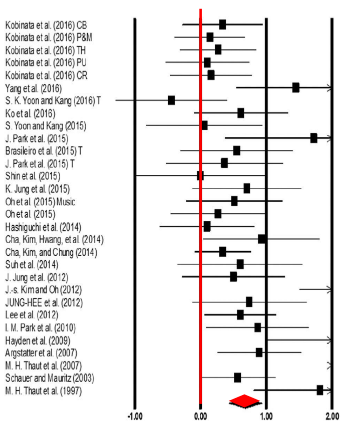


Ghai et al, *Aging Dis*, 2018

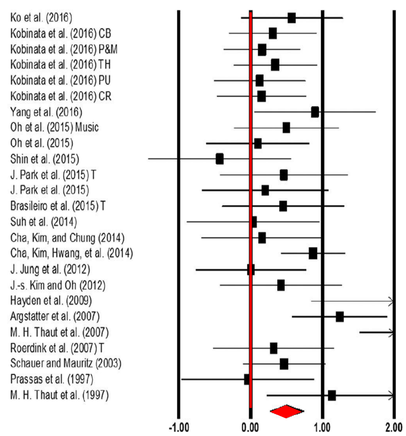
6

RAC and Stroke (Land-based)

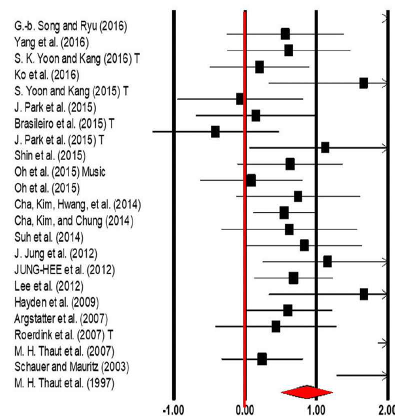
Gait Velocity



Stride Length



Cadence

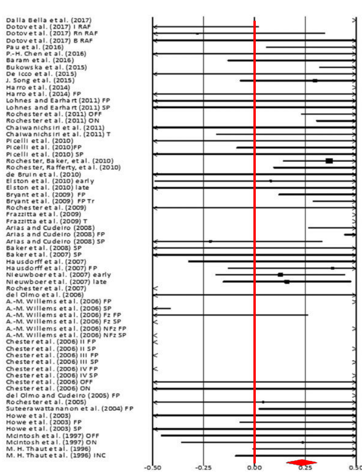


Ghai et al, *Sci Rep*, 2019

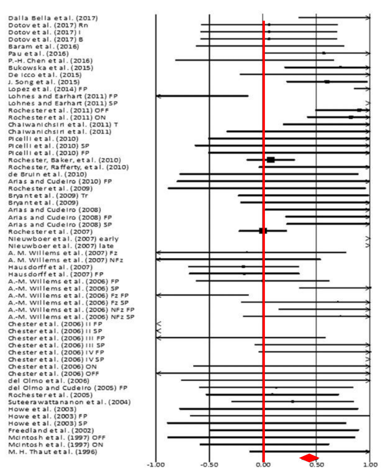
7

RAC and Parkinson’s Disease (Land-based)

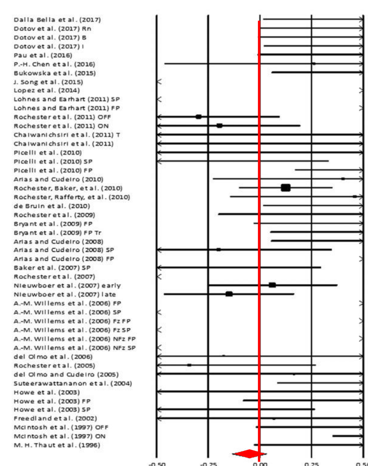
Gait Velocity



Stride Length



Cadence



Ghai et al, *Sci Rep*, 2018

8

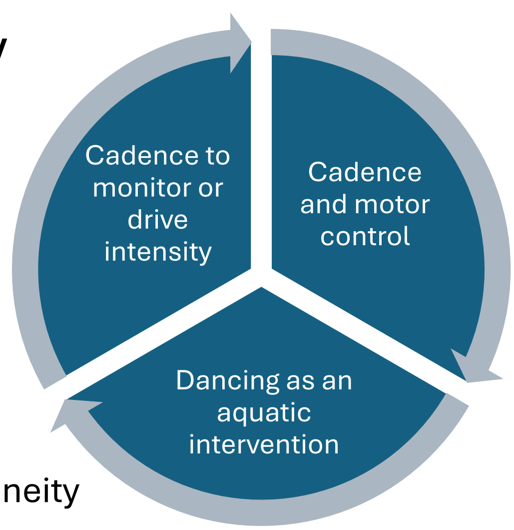
Rhythm/music works for many – but not all!

9

Aquatic Evidence Summary

Low Certainty of Evidence
(in Emily's opinion)

Low number of studies
Small sample sizes
Mostly healthy populations
Mostly observational studies
Few intervention studies – high heterogeneity



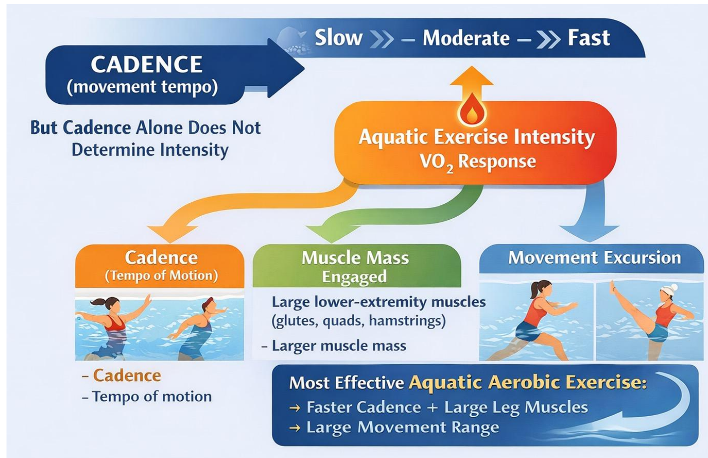
It's a start!!! AND we have land-based research to support use of music and rhythm as a rehabilitation tool

10

Cadence to Monitor or Drive Intensity

All observational studies

- Alberton et al. *Int. J. Aquat. Res. Educ.* 2007 (post-menopausal women)
- Alberton et al. *J Strength Cond Res.* 2011(healthy young women)
- Alberton et al. *Eur J Appl Physiol.* 2011 (healthy young women)
- Andrade et al. *Int J Environ Res and Pub Health. 2020 (older women)*
- Andrade et al. Eur J Sport Sci. 2021 (post-menopausal women)
- Bartolomeu et al. *Women & Health*, 2017 (young vs older women)



11

Cadence and Motor Control

All observational studies

- De Brito Fontana et al. *Hum Mov Sci*. 2018 (young adults)
- Gomes et al. *Obesities*. 2021 (overweight children)
- Santos et al. *Healthcare*. 2021 (older women)
- Santos et al. *Int J Environ Res and Pub Health*. 2019 (young adults)
- Santos et al. J Hum Sport Exerc. 2019 (young adults)
- Santos et al. *Motricidade*. 2019 (young adults)

Reduced loading and altered force production

Movement symmetry can improve with certain cadences

Exercise mechanics influence force production

12

Dancing as an Aquatic Intervention

Mostly intervention studies

- Casilda-López et al. *Menopause*. 2017 (**obese women with knee OA** – 8 weeks)
- Wantanabe et al. *Percept Mot Skills*. 2000 (**healthy older adults** – one bout exercise)
- Lundqvist et al. *Sci Rep*. 2022 (adults with **intellectual and multiple disability** – 12 weeks)
- Materne et al. *Heliyon et al*. 2021 (adults with **intellectual and multiple disability** – 12 weeks)
- López-Rodríguez et al. *Atención primaria*. 2012 (**Fibromyalgia** – 12 weeks)

13

Practical Strategies for Using Rhythm and Music in Aquatic Therapy

14

Select the Cadence/Tempo

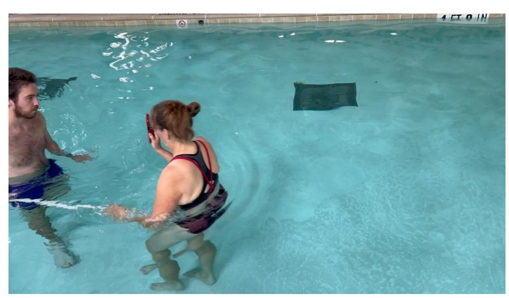
- Self selected water walking (or any activity) for 1 min
  - Count steps
    - If gait is even #steps/min = starting cadence
    - If gait is uneven #steps/min * 0.85 = starting cadence
- Set metronome to starting cadence
  - If able to entrain = keep cadence
  - If not able to entrain to cadence
    - Stepping faster than beat = slowly increase cadence until can entrain
    - Stepping slower than the beat = slowly decrease cadence until can entrain
- Progression/Modification
  - Adjust cadence based on therapeutic goals
    - Increase cadence for higher intensity
    - Decrease cadence for postural stability/balance/ coordination
    - Vary cadence (e.g. fast-slow-fast) for dynamic reactions

15

Gait Training with Metronome

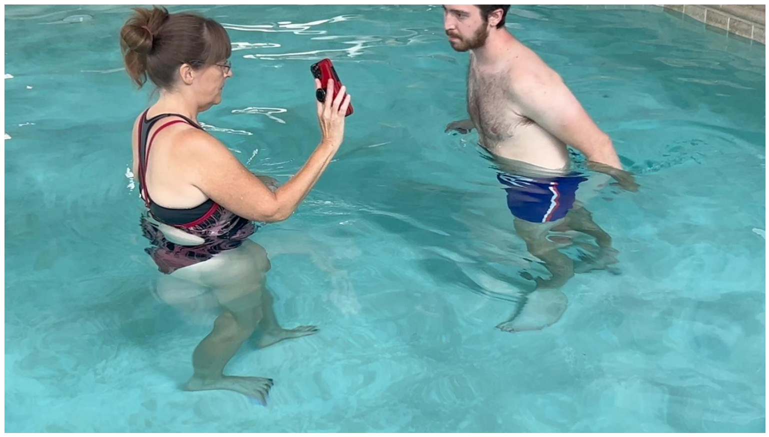
62 bpm – Note R UE with poor arm swing

PVC used to facilitate R UE swing / reciprocal gait



16

Progress with Dual-Task Activity

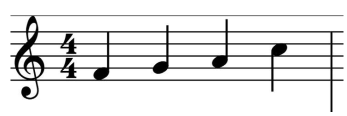


53 bpm + dual-task ball pass activity

Matching Rhythm to Movement Goals

Most exercise music time signature : 4/4 time (4 beats per measure)

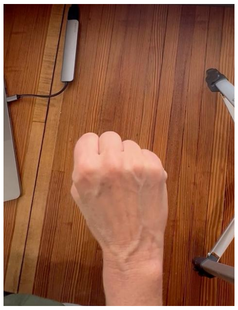
- Predicable and symmetrical
- Easy for patterns of movements
  - singles
  - doubles
  - single/single/double
  - one-two-three-hold
  - 4 direction pattern
- Works well with gait and bilateral patterns



Waltz Rhythm: 3/4 time (3 beats per measure)

- Encourages weight shifting and balance control
- Creates flowing or circular movement patterns

Finger Dance Challenge



INTRODUCTION							
3				4			
5		0		1	2	3	4
CHORUS							
2	0	2	👍	3	5	3	👍
2	0	2	👍	3	5	3	👍
2	0	2	👍	3	5	3	👍
1	0	1	👍	2	5	2	👍

19

Music for Motor Initiation and Coordination

20

20

Design Exercises that Align the Rhythm and Feel of Music with Treatment Goals

Patient 1	Patient 2	Patient 3
Chronic pain - Fibromyalgia	**Stroke**	**Older adult – Balance/Falls**
Nociplastic Pain	Ambulatory with walker (.45 m/s)	Ambulates with cane out of the water (.86 m/s)
Comes into today's session with high state of stress/anxiety	Balance and coordination challenges	Difficulty with single leg stance and turns
Main goal - reduce state of anxiety and facilitate active movement	**Main goal - improve gait speed, gait symmetry, and balance**	**Main goal – improve balance and reduce falls**

21

Self-Expression and Movement Exploration

For some self-expression comes naturally and is uninhibited.

Others – not so much. Need to build trust first. But this is often worth the effort and can be very powerful!!!

