Wet & Healthy

The Health Benefits of Aquatic Activity

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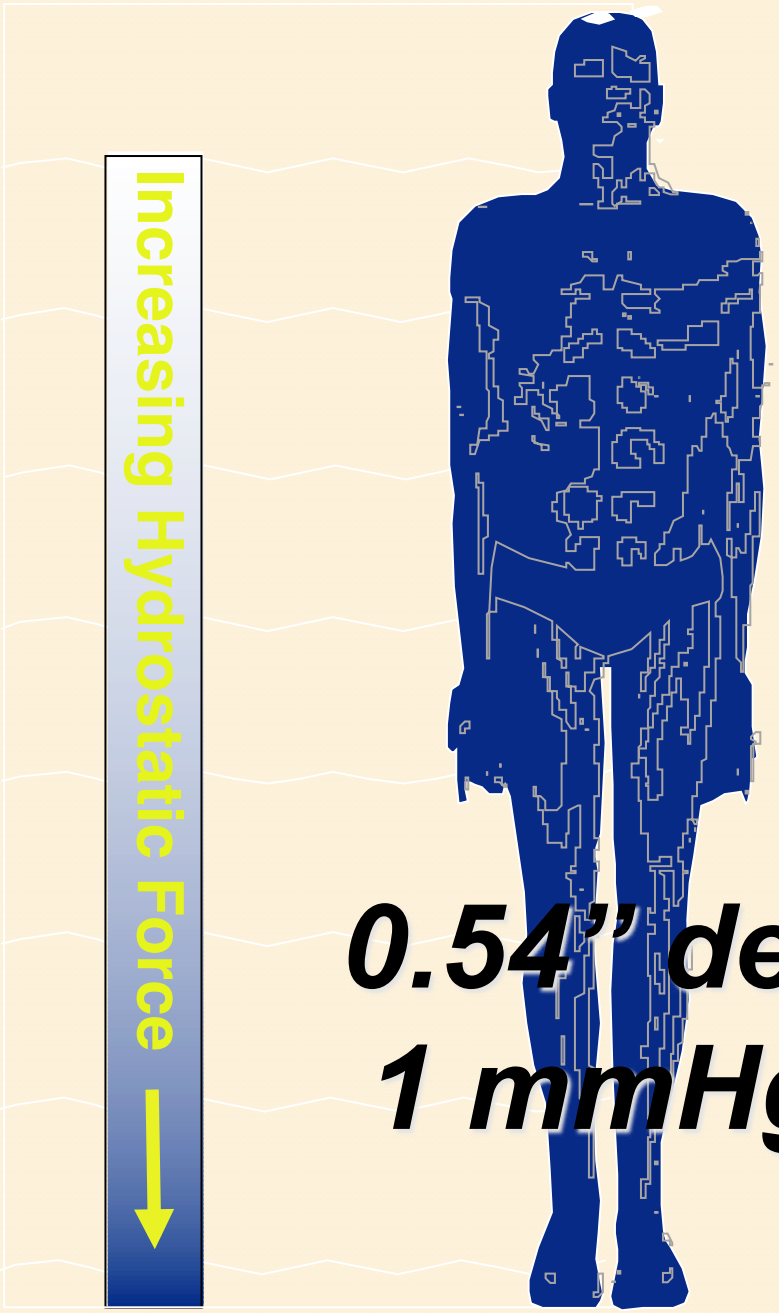
Aquatic vs. Land Activity

- Buoyancy creates unique opportunities
- Multidimensional movement is easy
- Viscosity adds graded resistance
- Immersion is usually pleasurable
- Relaxation is nearly automatic for most
- The water has its own healing properties with unique physiologic effects



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Pressure Increases

Neck depth = negligible

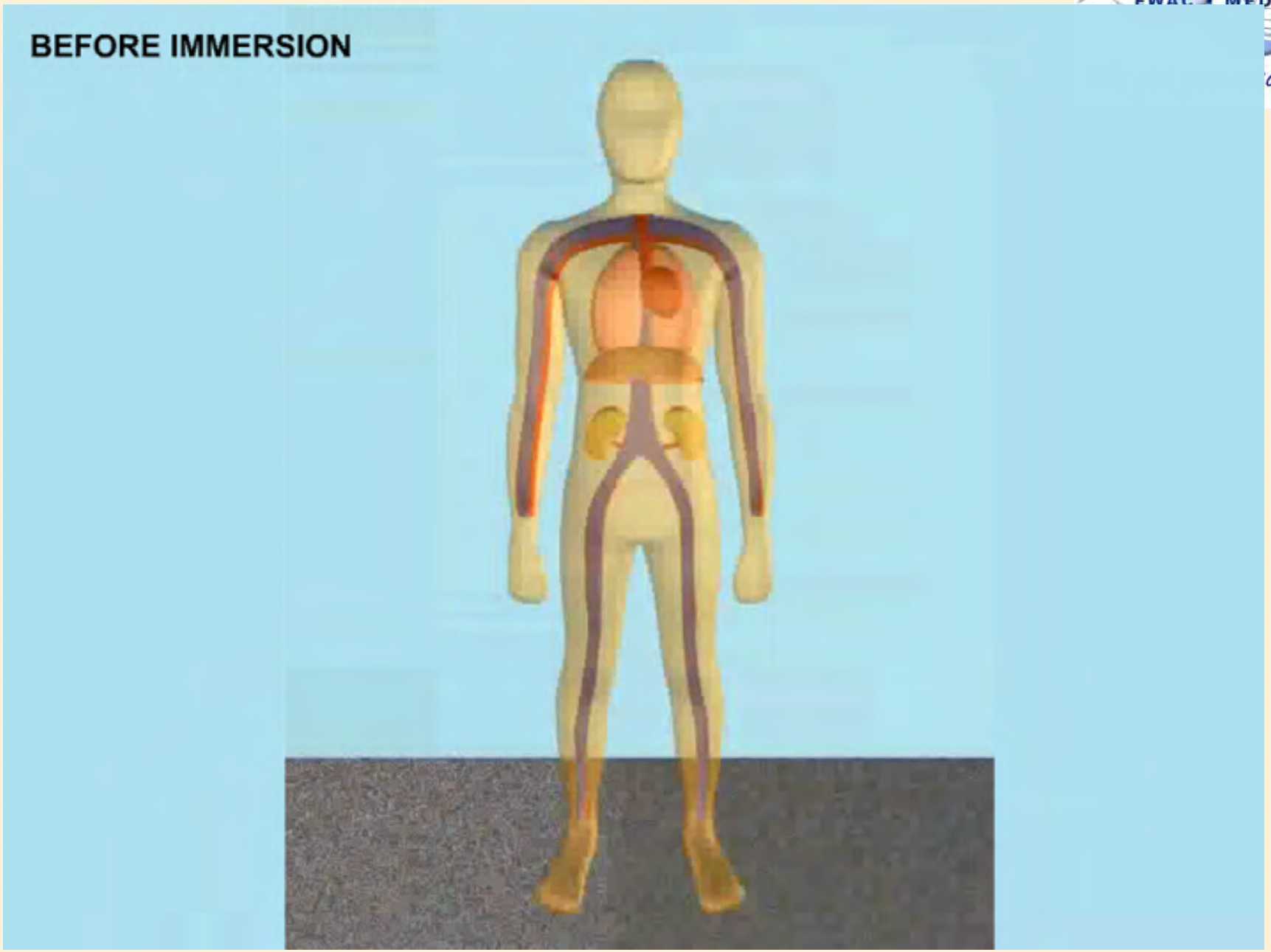
Chest depth = ± 18 mmHg