22

Other Considerations

- Depth considerations: chest level for shallow exercise (ideally not over nipple line)
- Heel to floor often: avoid always jumping on toes/balls of feet
- Water footwear: well fitting
- Avoid repetitive lifting of arms in + out of water (surface tension)
- Cue on deck with complicated choreography
- Instructor comfort/safety on deck: Non-slip cushioned floor mat, proper footwear, chair to demonstrate suspended activities.
- Waterproof speaker/sound system + microphone (or visual cues instead of microphone)

23

Use Tools

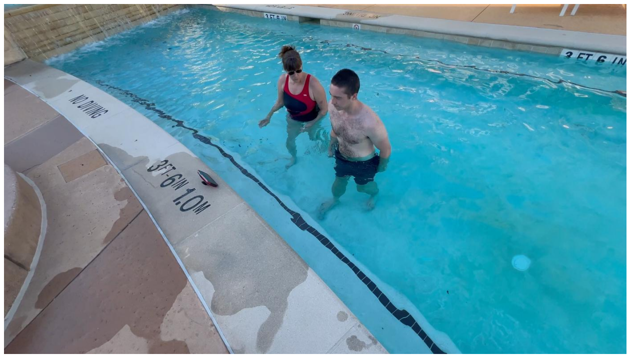
Handheld metronome / ipod (kickin' it old school)
Metronome app – (free or paid)
Music Streaming Platforms (usually paid)

Example: Spotify

- **Just type 'BPM' in the search bar on Spotify:** This simple trick will pull up playlists curated by beats per minute (BPM).
- **Syncing your BPM with your cadence:** Once you know your average walking/running cadence, you can choose music with the right BPM to complement your natural rhythm.
- **'Sort your music':** Can sort music in your custom playlists by bpm.

24

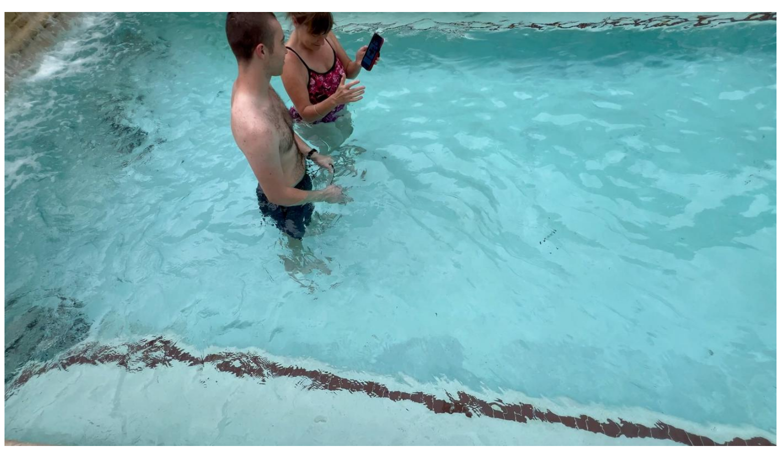
Preparing with Metronome before adding music



Step forward/backward/together/pause
57 bpm

25

Bringing in Music after Metronome



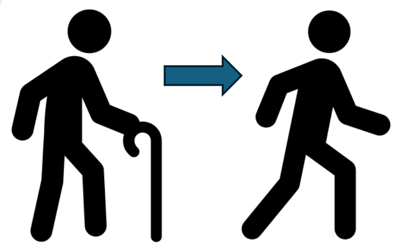
Selected Song: Perfect by Ed Sheeran 64 bpm

26

Bringing It All Together: Rhythm in Practice

- **Rhythm enhances** timing, coordination, and motor learning
- Find the **right tempo** - start at self-selected pace - adjust for therapeutic goal
- Align **music/beat structure** with exercise design
- Use rhythm to guide **dose, progression, and engagement**

Integrate rhythm with aquatic therapy



Better outcomes on land

27

References

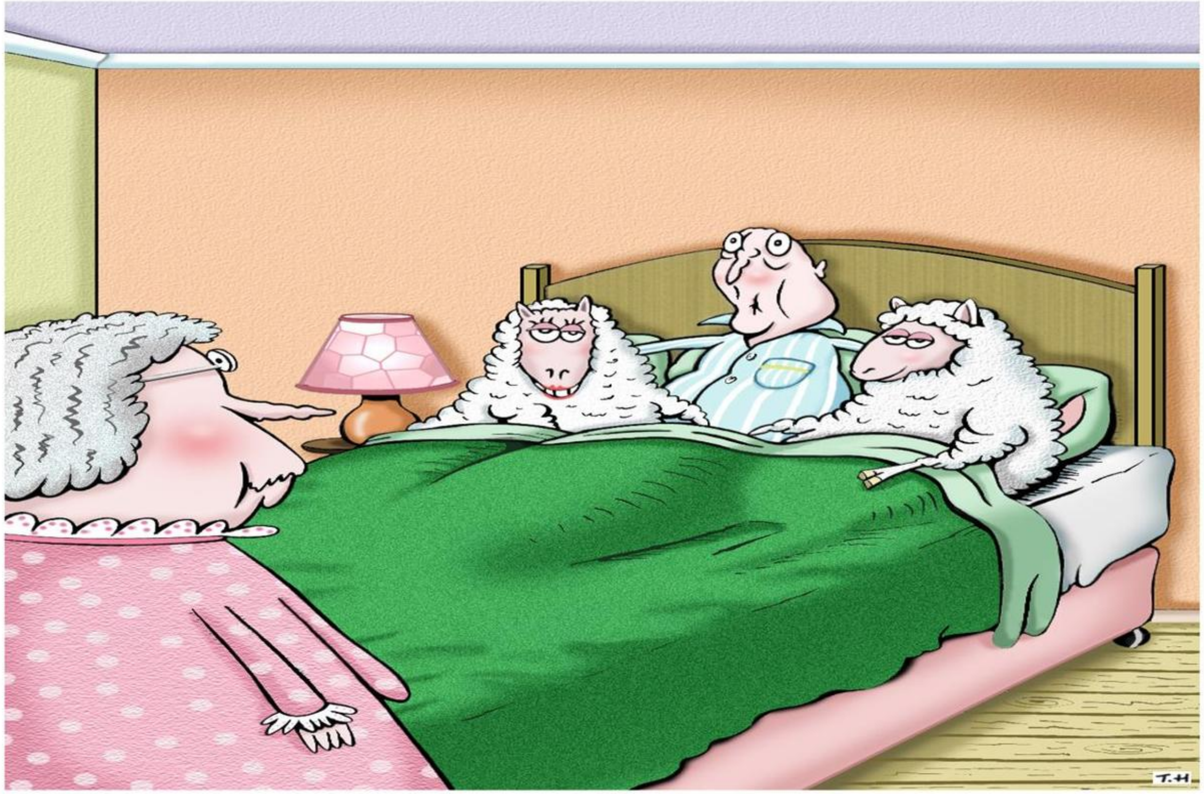
1. Alberton et al. “Cardiorespiratory Responses of Post-Menopausal Women to Different Water Exercises.” International Journal of Aquatic Research and Education (Champaign, Ill.), vol. 1, no. 4, 2007, https://doi.org/10.25035/ijare.01.04.06.
2. Alberton et al. “Cardiorespiratory, Neuromuscular and Kinematic Responses to Stationary Running Performed in Water and on Dry Land.” European Journal of Applied Physiology, vol. 111, no. 6, 2011, pp. 1157–66, https://doi.org/10.1007/s00421-010-1747-5.
3. Alberton et al. “Correlation Between Rating of Perceived Exertion and Physiological Variables During the Execution of Stationary Running in Water at Different Cadences.” Journal of Strength and Conditioning Research, vol. 25, no. 1, 2011, pp. 155–62, https://doi.org/10.1519/JSC.0b013e3181bde2b5.
4. Alberton CL, Zaffari P, Pinto SS, Reichert T, Bagatini NC, Kanitz AC, et al. Water-based exercises in postmenopausal women: Vertical ground reaction force and oxygen uptake responses. Eur J Sport Sci. 2021;21(3):331–40. https://doi.org/10.1080/17461391.2020.1746835 PMID: 32207382
5. Andrade et al "Relationship between Oxygen Uptake, Heart Rate, and Perceived E ort in an Aquatic Incremental Test in OlderWomen" Int J Enivron Res and Pub Health, 2020
6. Casilda-López et al. “Effects of a Dance-Based Aquatic Exercise Program in Obese Postmenopausal Women with Knee Osteoarthritis: A Randomized Controlled Trial.” Menopause (New York, N.Y.), vol. 24, no. 7, 2017, pp. 768–73, https://doi.org/10.1097/GME.0000000000000841.
7. de Brito Fontana, et al. “Vertical Ground Reaction Force in Stationary Running in Water and on Land: A Study with a Wide Range of Cadences.” Human Movement Science, vol. 58, 2018, pp. 279–86, https://doi.org/10.1016/j.humov.2018.03.003.
8. Ghai S, Ghai I, Effenberg AO. Effect of Rhythmic Auditory Cueing on Aging Gait: A Systematic Review and Meta-Analysis. Aging Dis. 2018 Oct 1;9(5):901-923. doi: 10.14336/AD.2017.1031. PMID: 30271666; PMCID: PMC6147584.
9. Ghai S, Ghai I, Schmitz G, Effenberg AO. Effect of rhythmic auditory cueing on parkinsonian gait: A systematic review and meta-analysis. Sci Rep. 2018 Jan 11;8(1):506. doi: 10.1038/s41598-017-16232-5. PMID: 29323122; PMCID: PMC5764963.
10. Ghai S, Ghai I. Effects of (music-based) rhythmic auditory cueing training on gait and posture post-stroke: A systematic review & dose-response meta-analysis. Sci Rep. 2019 Feb 18;9(1):2183. doi: 10.1038/s41598-019-38723-3. PMID: 30778101; PMCID: PMC6379377.
11. Gomes et al. The Role of Water-Based Exercise on Vertical Ground Reaction Forces in Overweight Children: A Pilot Study. Obesities. 2021; 1(3):209-219. https://doi.org/10.3390/obesities1030019
12. López-Rodríguez, María del Mar, et al. “Comparison between aquatic-biodanza and stretching for improving quality of life and pain in patients with fibromyalgia.” Atención primaria, vol. 44, no. 11, 2012, p. 641, https://doi.org/10.1016/j.aprim.2012.03.002.
13. Lundqvist et al. Salivary cortisol levels and stress in adults with profound intellectual and multiple disabilities participating in the Structured Water Dance Intervention: a randomised controlled crossover trial. Sci Rep. 2022 Oct 19;12(1):17418. doi: 10.1038/s41598-022-21573-x. PMID: 36261594; PMCID: PMC9581886.
14. Santos et al. “Comparison of propulsive forces between two head-out water exercises” JHSE Supplementary Issue: International Seminar of Physical Education, 2019 DOI: 10.14198/jhse.2019.14.Proc4.82
15. Santos et al. “Force Production and Coordination from Older Women in Water Fitness Exercises.” Healthcare (Basel), vol. 9, no. 8, 2021, p. 1054, https://doi.org/10.3390/healthcare9081054.
16. Santos et al. “Force Production and Symmetry in Water Fitness Exercises: A Gender Comparison.” Motricidade, vol. 17, no. 4, 2021, pp. 399–405.
17. Santos et al. “Kinetic Analysis of Water Fitness Exercises: Contributions for Strength Development.” International Journal of Environmental Research and Public Health, vol. 16, no. 19, 2019, p. 3784, https://doi.org/10.3390/ijerph16193784.
18. Thaut MH, McIntosh GC, Hoemberg V. **Neurobiological foundations of neurologic music therapy.** *Trends in Neurosciences*. 2015.
19. Watanabe et al. “Comparison of Water- and Land-Based Exercise in the Reduction of State Anxiety among Older Adults.” Perceptual and Motor Skills, vol. 91, no. 1, 2000, pp. 97–104, https://doi.org/10.2466/pms.2000.91.1.97.

28

Northumbria University NEWCASTLE

Sleeping With The Enemy

Professor Jason Ellis



"It's not what it looks like Laura, I just couldn't sleep."

What Is Sleep?