Waist depth = ± 36 mmHg

Thigh depth = ±70 mmHg

0.54" depth equals 1 mmHg pressure

Ankle depth = ±110 mmHg


BEFORE IMMERSION

Cardiovascular Changes with Immersion

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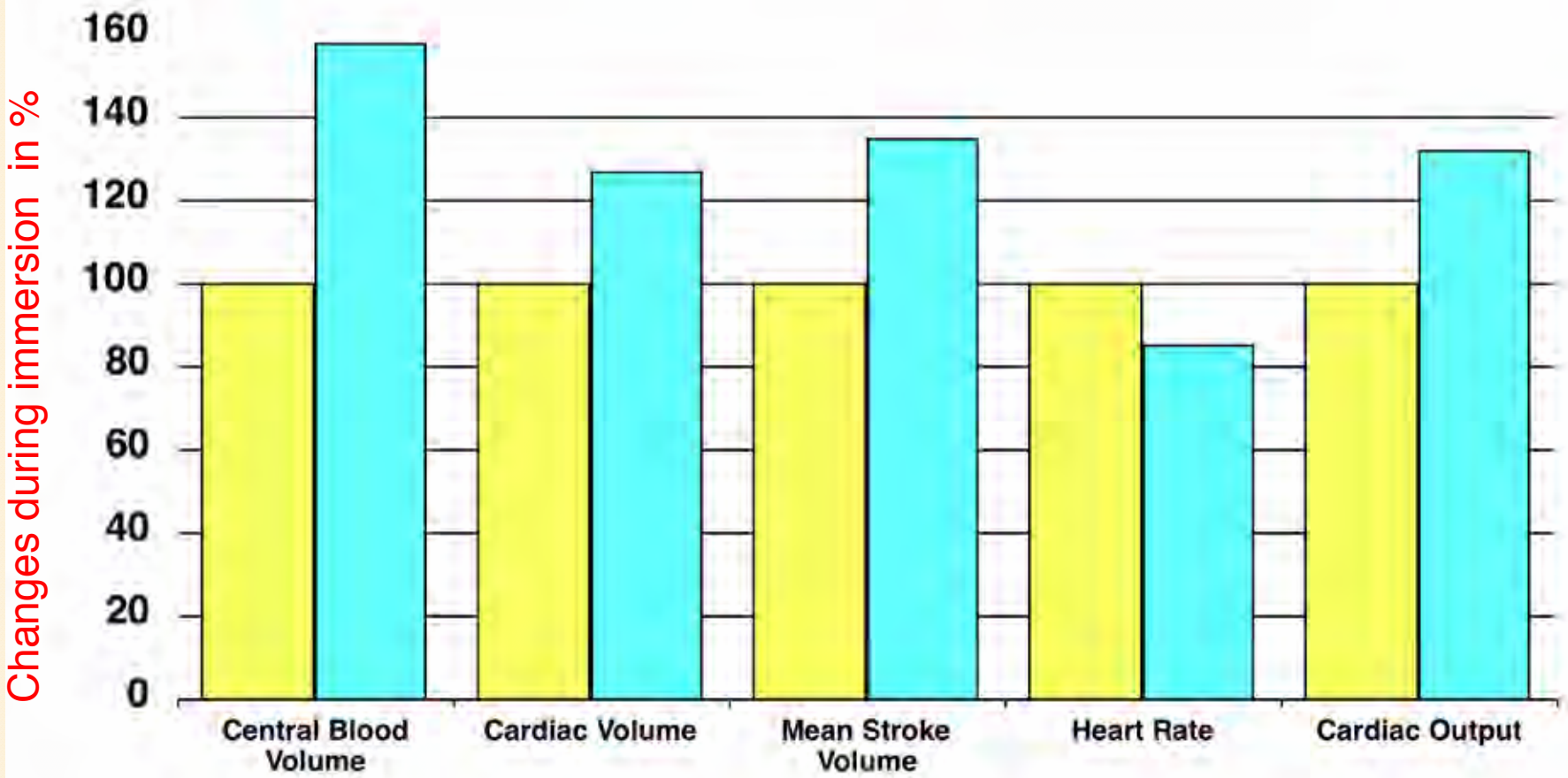
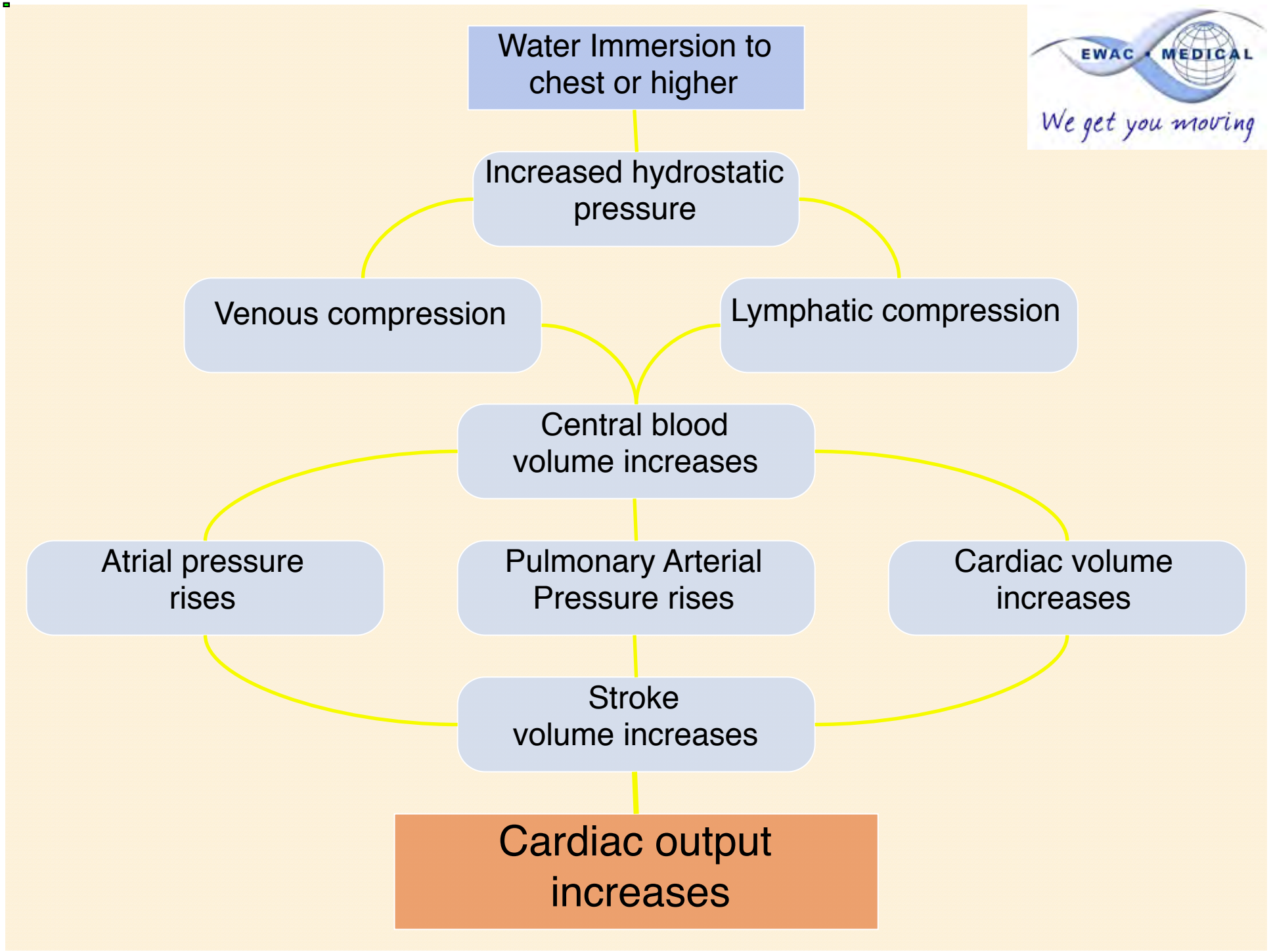
Thermoneutral water temperature, neck depth



Arborelius, Aerospace Med 43:701-707, 1978; Risch, Pflugers Arch, 374:119-120, 1978


Water Immersion to chest or higher
Increased hydrostatic pressure
Venous compression
Lymphatic compression
Central blood volume increases
Atrial pressure rises
Pulmonary Arterial Pressure rises
Cardiac volume increases
Stroke volume increases
Cardiac output increases
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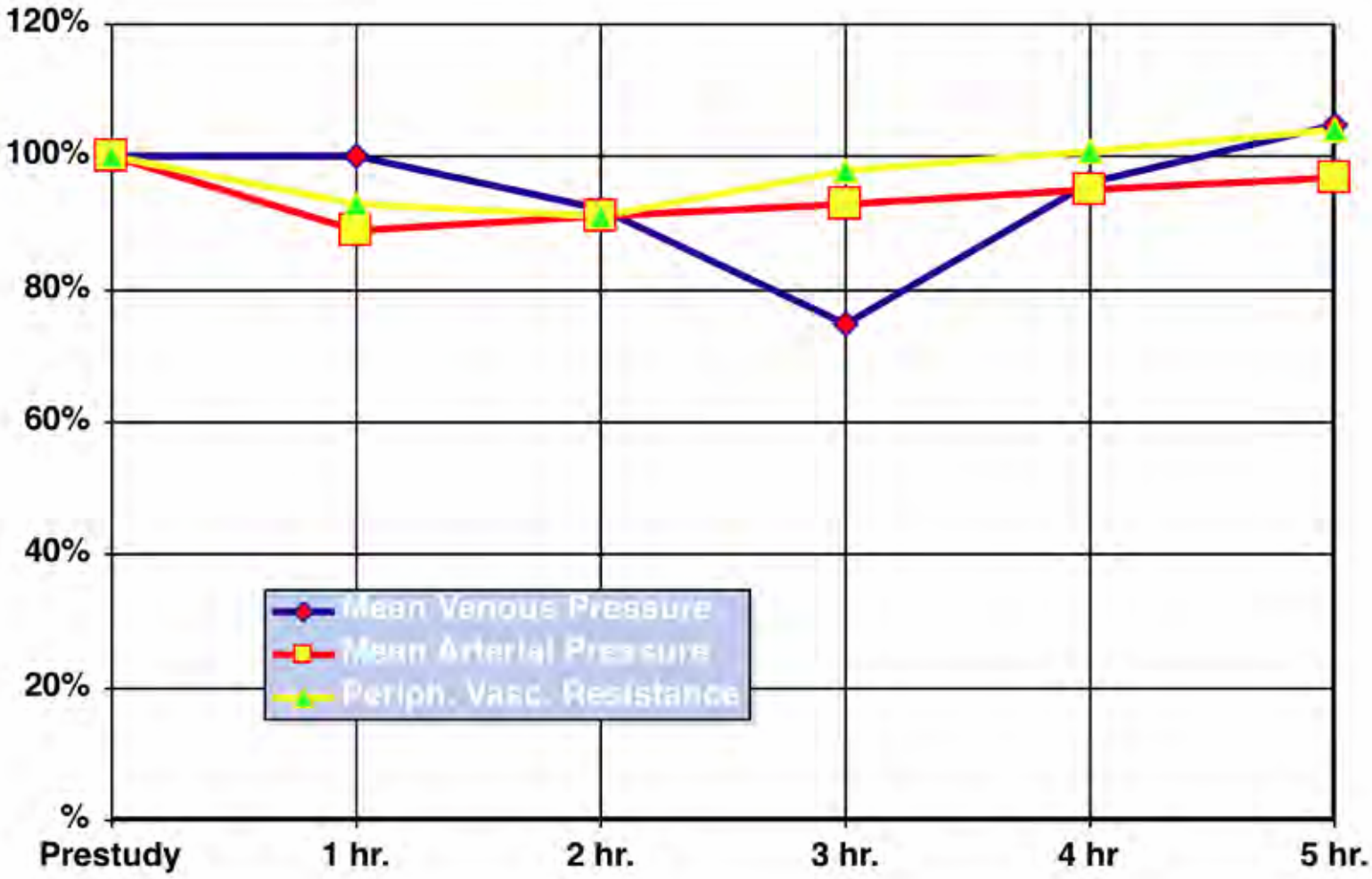
Vascular Pressures with Immersion