A physical state of:

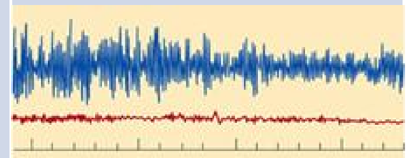
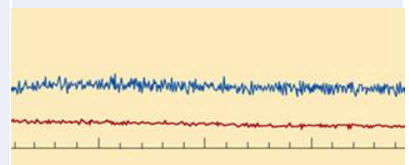
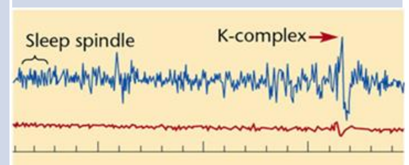
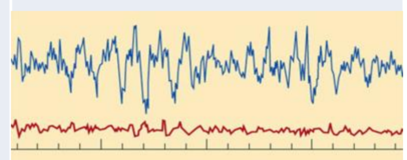
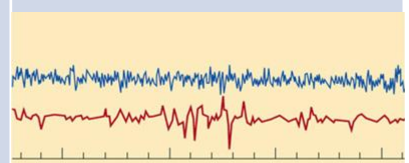
Postural recumbency
Quiescence
Closed eyes

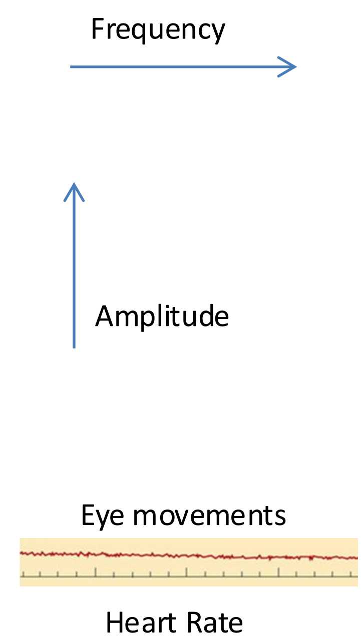
However, two separate states of sleep have been identified

REM-Rapid Eye Movement

Non-REM-(4 semi-distinct sleep stages)

The Stages of Sleep

Sleep Stage	Architectural Characteristics	Pattern
Relaxed, Wakefulness	*Alpha waves* are present when one begins a state of relaxation, high frequency	
Stage N1	Irregular, jagged, low amplitude waves; brain activity begins to decline, decreases in frequency	
Stage N2	Presence of sleep spindles and K-complexes	
Stage N3	Low frequency (slow), high amplitude waves (delta waves, Slow Wave Activity - SWA)	
REM	Irregular, low-amplitude and high frequency (fast) waves; PGO waves; rolling eye movements; loss of muscle tone	

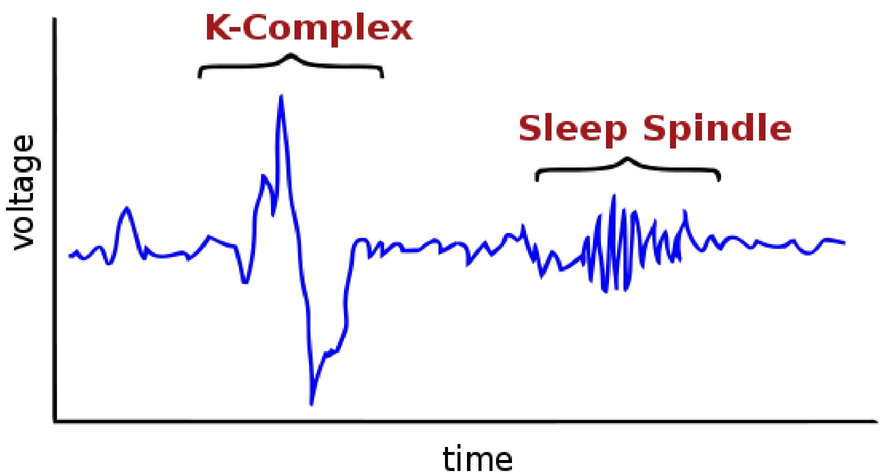


Biological Psychology, 4th Edition (2004) Sineuer Associates

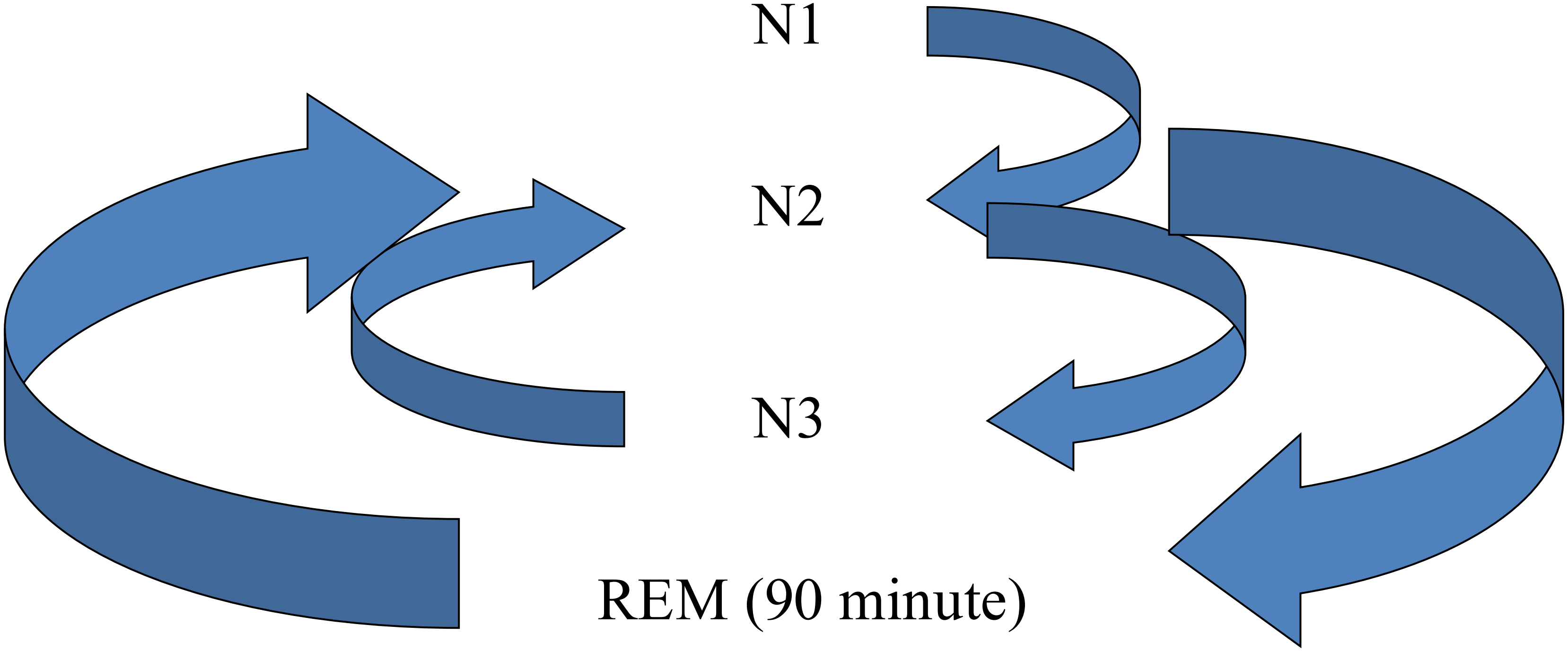
Specifics of Stage 2 Sleep

NREM takes up 75% of the whole night and REM takes up approximately 20-25%

Stage 2 takes up between 45-55% of the whole night



What Happens on a Typical Night?



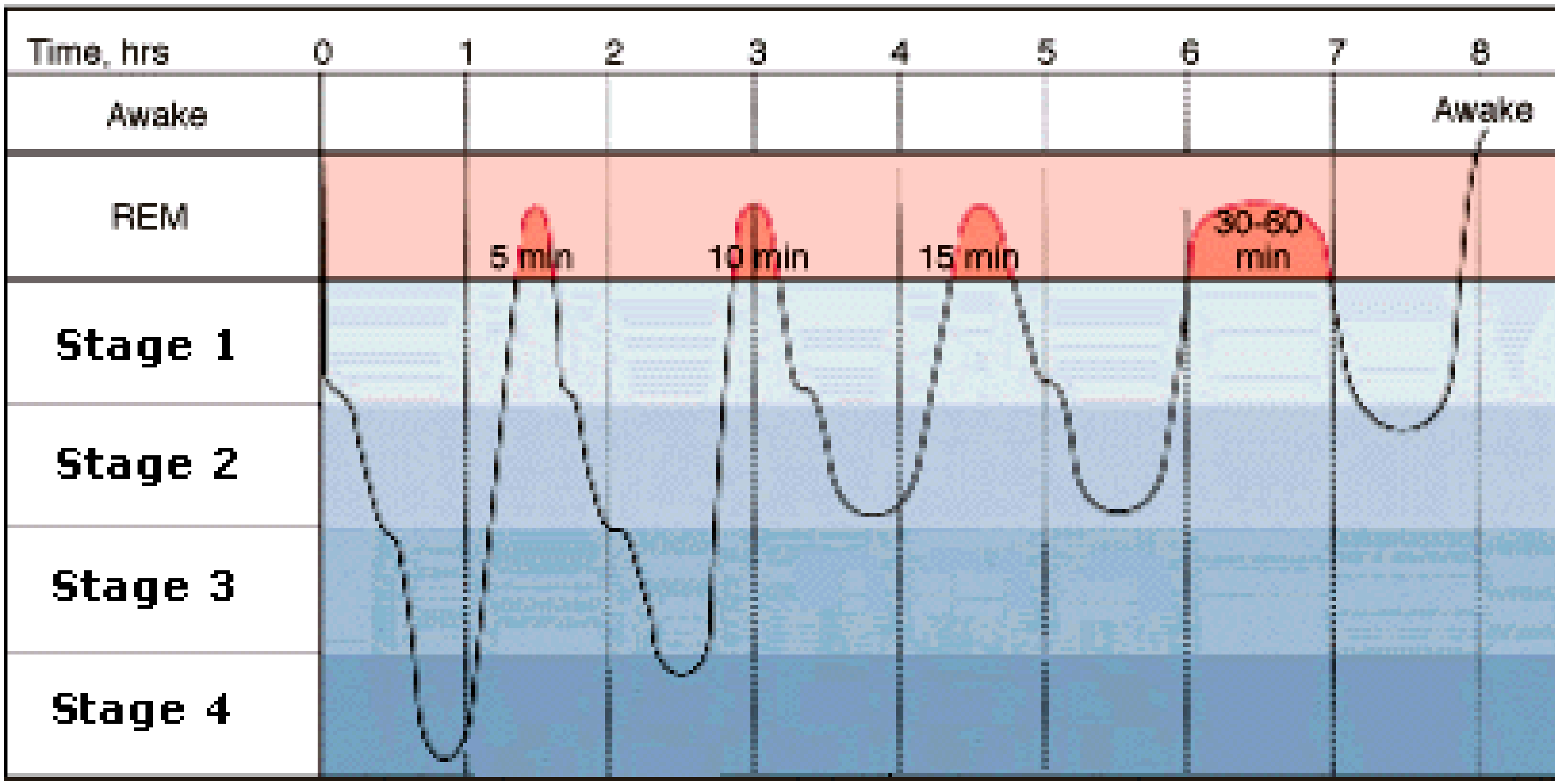
Muscle tension non-existent

Body Paralysis

Eye movements and Respiratory System Active

Dream Activity

Distribution Across the Night



Why do we stay awake?

The brain produces a series of hormones when we are awake

- Acetylcholine (Ach)
- Norepinephrine (NE)
- Dopamine (DA)
- Serotonin (5-HT)
- Histamine (HA)
- Hypocretin / Orexin

Actively suppressing sleep

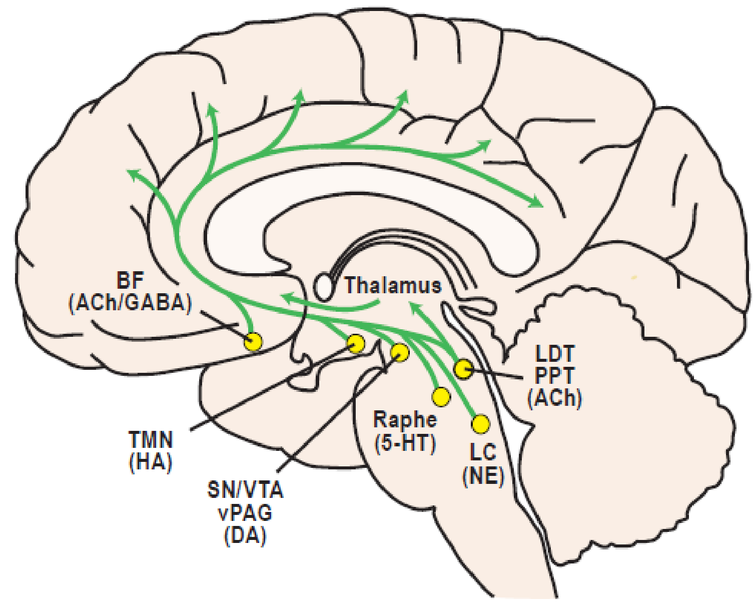


Figure 1—A variety of neurochemical systems promote arousal via projections to the forebrain. Cortical and subcortical regions are excited by monoaminergic neurotransmitters including norepinephrine (NE) from the locus coeruleus (LC), serotonin (5-HT) from the dorsal and median raphe nuclei, histamine (HA) from the tuberomammillary nucleus (TMN); and dopamine (DA) from the substantia nigra, ventral tegmental area, and ventral periaqueductal gray (SN/VTA/vPAG). Neurons of the basal forebrain (BF) promote cortical activation using acetylcholine (ACh) and γ-aminobutyric acid (GABA). Neurons in the laterodorsal and pedunculopontine tegmental nuclei (LDT/PPT) release ACh to excite neurons in the thalamus, hypothalamus, and brainstem.

from España & Scammell (2011)

Why do we fall asleep?