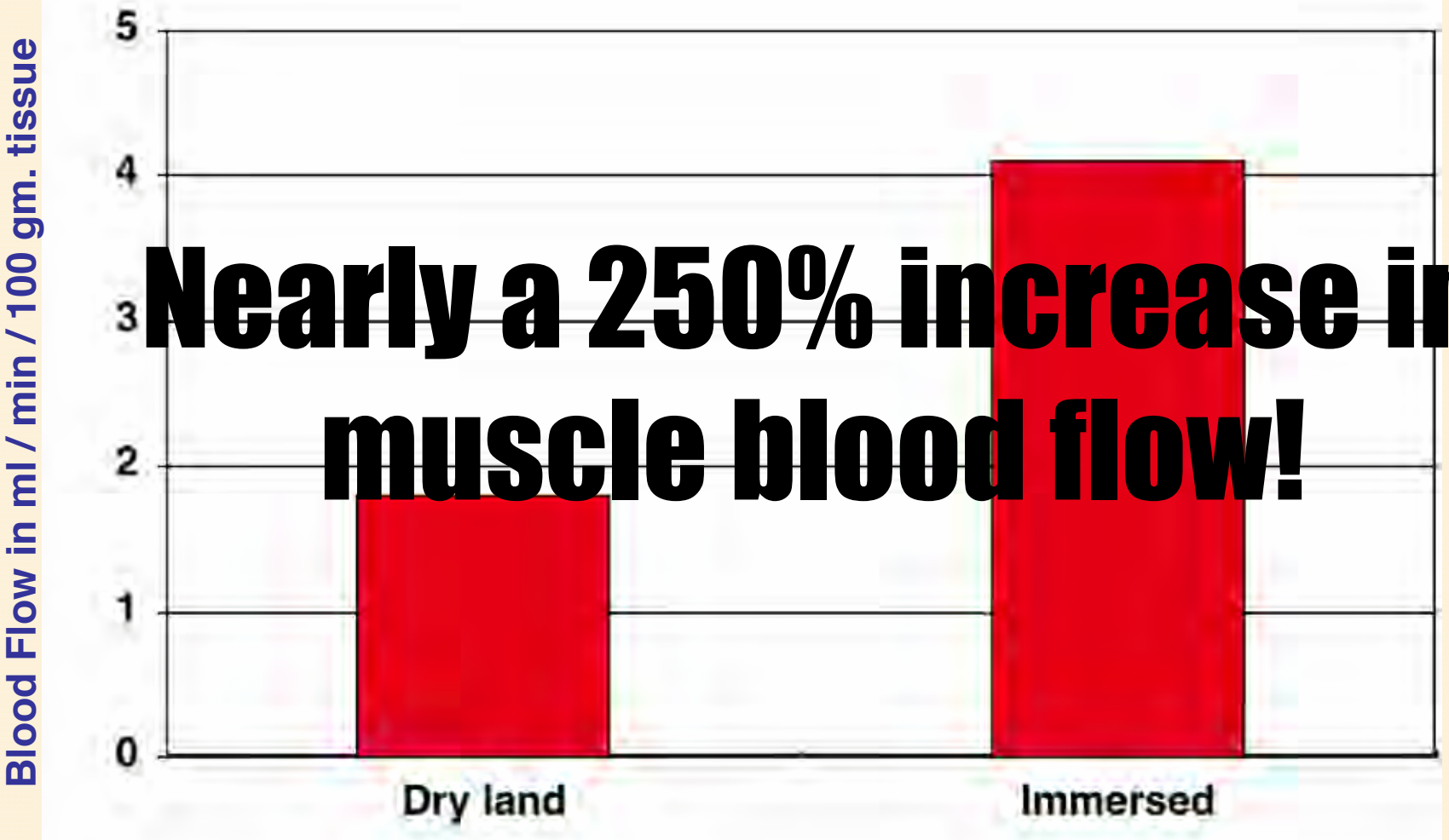
Thermoneutral temperature



Epstein, Circ Res 39:619-628, 1976

Muscle Blood Flow with Immersion