- γ-aminobutyric acid (GABA)

Actively suppressing wake

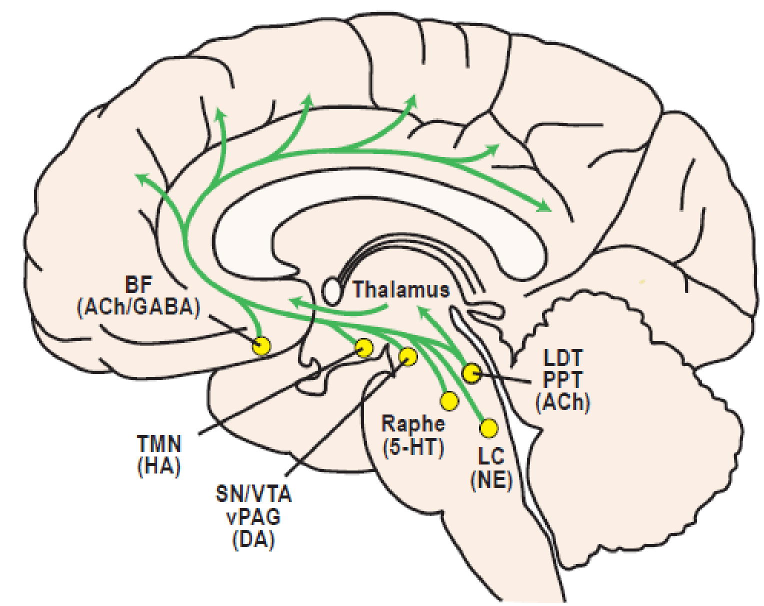
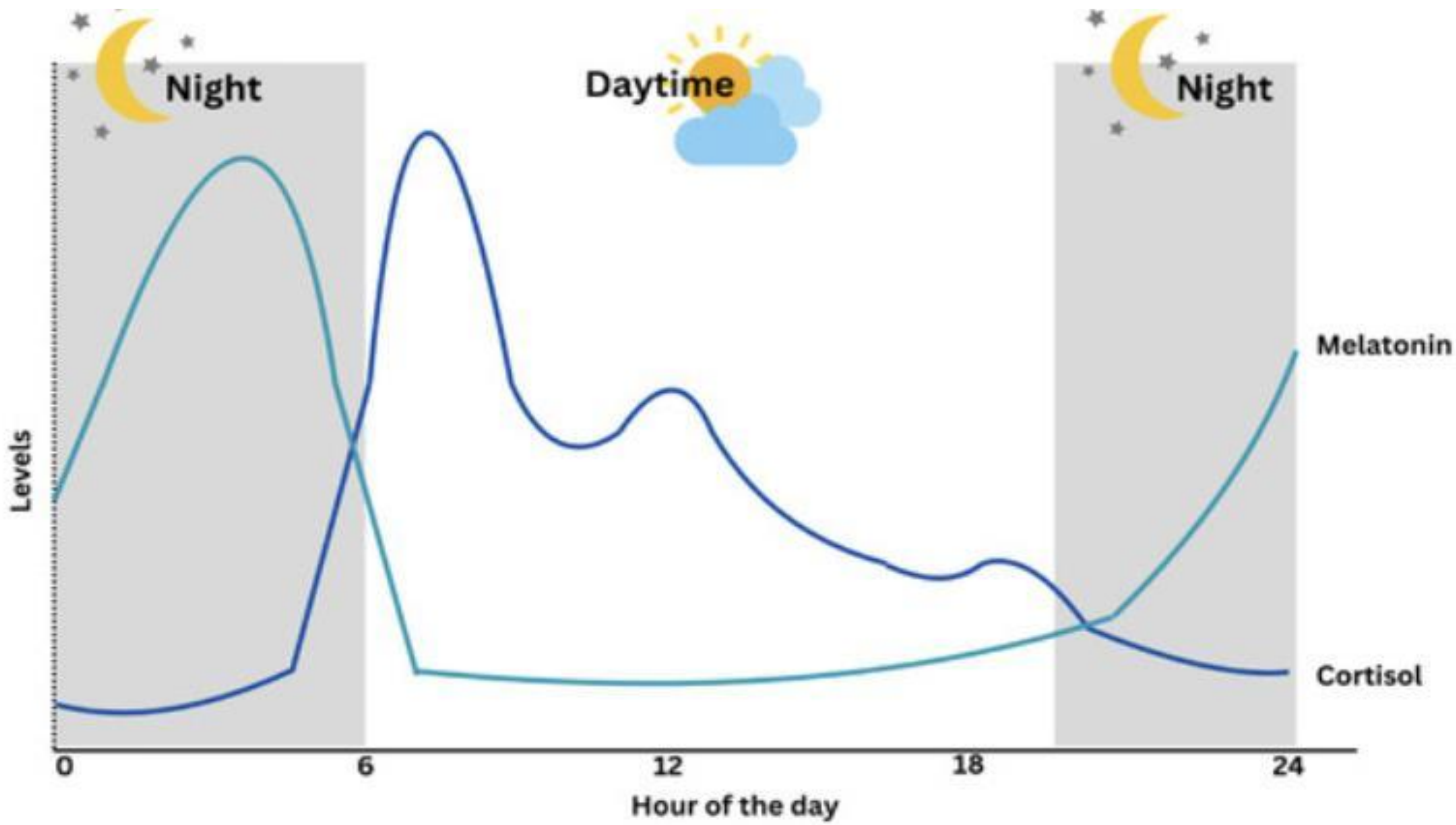


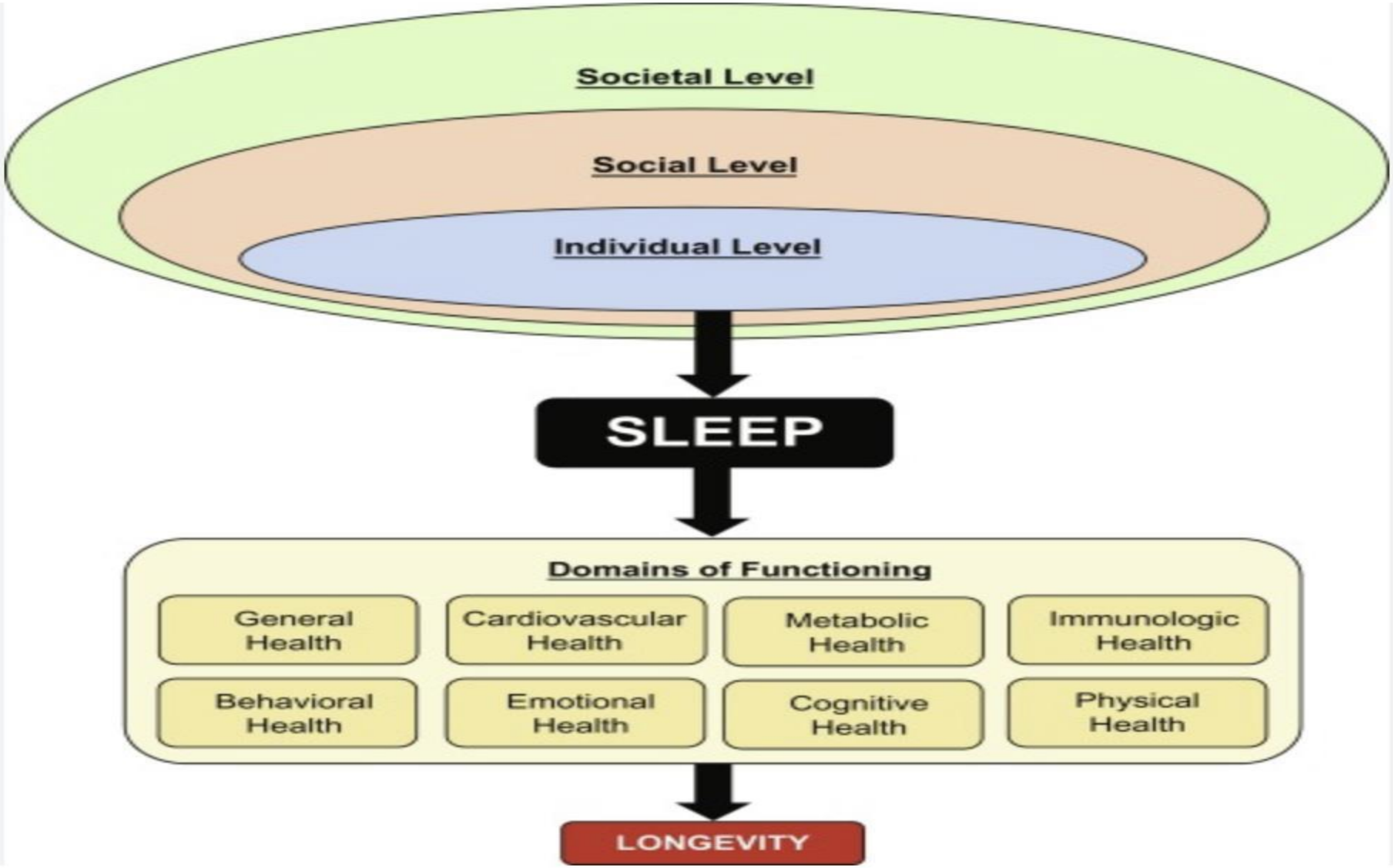
Figure 1—A variety of neurochemical systems promote arousal via projections to the forebrain. Cortical and subcortical regions are excited by monoaminergic neurotransmitters including norepinephrine (NE) from the locus coeruleus (LC), serotonin (5-HT) from the dorsal and median raphe nuclei, histamine (HA) from the tuberomammillary nucleus (TMN); and dopamine (DA) from the substantia nigra, ventral tegmental area, and ventral periaqueductal gray (SN/VTA/vPAG). Neurons of the basal forebrain (BF) promote cortical activation using acetylcholine (ACh) and γ-aminobutyric acid (GABA). Neurons in the laterodorsal and pedunculopontine tegmental nuclei (LDT/PPT) release ACh to excite neurons in the thalamus, hypothalamus, and brainstem.

from España & Scammell (2011)

Hormonal Regulation of Sleep Timing



So Why is Sleep Important?



Socio-Ecological Model of Sleep Health (Grandner et al, 2015)

Endocrine System during Sleep

HORMONE	MAIN SECRETING ORGAN	MAIN ACTION IN ADULTS
Growth hormone (GH)	Pituitary gland	Anabolic hormone that regulates body composition
Prolactin (PRL)	Pituitary gland	Stimulates lactation in women; pleiotropic actions
Adrenocorticotropic hormone (ACTH)	Pituitary gland	Stimulates release of cortisol from adrenal cortex
Cortisol	Adrenal cortex	Stress hormone, antiinsulin effects
Thyroid-stimulating hormone (TSH)	Pituitary gland	Stimulates the release of thyroid hormones from the thyroid gland
Luteinizing hormone (LH)	Pituitary gland	Stimulates ovarian and testicular function
Follicle-stimulating hormone (FSH)	Pituitary gland	Stimulates ovarian and testicular function
Testosterone	Gonads	Stimulates spermatogenesis
Estradiol	Ovaries	Stimulates follicular growth
Insulin	Pancreas	Regulates blood glucose levels
Melatonin	Pineal gland	Hormone of the dark that transmits information about the light–dark cycle
Leptin	Adipose tissue	Satiety hormone regulating energy balance
Ghrelin	Stomach	Hunger hormone regulating energy balance

Hormones that vary during sleep

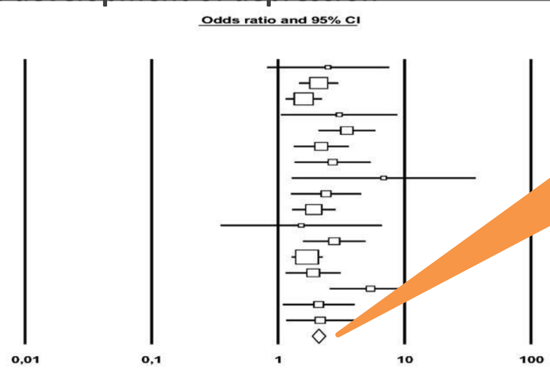
From Van Cauter & Tasali, (2011)

Glymphatic System during Sleep

Impact of Sleep on Mood

Insomnia is a risk factor for the development of depression

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Szklo-Coxe et al 2010	2,49	0,83	7,48	1,62	0,10
Kim et al 2009	2,10	1,48	2,97	4,20	0,00
Buysse et al 2008	1,60	1,16	2,21	2,85	0,00
Cho et al 2008	3,05	1,07	8,72	2,08	0,04
Jansson-Fröjmark & Lindblom 2008	3,51	2,11	5,83	4,84	0,00
Roane & Taylor 2008	2,20	1,35	3,60	3,15	0,00
Morphy et al 2007	2,71	1,37	5,37	2,86	0,00
Perlis et al 2006	6,86	1,30	36,14	2,27	0,02
Hein et al 2003	2,40	1,28	4,51	2,72	0,01
Roberts et al 2002	1,92	1,30	2,83	3,30	0,00
Johnson et al 2000	1,53	0,36	6,56	0,57	0,57
Mallon et al 2000	2,78	1,59	4,88	3,58	0,00
Foley et al 1999	1,70	1,29	2,24	3,80	0,00
Chang et al 1997	1,90	1,16	3,10	2,57	0,01
Weissman et al 1997	5,40	2,59	11,26	4,50	0,00
Breslau et al 1996	2,10	1,10	4,00	2,25	0,02
Vollrath et al 1989	2,16	1,17	3,99	2,46	0,01
FIXED MODEL	2,10	1,86	2,38	11,96	0,00



have a **two-fold risk of developing depression** compared with people with no sleep

Baglioni et al

Sleep is Good!

How Does Sleep Influence Exercise

- Sleep deprivation negatively impacts on performance (reduces reaction time, coordination, and endurance)
- Limited sleep impairs muscle recovery and increases perceived exertion
- Hormonal disruption (cortisol ↑, testosterone ↓) can slow muscle repair
- Poor sleep increases injury risk and reduces motivation
- Poor sleep impacts negatively on mood

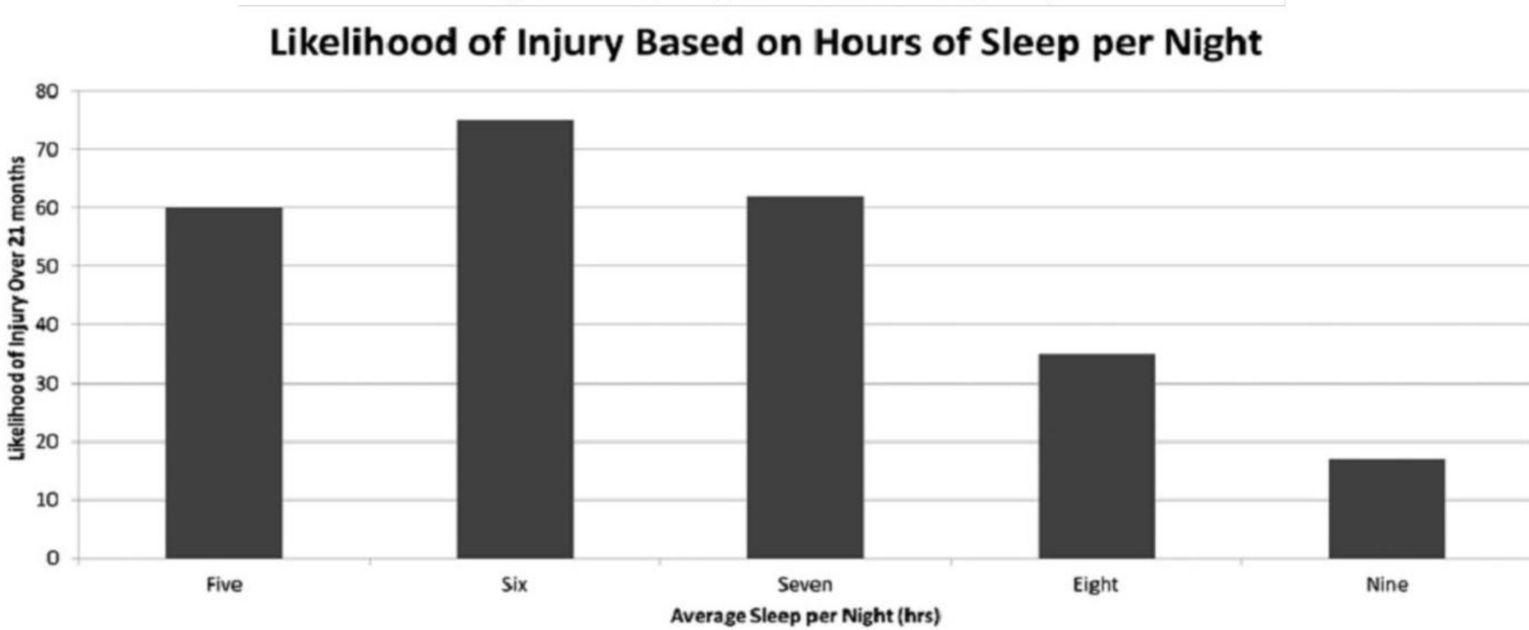
How Does Sleep Influence Exercise

ORIGINAL ARTICLE

J Pediatr Orthop • Volume 34, Number 2, March 2014

Chronic Lack of Sleep is Associated With Increased Sports Injuries in Adolescent Athletes

Matthew D. Milewski, MD, David L. Skaggs, MD, MMM,† Gregory A. Bishop, MS,‡ J. Lee Pace, MD,† David A. Ibrahim, MD,† Tishya A.L. Wren, PhD,† and Audrius Barzdukas, MEd‡*

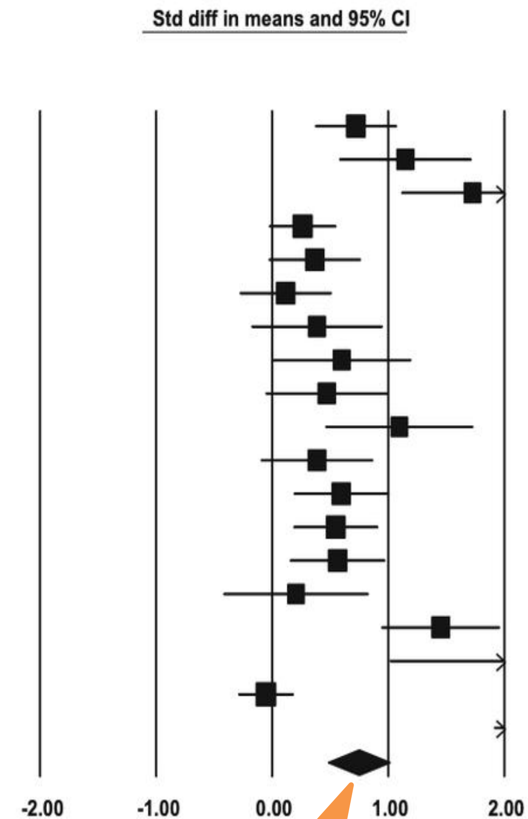


The Influence of Exercise on Sleep

- Regular physical activity helps regulate circadian rhythms
- Reduces time to fall asleep and increases deep (slow-wave) sleep
- Decreases stress and anxiety that can disrupt rest
- Consistent aerobic exercise (e.g., running, cycling) has strong effects on sleep quality
- Moderate intensity works best; vigorous exercise right before bed may disrupt sleep for some

Does Exercise Influence Sleep

Study name	Subgroup within study	Outcome	Statistics for each study			
			Std diff in means	Lower limit	Upper limit	p-Value
Chen et al 2009	None	SQ	0.72	0.36	1.08	0.00
Chen et al 2010	None	SQ	1.15	0.57	1.72	0.00
Chen et al 2012	None	SQ	1.73	1.11	2.35	0.00
de Jong et al 2006	None	SQ	0.26	-0.03	0.56	0.08
Elavsky et al 2007	Walking	SQ	0.37	-0.04	0.77	0.07
Elavsky et al 2007	Yoga	SQ	0.12	-0.29	0.52	0.57
Frye et al 2007	Low Impact Exercise	SQ	0.39	-0.18	0.96	0.18
Frye et al 2007	Tai Chi	SQ	0.60	-0.01	1.20	0.05
Hosseini et al 2011	None	SQ	0.47	-0.06	1.00	0.08
King et al 1997	None	SQ	1.10	0.45	1.74	0.00
King et al 2008	None	SQ	0.39	-0.10	0.88	0.12
Kline et al 2012	12 KKW	SQ	0.59	0.18	1.01	0.00
Kline et al 2012	4 KKW	SQ	0.55	0.18	0.92	0.00
Kline et al 2012	8 KKW	SQ	0.56	0.15	0.98	0.01
Manzaneque et al 2009	None	SQ	0.21	-0.43	0.84	0.52
Nguyen et al 2012	None	SQ	1.45	0.93	1.97	0.00
Reid et al 2010	None	SQ	2.23	1.01	3.45	0.00
Tworoger et al 2003	None	SQ	-0.05	-0.30	0.19	0.67
Yeh et al 2012	None	SQ	2.54	1.91	3.17	0.00
			0.74	0.48	1.00	0.00



Moderate influence of exercise on sleep quality

Kredlow et al. (2015)

Bi-directional Mechanisms

- Sleep supports muscle recovery and growth hormone release
- Exercise increases adenosine build up, promoting sleep pressure
- Both influence the autonomic nervous system and inflammation pathways
- Reductions in stress from exercise promote sleep and sleep promotes positive mood

Socio-Demographic Factors

- Exercise has more pronounced impact on individuals with insomnia, mood disorders and chronic illnesses
- Individual differences in exercise tolerance and recovery
- Age-related factors
- Barriers to sleep and exercise

Are there Additional Benefits for Aquatic Exercise on Sleep

- Reductions in Pain Intensity
- Buoyancy and reduced Joint Stress
- Improved movement
- Hydrostatic Pressure on Blood Pressure

Aquatic Techniques	Neuromuscular disease	Multiple Sclerosis	Parkinsonism	Cerebral Palsy	SCI	Spine and fracture	Obesity	Arthritis	Pregnancy	Athletic rehab	Cross-training
One-on-one therapies	✔	✔	✔	✔	✔	✔				✔	
Respiratory training	✔	✔		✔	✔						
Aquatic spine stabilization						✔			✔	✔	
Deep water joint mobilization					✔	✔		✔		✔	
Watsu	✔	✔		✔	✔						
Group warm water therapies	✔						✔	✔			
Balance programs		✔	✔								
YMCA Arthritis								✔			
Ai Chi			✔			✔		✔			
Yogalates			✔				✔	✔	✔		
Aquarobics							✔	✔	✔		✔
Aquajogging							✔		✔	✔	
Aquarunning etc. (deep water)											✔
Aquatic plyometrics											✔
Aquatic treadmill			✔				✔			✔	✔

Altering Thermodynamics

Evidence for Aquatic Exercise

ELSEVIER

Mental Health and Physical Activity
Volume 28, March 2025, 100670

Aquatic training and sleep quality, depressive symptoms and quality of life in patients with type 2 diabetes: Diabetes and Aquatic Training Study (DATS2)- A Randomized Controlled Trial

Rodrigo Sudatti Delevatti [a], Larissa Leonel [a], Felipe Barreto Schuch [b c f], Elisa Côrrea Marson [d], Salime Donida Chedid Lisboa [d], Thais Reichert [e], Ana Carolina Kanitz [d], Vitória de Mello Bones [d], Luiz Fernando Martins Kruel [d]

PTJ Physical Therapy & Rehabilitation Journal

Issues | Subject ▾ | More Content ▾ | Submit ▾ | Purchase | Alerts | About ▾ | Physical Therapy ▾

Volume 94, Issue 10
1 October 2014

JOURNAL ARTICLE

Effect of Therapeutic Aquatic Exercise on Symptoms and Function Associated With Lower Limb Osteoarthritis: Systematic Review With Meta-Analysis

Get access >

Benjamin Waller, Anna Ogonowska-Slodownik, Manuel Vitor, Johan Lambeck, Daniel Daly, Urho M. Kujala, Ari Heinonen

Evidence for Aquatic Exercise vs. Land Based Exercise

Journal of Functional Morphology and Kinesiology
MDPI

Review

Aquatic Therapy Versus Land-Based Therapy in Patients with Parkinson's Disease: A Systematic Review

Gema Santamaría [1], Mario Fernández-Gorgojo [2], Eduardo Gutiérrez-Abejón [3,4,5,6,7], Blanca García Gómez [8], Ángela Molina [9] and Diego Fernández-Lázaro [10,*]

ACRM AMERICAN CONGRESS OF REHABILITATION MEDICINE
Archives of Physical Medicine and Rehabilitation
journal homepage: www.archives-pmr.org
Archives of Physical Medicine and Rehabilitation 2023;104: 1775–84

ORIGINAL RESEARCH

Effectiveness of Land- and Water-based Exercise on Fatigue and Sleep Quality in Women With Fibromyalgia: The al-Ándalus Quasi-Experimental Study

Check for updates

Blanca Gavilán-Carrera,[a,b,c,d] Milkana Borges-Cosic,[c,e] Inmaculada C. Álvarez-Gallardo,[f,g] Alberto Soriano-Maldonado,[h,i] Pedro Acosta-Manzano,[d,j,k] Daniel Camiletti-Moirón,[f,g] Ana Carbonell-Baeza,[g,l] Antonio J. Casimiro,[h,i] María José Girela-Rejón,[c,d,m] Brian Walitt,[n] Fernando Estévez-López,[o]

ELSEVIER
Physiotherapy
Physiotherapy 123 (2024) 91–101

Efficacy of aquatic vs land-based therapy for pain management in women with fibromyalgia: a randomised controlled trial

Check for updates

S. Rivas Neira[a,*], A. Pasqual Marques[b], R. Fernández Cervantes[a], M.T. Seoane Pillado[c], J. Vivas Costa[a]

[a] Department of Physiotherapy, Medicine and Biomedical Sciences, Faculty of Physiotherapy, Universidade da Coruña, A Coruña, Spain
[b] Department of Physiotherapy, Speech–Language Pathology and Audiology, and Occupational Therapy, Faculty of Medicine, Universidade de São Paulo, São Paulo, Brazil
[c] Department of Health Sciences, Faculty of Nursing and Podiatry, Universidade da Coruña, Spain

Comparative Evidence for Aquatic Exercise vs. Land-based Exercise

healthcare

MDPI

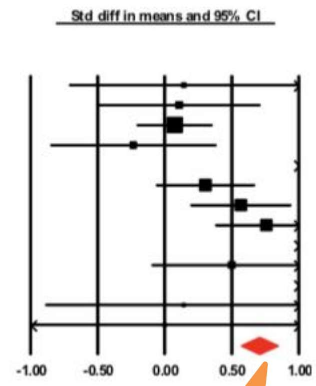
Systematic Review

Effects of Aquatic Exercise on Sleep Quality in Patients with Chronic Diseases: A Meta-Analysis

Shuzhang Zhou [1], Ming Fang [1], Billy Chun-Lung So [2,*], Hei Wa So [3], Paul H. Lee [4] and Siushing Man [1]

Comparative Evidence for Aquatic Exercise vs. Land-based Exercise

Study name	Intervention duration (week)	Outcome	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
			Statistics for each study						
Delevatti, et al. (2018)	12.000	nighttime sleep quality	0.143	0.437	0.191	-0.714	1.001	0.327	0.744
De Medeiros, et al. (2020)	12.000	nighttime sleep quality	0.108	0.309	0.095	-0.497	0.713	0.350	0.726
Maindet, et al. (2021)	12.000	nighttime sleep quality	0.075	0.145	0.021	-0.210	0.359	0.513	0.608
Bestas, et al. (2021)	4.000	nighttime sleep quality	-0.233	0.317	0.101	-0.855	0.389	-0.735	0.462
Loureiro, et al. (2022)	9.000	nighttime sleep quality	2.490	0.503	0.253	1.504	3.476	4.950	0.000
Peng, et al. (2022)	12.000	nighttime sleep quality	0.304	0.189	0.036	-0.067	0.675	1.607	0.108
Gavilán-Carrera, et al. (2023) - 1	24.000	nighttime sleep quality	0.568	0.193	0.037	0.190	0.946	2.947	0.003
Gavilán-Carrera, et al. (2023) - 2	24.000	nighttime sleep quality	0.759	0.196	0.038	0.375	1.143	3.877	0.000
Lee and Kim (2024)	12.000	nighttime sleep quality	2.273	0.209	0.044	1.863	2.682	10.884	0.000
Neira, et al (2024)	12.000	nighttime sleep quality	0.500	0.306	0.094	-0.100	1.100	1.634	0.102
Ovejero, et al. (2025)	4.000	nighttime sleep quality	3.596	0.341	0.116	2.927	4.264	10.541	0.000
Delevatti, et al (2025) - 1	15.000	nighttime sleep quality	0.142	0.528	0.278	-0.892	1.177	0.270	0.787
Delevatti, et al (2025) - 2	15.000	nighttime sleep quality	0.000	0.556	0.310	-1.090	1.090	0.000	1.000
			0.703	0.070	0.005	0.566	0.839	10.107	0.000



Overall better outcomes using aquatic vs. land based exercises

Comparative Evidence for Aquatic Exercise vs. Land-based Exercise

Table 3. Characteristics of intervention groups and control groups.

Article Number	Intervention Details	Control Treatment
01	Deep-water running using a flotation vest, 30 °C, 85–100% HR_{AT}	Land-based running on athletic track
02	Continuous aquatic aerobic exercise, 32 °C, Borg 12–14	Mat Pilates
03	Supervised pool exercises and high-pressure underwater jets massage	Usual care
04	Muscle strengthening and flexibility in pool	Land-based strengthening
05	Recreational group activities (ball games, hiking) combined with individual passive WATSU relaxation, 34 °C, and land-based therapy	Land-based conventional therapy
06	Therapeutic strength and core stability training, 29–31 °C, Borg 12–14	Physical therapy modalities
07	Water-based resistance exercises using drag equipment, 60–70% *HRmax*	Usual care
08	Aquarobics, 29–30 °C, RPE 11–13	Educational program
09	Group recreational therapeutic exercises, 32–34 °C, Borg CR-10: 3–5	Land-based therapeutic exercise
10	Calisthenics and mobilization in pool, 34 °C	No intervention
11	Two groups: (1) Aerobic circuit training alternating lower/upper limbs, 30 °C, 85–100% HR_{AT}. (2) Combined training: Identical aerobic circuit training and land-based therapeutic exercise	Sedentary control

Abbreviations: HR_{AT}: Heart Rate at Anaerobic Threshold; *HRmax*: Maximum Heart Rate; Borg 12–14: Borg Rating of Perceived Exertion 6–20 Scale; RPE: Rating of Perceived Exertion Borg; CR-10: Borg Category-Ratio 0–10 Scale.

Managing Exercise for Better Sleep

- An exercise routine will help regulate the circadian system
- Moderate exercise increases alertness
- Avoid intensive exercise 2 hours before intended bedtime
- Exercise even when sleepy or fatigued

Conclusions

- Sleep and exercise are great bedfellows

Thank You!


STRONG BODY. STRONG MIND.
REST RECHARGE REPEAT
FLOW BREATHE THRIVE
EXERCISE
SLEEP
AQUATIC EXERCISE
LAND BASED EXERCISE
SLEEP
AQUATIC EXERCISE

Implementing Evidence-Based Strategies for Shoulder Recovery in Swimmers

Michael Murray

Special Thanks to Melissa McDonald

DukeHealth

1

Objectives

- Discuss the prevalence of injuries in swimmers at different levels of expertise
- Evaluate tests and measures to consider when in early and late stages of rehabilitation
- Explore interventions to progress from rehabilitation to performance stages utilizing pool and land exercises.
- Demonstrate swim mechanic techniques including compensations to help swimmers return to swimming.

2

Duke Health Aquatic PT

Michael Murray, PT, DPT

Prevalence of Swimming Injuries

DukeHealth

Prevalence of injuries:

- Systematic review looking mostly at Elite Swimmers from 9 studies[1]
- Shoulder the most frequently affected joint.
  - Tendinitis and shoulder impingement were the most common injuries
  - Muscle Strains are the next highest injury
- Other commonly affected regions
  - Knee - associated with the biomechanical demands of breaststroke. Reported Meniscus tears, ACL and LCL tears/sprains.
  - Lumbar spine - Potentially from degenerative changes from high training volumes.
- Higher incidence of injuries in female swimmers compared to males.
  - 48% of female swimmers compared to 41.4% of males

5

Prevalence of injuries:

- Risk Factors[1]:
  - Elite swimmers exhibit the highest injury rates, particularly shoulder tendinitis, impingement, and knee injuries, primarily due to higher training volumes and repetitive overhead motions.
  - Recreational swimmers present a lower overall injury prevalence, though shoulder impingement and tendinitis remain common
  - Improper training load management—both excessive and insufficient—can increase the injury risk by disrupting the balance between stress and recovery
  - Repetitive movements, including shoulder rotations, turns, and push-offs, contribute to progressive tissue strain.
  - Higher prevalence of female injuries may be partially attributed to the Female Athlete Triad, a syndrome characterized by low energy availability, menstrual dysfunction, and poor bone health, which increases injury susceptibility.

6

Study	S (n)/ Gender	Participant Age	Level	Prevalence of Injury	Anatomical Location	Type of Injury	Injury Measure	Training Load (Meters per Day)
de Almeida et al. (2015) [2]	140 M 117 F	20.6 ± 3.7	Elite and NT	12 months 56% ≥ 1 I	Ankle (4.9%) Elbow (4.2%) Knee (16%) L. back (6.2%) Shoulder (46.5%)	Ligamentous rupture (6.7%) Meniscus tear (6.7%) Muscle strain (7.7%) Tendinitis (58.7%)	Author Devel—Q	12,000 ± 2000 m 4–6 days
Knobloch et al. (2008) [9]	141 M 155 F	19 ± 10 18.3 ± 9.6	Elite and NT	UL (0.106 I/1000 h)	Hip (3.2%) Knee (30.8%) Shoulder (49.9%) Trunk (13.4%)	Knee tear (27.6%) Muscle strain (49%) Overuse injuries (71.7%)	Author Devel—Q	12,000 ± 2000 m 4–6 days
Aguiar et al. (2010) [10]	135 M 80 F	19.76 ± 2.79	Elite and NT	12 months 56.3% ≥ 1 I	Knee (13.56%) L. back (15.25%) Shoulder (47.46%) Upper arm [1] (5.08%)	Tendinitis (no data) Muscle or tendon strain (no data)	Author Devel—Q	12,000 ± 2000 m 4–6 days
Witkoś et al. (2022) [16]	64 F	24.69 ± 2.15	Trained	12 months 76.69% ≥ 1 I	Ankle (6.45%) Elbow (4.30%) Knee (27.96%) Shoulder (36.56%)	Joint inflammation (31.58%) Knee contusion (12.63%) Ligamentous injury (5.26%) Meniscus tear (15.79%) Muscle strain (27.37%) Overuse injuries (52.1%)	Author Devel—Q Questionnaire LEAF-Q	5000 ± 2000 m 3 days
Wolf et al. (2009) [23]	44 M 50 F	"freshman" [2] "sophomore" [2] "junior" [2] "senior" [2]	Recreationally active	M (3.78 I/1000 h) F (4 I/1000 h)	Shoulder (36%) Upper arm [1] (31%)	Impingement (no data) Overuse injuries (no data) Tendinitis (no data)	SIMS-Med Sport Systems	No data
Salerno et. (2022) [24]	21 both	19.4 (range 14–30)	Trained	12 months 52.4% ≥ 1 I	Ankle (4.8%) Knee (4.8%) Shoulder (23.8%) Upper arm [1] (9.5%)	Muscle or tendon strain (no data) Tendinitis (no data)	Author Devel—Q Skype interview	4100 ± 2000 m 3 days
Chase et al. (2013) [25]	16 M 18 F	19.5	Elite and NT	M (2.74 I/1000 h) F (3.32 I/1000 h)	Ankle (12.9%) Knee (12.9%) L. back (16.1%) Shoulder (38.7%)	Knee tear (25.8%) Knee sprain (ACL y LCL) (6.5%) Tendinitis/impingement (58%)	Author Devel—Q	12,000 ± 2000 m 4–6 days
Mountjoy et al. (2010) [26]	872 M 630 F	19.5 ± 1.4	Elite and NT	M (52.1 I/1000 S) F (65.6 I/1000 S)	Knee/hip (27.5%) Shoulder (36.8%) Trunk (16.4%)	Tendinitis and shoulder impingement (24%)	Author Devel—Q	12,000 ± 2000 m 4–6 days
Atilla et al. (2020) [27]	88 M	47.1 ± 13.2	Elite and NT	No data	Ankle (2.3%) Elbow (9.1%) Hip (5.7%) Knee (19.8%) L. back (26.7%) Shoulder (35.6%)	ACL rupture (6.6%) Ankle sprain (2.2%) Lumbar disc injury (18.3%) Meniscus injury (2.2%) Tendinitis and shoulder impingement (22.7%)	Author Devel—Q	10,081 ± 7601.8 m 4–6 days

S = sample; M = male; F = female; NT = national team; NCAA = National Collegiate Athletic Association; L/h = injury per hour; L/S = injury per swimmer; I = injury; L.back = lower back; UL = upper limb; ACL = anterior cruciate ligament; LCL = lateral collateral ligament; LEAF-Q = Low Energy Availability in Females Questionnaire; Author Devel—Q = Author Development Questionnaire; SIMS-Med: Integrated Monitoring and Tracking System for Sport Medicine; [1] Upper arm = biceps brachii, brachialis, and triceps brachii; [2] the levels 'freshman', 'sophomore', 'junior', and 'senior' correspond to the academic years in the American education system and form part of the recreationally active group, representing progression and engagement in physical activity at a casual level; m = meters.

7

Prevalence of injuries:

- Limitations[1]
  - Variability in injury prevalence reporting due to differences in study designs, injury definitions, and data collection protocols,
  - Focusing on elite swimmers, reducing the generalizability of the findings to other populations.
  - Very young population ranging from 14-30 but mostly collage aged elite swimmers.
  - Better assessment of training load, time and load intensity of dry land exercise programs, as well as assessment of preventative measures including use of technology of swimwear or other equipment may be helpful in the future.

8

Research on Non-Op Shoulder Patients

DukeHealth

9

Prediction of Shoulder Pain in Youth Compettive Swimmers: The development of Internal Validation of a Prognostic Prediction Model[5]

- Strongest predictors of shoulder pain were:
  - Regional competition swim level
  - Acute:Chronic Workload Ratio
    - Distance swum in previous 7 days/average of past 28 days
    - Swimmers who were exposed to a 1-unit increase in the ACWR, the odds for shoulder pain increased by a factor of 4.3.
      - 1 unit increase would be at least doubling yardage in a one week period
  - Posterior shoulder muscle endurance
    - A 1 count increase in PSE had a 5% decrease in the odds for shoulder pain
    - Prone lifting 2% of bodyweight to 90 degrees abduction, 1s up, hold 1s and down as many times as possible
  - Hand entry error
    - Participants that developed shoulder pain were already entering hand in slightly ABD from their body which was possibly a protective posturing meaning they were already compensating for shoulder pain

10

Shoulder muscle imbalance as Risk for Shoulder Injury in Elite Adolescent Swimmers: A prospective Study[4]

- Functional Ratio (Eccentric ER strength verse concentric IR strength) maybe an interesting and relevant variable for identifying swimmers at higher risk of shoulder injury
- Functional ratio below .68 was associated with a significant 4.5 fold increase risk of developing a shoulder injury
- MMT and previous ratios looked at concentric strength ratio (conER:conIR) and this has not been significantly connected with shoulder pain in swimmers
- They also found that this ratio lowered in season indicating an undertraining of eccentric ER
- Johansson et. al[8] did paper on how to measure eccentric ER with a handheld dynameter that is linked in the references

11

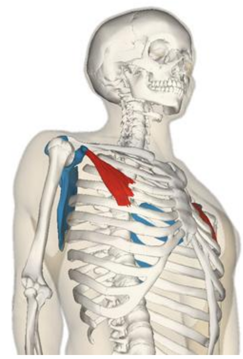
Update on Rehabilitation Strategies for Swimmers' Shoulder: A narrative Review[2]

- The following resulted in notable reduction in pain and enhanced strength and endurance of the rotator cuff:
  - Aquatic exercises
  - Core stabilization exercises
  - Open and close chain exercises
  - Rhythmic and scapular stabilization exercises
  - Land based and aquatic strengthening
  - Kinesio taping

12

Sink or Swim? Clinical Objectives Tests and Measures Associated with shoulder Pain in Swimmers of Varied Age lebels of Competition: A sysemic Review[6]

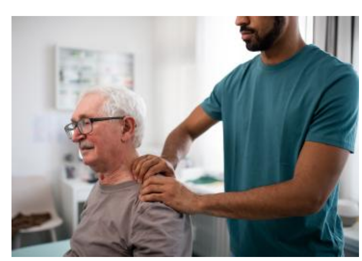
- Objective measures to consider for adult/adolescent swimmers:
    - Conventional ER:IR ratios were not correlated with swimmer shoulder but functional ratios were more helpful
    - Low to moderate evidence that scapular positioning is associated with swimmer's shoulder
    - Moderate evidence that reduced pec minor length is associated with shoulder pain due to anterior shifting of scapula



13

The Effect of Exercise Therapy Interventions on Shoulder Pain and Musculoskeletal Risk Factors of Shoulder Pain in Competitive Swimmers: A scoping Review[3]

- Swimmers performing 6 to 8 weeks of shoulder and scapular strengthening exercises in combo with pectoralis minor stretches have less incidence of shoulder pain
- Combo of strengthening exercises, and stretches with other therapeutic modalities, such as manual therapy techniques can decrease shoulder pain in injured swimmers.
    - The most common MT techniques were myofascial release and joint mobilization



14

Case Study

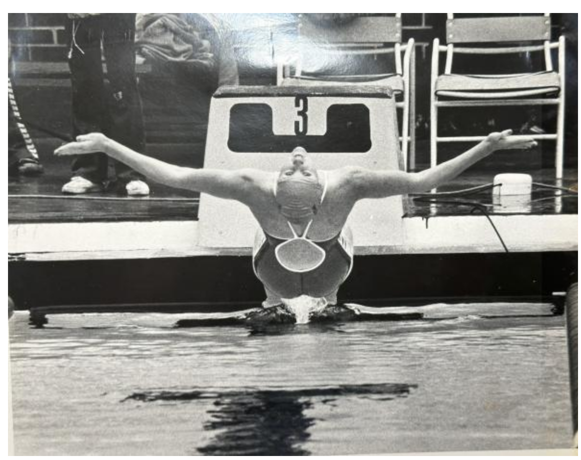
TSA --> RTSA

DukeHealth

15

Case ME:

- Former colligate swimmer (almost Olympian)
- Surgical history
- Swim history
- Initial treatment leading up to return to swimming
- Return to swimming progression
- Regression and new injury
- Re-Return to swim



16

Case ME: Swim History

- Swam at University of Florida
- Olympic hopeful in Breaststroke and very good at other strokes
- Team issues prevented her from making it to the time trials
- Worked in aquatics teaching deep water swim classes for years at local facility (needed to be able to do CPR to keep this job)
- Also enjoyed swimming until shoulder prevented this.
- Major mental concerns about returning to swimming and injuring her arm further.
- Land PT also had concerns, so we discussed options frequently.

17

Evidence for Patients with Total Shoulder Arthroplasty

DukeHealth

18

What does the research say?

Evidence for Return to Swim after TSA/RTSA[7]

- Level III -Retrospective Cohort Comparison-Treatment Study
- "The purpose of this study is to characterize the rate of return to swim following both aTSA and rTSA as well as swimming-specific performance at a minimum of 2 years postoperatively."
- Overall rate return to swim was 72.5%,
  - 82% of aTSA
  - 64% of rTSA
  - No significant difference in the amount of time to return to swimming between groups ~ 4 vs. 5 months

Mousad, A. D., Xie, J., Schodlbauer, D. F., Beleckas, C. M., & Levy, J. C. (2025). Return to swimming after shoulder arthroplasty. Journal of Shoulder and Elbow Surgery, 34(7), e505-e512. https://doi.org/10.1016/j.jse.2024.10.013

19

What does the research say?

Evidence for Return to Swim after TSA/RTSA[7]

- "Among those patients who were able to swim, both cohorts demonstrated similar improvements in the quality of swim performance, time to return to swimming and improvements in patient-reported outcome measures and shoulder range of motion."
- Authors note that altered shoulder kinematics, decreased overall ROM, and tendency to lack some rotator cuff musculature in the rTSA groups likely resulted in less returning to swim but those that did return to swimming showed improvements at a similar rate to the aTSA group.
- "Of those who returned to swim, overall swimming ability increased in 70%of aTSA and 74% of rTSA patients, and overall enjoyment increased in 70%of aTSA and 71% of rTSA patients."

20

Case ME: Surgical History

- 8/21/2018 Left Anatomic Total Shoulder (TSA)
- 12/24/2019 Left Revision Reverse TSA (RTSA)
- 3/7/2023 Left Revision reverse total shoulder (Missing L supraspinatus and subscapularis)

21

Case ME: Surgical History

- 8/21/2018 L Anatomic Total Shoulder
  - Worked on ROM and strength post surgery.
  - Started Aquatic PT 8-14-2019 (almost a year after surgery)
  - November followed up with PT who is shoulder specialist and had concerns with her strength and positive belly press test.
  - IR painful and ER had crepitus. Strengthening flared up shoulder with swelling.
  - Diagnostic ultrasound showed complete tear of Supraspinatus
  - Pt followed up in pool and land for prehab for surgery and getting advice from therapist on what to consider with upcoming surgeries.

22

Case ME: Surgical History

- 12/24/2019 left revision reverse TSA
  - At Post op visit had Hematoma which was drained and antibiotics prescribed.
  - Started normal post op care, ROM, isometrics,
  - 1/22/2020 - first aquatic PT session with land PT with buoyancy assisted ROM
  - Pandemic shuts clinic,
    - Did 1 telehealth visit.
    - Primary PT notes: "She may benefit from another formal PT session for advanced pool therapy exercises, and gym work out guidance when the COVID 19 crisis is passed"
  - Followed up in October 2020
    - Strained shoulder cleaning her Dog and was concerned with strength falling off since pools closed during the pandemic.

23

Case ME: Surgical History

- 12/24/2019 left revision reverse TSA
  - October: **Good ROM and strength** generally 4/5
    - LUE AROM (degrees)
      - L Shoulder Flexion : 150 Degrees
      - L Shoulder ABduction: 150 Degrees
      - L Shoulder Internal Rotation : (Posterior hip)
      - L Shoulder External Rotation at Neutral: 45 Degrees
  - November 2020 back to pool for swim instructions and started PT for L>R ankle pain
    - Did very well with first pool session for return to swim

24

Case ME: Surgical History

- 12/24/2019 left revision reverse TSA
  - First return to swim session 11/10/2020 (Program that day):
    - Flexion wall stretch
    - Pec release
    - Breaststroke - Cues to pull palm downs instead of thumbs down and pulling out. Shifted to sitting noodle arm pulls, Cues for pull breath kick glide
    - Elementary back stroke - Cues for shoulder blades down then pulling, Cues to get head back slightly to keep hips higher in water. Pt felt like it was dropping too much.
    - Side stroke - R side down/leading Looks and feels good
    - Freestyle - Cues for more body rotation and good pulling with bent elbow to catch water. Pt notes L arm is weak with pulling motion and she has to think about how it moves.
    - **Shoulder and neck muscle releases**
    - **Pec releases**
    - **Posterior shoulder release** - much more ROM.

25

Case ME: Surgical History

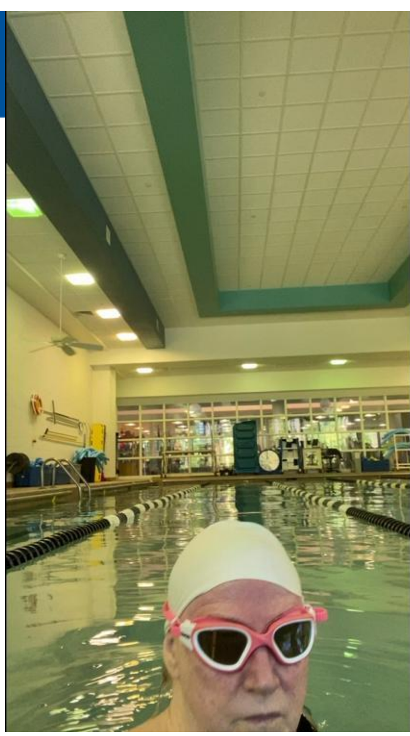
- 12/24/2019 left revision reverse TSA
  - Follow up message from Patient (after break and ramping up again after burning hand):
    - **I've been slowly increasing laps swum every 2 weeks. Was at 14-16, now at 28-30 laps,** comprised of Breaststroke, R side sidestroke, freestyle/crawl & Elementary Backstroke. Changing arm recovery on Elementary Backstroke made a huge difference: thank you! Overall shoulder doing better but still gets aches with forward extension on breaststroke and recovery on freestyle (goes from nothing 0/10, up to 4/10 depending on the day.)
- Doing very well so discharged from Aquatic PT and focusing on foot OA with 2nd land provider.

26

Case ME: Initial Return to Swim 2019-2022

- Swim progression
  - Shoulder ROM
  - Manual work
  - Scapular stability with DB and walking
  - Seated noodle arm pulls
  - Breast stoke
  - Elementary back stroke
  - Side stroke
  - Freestyle kick focus
  - Freestyle with excessive body roll and earlier hand entry in water

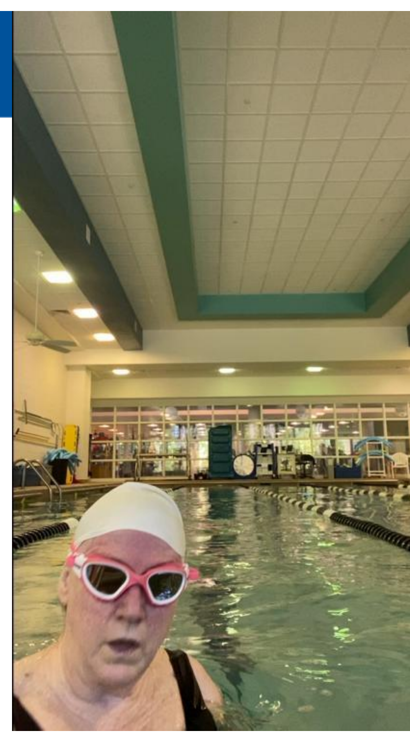
27



2022

← Breast Stroke after 2nd Surgery

Elementary Back stroke After 2nd surgery →

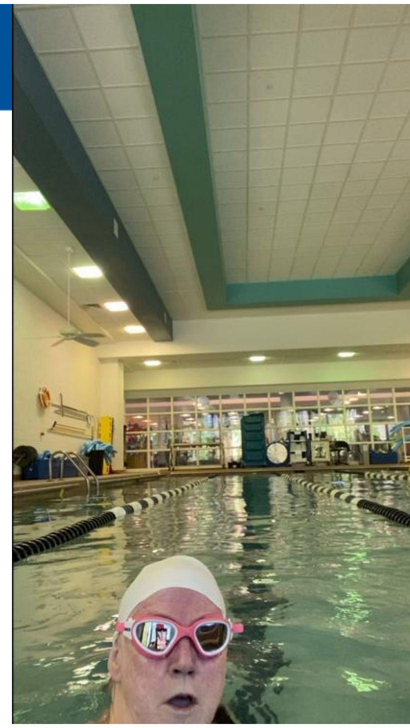


28

2022

← Freestyle Version 1

Freestyle Version 2 →



29

Case ME: Re-injury of shoulder

- Freak accident on Leg press with new PT closer to home
  - "Yesterday I was doing a leg press on a machine that has the body move (slide style). Weight was set (by someone else) at 60lbs. I was unaware of the weight, pressed out & immediately felt uncomfortable. After 1 press I stopped exercise. Left shoulder felt bad for a while. This morning, when laying down, got numbness in pinkie side of wrist & hand. Hoping this will quickly resolve. How long should I give this to resolve on its own (today is Friday 8/6/2021)?"
  - Initial imagining cleared of fracture by MD and not too concerned so followed up as needed. And only did 2 PT visits 9/2021 and 3/2022 and decided no major issues so no major follow up at that time.
  - Was down to 4 lengths of pool, and with some PT made it back up to 32 lengths of pool alternating between free, side, breast, and back stroke.
- Imaging on 10/2022 showed hardware loosened at 2 inferior screws and would need surgery.
  - Swimming was still helping her pain and strength until it wasn't so stopped.
  - Saw MD 11/2022 and booked surgery for 3/7/23

30

Case ME: Surgical History

- 3/7/2023 L Revision reverse total shoulder (Missing L supraspinatus and subscapularis)
  - Normal care with extended timelines to ensure healing
    - 6 month follow up with MD allowed to resume some swimming.
  - 11/6/23 - first pool PT, MD concerned with Freestyle and land PT concerned with pool entry using ladder until saw Pool PT.
    - Focused on scapular strengthening, rhythmic stabilizations, DB floats, and resistance training before swimming.
  - 1/12/24 - first time trying swimming
  - 4/24/24 - doing well so had one more session booked then considered D/C after that visit

31

Case ME: Surgical History

- 3/7/2023 L Revision reverse total shoulder (Missing L supraspinatus)
  - 6/2024 - Multiple missed visits later get message in June – hospitalized with **Dx ofAFib w/ Rapid Ventricular Response.**
  - Still did aquatic PT but no swimming until could get better assessed by cardiologist.
  - Focused on activity modification in the pool and found we could prevent breathlessness when doing rest breaks before she got to this point.
  - Message from patient saying heart catheterization looks good. Did more PT and 1/9/2025 told needs cardiac ablation
  - **4/30/2025 1st PT session in pool since cardiac ablation** (multiple land visits)

32

Case ME: Surgical History

- 3/7/2023 L Revision reverse total shoulder (Missing L supraspinatus)
  - Return to swim with cardiac and shoulder precautions
    - Freestyle – ok as long as not pain – fatigue most limiting factor – major focus on scapular stability with pulling motion and recovery made significant difference
    - Backstroke – never allowed due the IR needed for the stroke
    - Elementary backstroke – ok to do and easy to recover
    - Breaststroke – needed to modify to improve stroke performance and can't swim like she was in college anymore.
    - Side stroke – easy stroke
  - Discharged from PT 11/5/2025 - (ankle replacement surgery 11/14/25)

33

Case ME: Initial Return to Swim 2020-2022

- Swim progression
  - Shoulder ROM
  - Manual work
  - Scapular stability with DB and walking
  - Seated noodle arm pulls
  - Breast stoke
  - Freestyle with excessive body roll
  - Larger focus on scapular control and land therapy to get strength within MD limits of weightlifting to 20 lbs.
  - Focused on scapular depression and retraction during recovery phase "fixed" her stroke.

34

**2025 Videos **

- Breaststroke – before and after cues
- Elementary Backstroke – before and after cues
- Side stroke – both sides
- Freestyle – early issues, fatiguability, corrections, and at D/C

35

2025

← Breast Stroke after 3nd Surgery UE dominant

Breast Stroke full length after 3rd surgery →

36

2025

Elementary Backstroke BEFORE scapular stability cues

2025

Elementary Backstroke AFTER scapular stability cues

37

2025

← Side stroke both sides

38

2025

← Freestyle - Weak L UE especially at scapula in recovery phase and too much twisting from body

Freestyle – focus on Body Roll driven from hips→

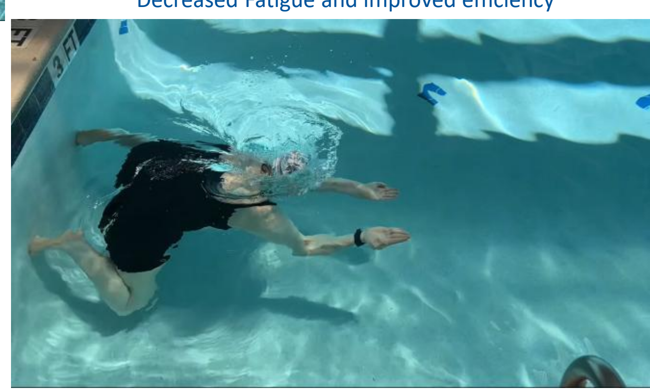
39

2025

Freestyle with Shoulder Fatigued

2025

Freestyle with integrating all scapular and body roll cues
Decreased Fatigue and improved efficiency



40

2025

← Freestyle – cued for Body Roll and Scapular Depression when pulling water and in recovery phase

Freestyle and Elementary Backstroke at Discharge →

41

What about land?

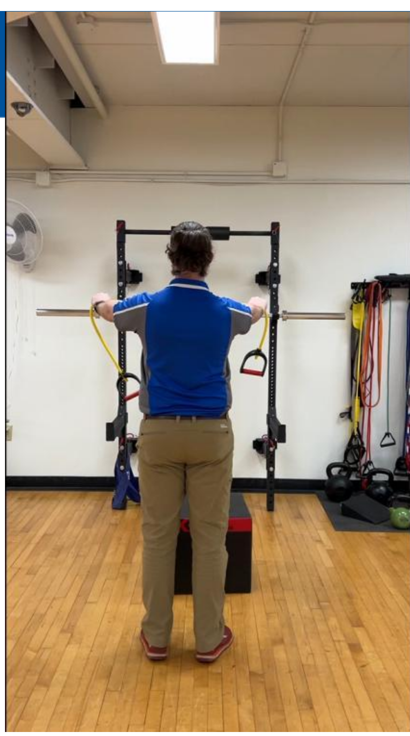
DukeHealth

42

Land Interventions - Late Stages Rehab

- Incline Dumbbell Chest Press
- Incline Dumbbell Rows
- Incline Dumbbell Rear Deltoid
- Lateral Dumbbell Raises
- Machine Lat Pull Down
- Machine Rows
- Machine Dip
- Cable Machine Straight arm Lat pull downs
- Cable Machine Rows
- Cable Machine Triceps
- Cable Machine Biceps

43



2025

← Band Pull Apart

Lat Pull Downs→

44

2025

← Seated Dip Machine

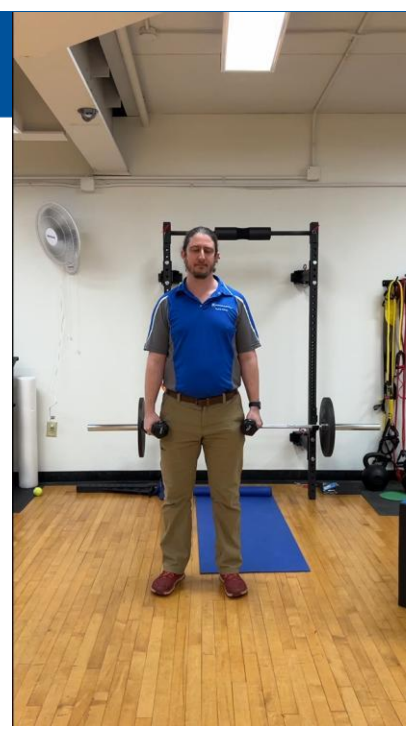
Row Machine→

45

2025

← Incline Chest Press (also did with bands)

Deltoid Lateral Raise→



46

2025

← Incline Rows

Incline Rear Deltoid and Scapular Retraction→

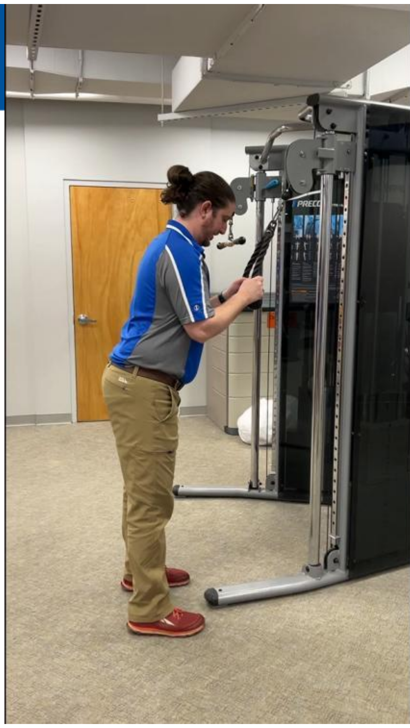
47

2025

← Cable Machine rows

Cable Machine Straight Arm Lat Pulldowns →

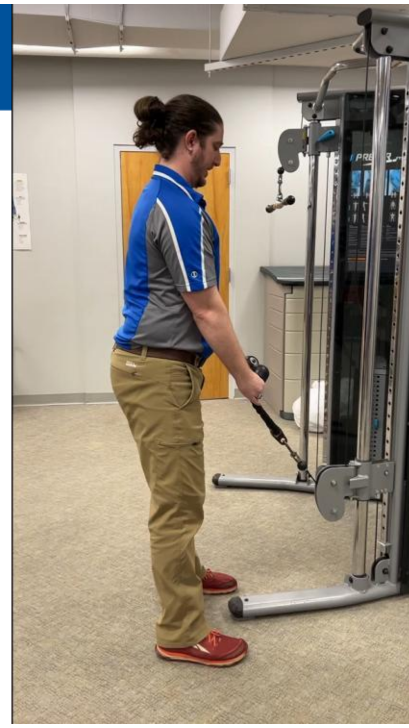
48



2025

← Cable Machine Triceps Pulldown

Cable Machine Biceps → Curls



Presentation Summary

- Shoulder injuries tend to be the most prevalent injury in elite and recreational swimmers.
- Swimming after aTSA and rTSA can be safe even in complicated cases.
- A mix of pool and land exercises are needed to return to swimming (within lifting and ROM restrictions).
- Some strokes will be easier to focus on than others with and without modifications depending on type of surgery/injury and involved musculature.
- Getting eyes on stroke via video or in person is important
- Ratios are important, ACWR and Functional strength ratio have been shown to be important factors to consider with swimmer's shoulder

References

DukeHealth

51

1. Fernández-Galván LM, Alcain Sein J, López-Nuevo C, Sánchez-Sierra A, Ladrián-Maestro A, Sánchez-Infante J. Injury Patterns and Frequency in Swimming: A Systematic Review. Applied Sciences. 2025; 15(3):1643. https://doi.org/10.3390/app15031643
2. Dcosta, Selena & Nair, Aishwarya. (2024). Update on Rehabilitation Strategies for Swimmers' Shoulder: A Narrative Review. Journal of Health and Allied Sciences NU. 15. 10.1055/s-0044-1787878.
3. Yoma, M., Herrington, L., & Mackenzie, T. A. (2022). The Effect of Exercise Therapy Interventions on Shoulder Pain and Musculoskeletal Risk Factors for Shoulder Pain in Competitive Swimmers: A Scoping Review. *Journal of Sport Rehabilitation*, *31*(5), 617–628. https://doi.org/10.1123/jsr.2021-0403
4. Drigny, Joffrey et al. "Shoulder Muscle Imbalance as a Risk for Shoulder Injury in Elite Adolescent Swimmers: A Prospective Study." *Journal of human kinetics* 75 (2020): n. pag. Web.
5. Feijen, S., Struyf, T., Kuppens, K., Tate, A., & Struyf, F. (2021). Prediction of Shoulder Pain in Youth Competitive Swimmers: The Development and InternalValidation of a Prognostic Prediction Model. *American Journal of Sports Medicine*, *49*(1), 154–161. https://doi.org/10.1177/0363546520969913
6. Kennedy J, Otley T, Hendren S, Myers H, Tate A. Sink or Swim? Clinical Objective Tests and Measures Associated with Shoulder Pain in Swimmers of Varied Age Levels of Competition: A Systematic Review. Int J Sports Phys Ther. 2024 Jan 2;19(1):1381-1397. doi: 10.26603/001c.90282. PMID:38179580; PMCID: PMC10761606.
7. Mousad, A. D., Xie, J., Schodlbauer, D. F., Beleckas, C. M., & Levy, J. C. (2025). Return to swimming after shoulder arthroplasty. Journal of Shoulder and Elbow Surgery, 34(7), e505-e512. https://doi.org/10.1016/j.jse.2024.10.013
8. Johansson, F. R., P.T., Skillgate, E., PhD., Lapauw, M. L., P.T., Clijmans, D., P.T., Deneulin, V. P., P.T., Palmans, T., & Cools, Ann M,PhD., P.T. (2015). Measuring eccentric strength of the shoulder external rotators using a handheld dynamometer: Reliability and validity. *Journal of Athletic Training, 50*(7), 719-725. Retrieved from https://login.proxy.lib.duke.edu/login?url=https://www.proquest.com/scholarly-journals/measuring-eccentric-strength-shoulder-external/docview/1697733879/se-2

52

Questions?

DukeHealth

53