Thermoneutral temperature, neck depth, seated

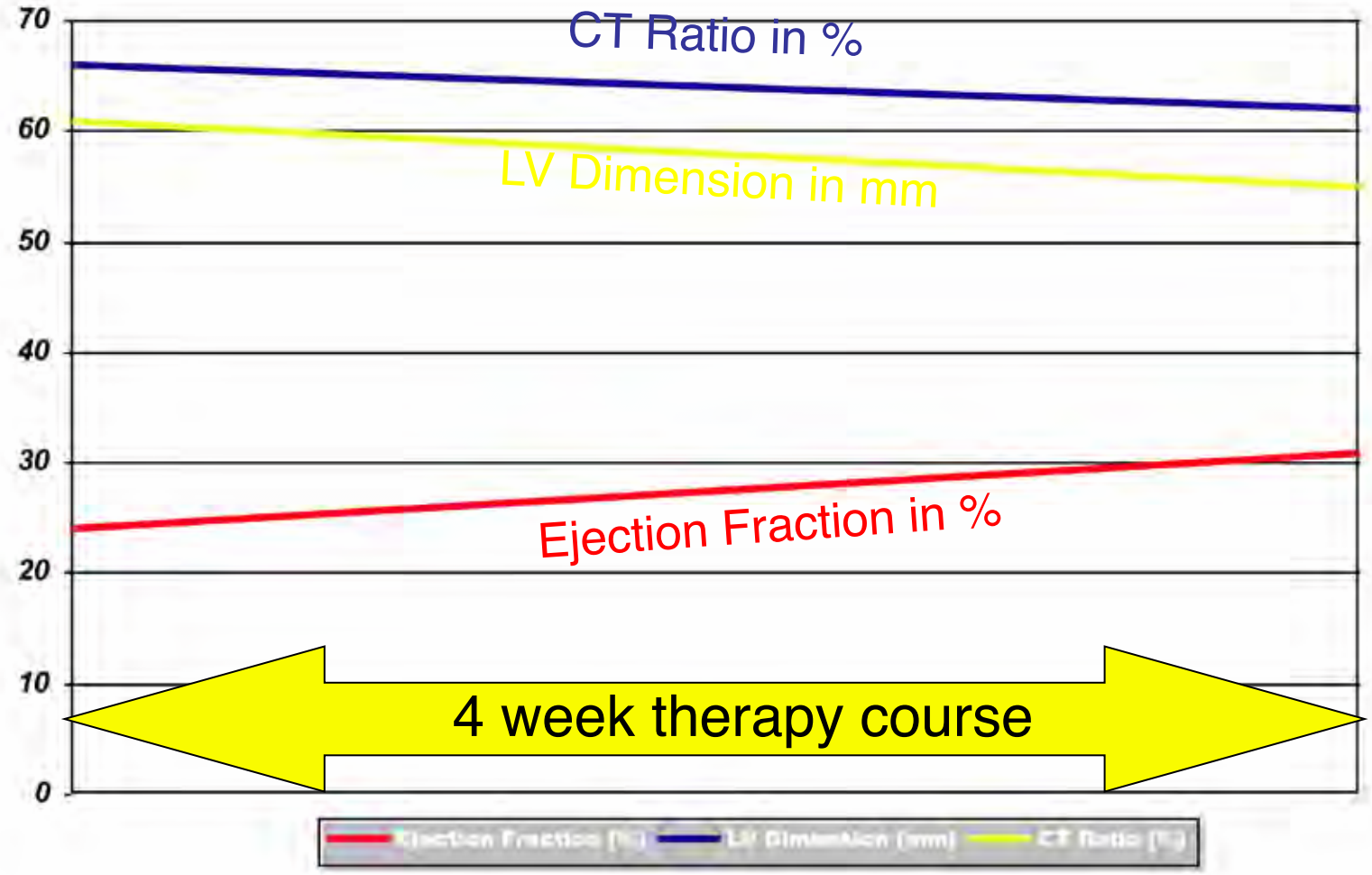


Nearly a 250% increase in muscle blood flow!

Balldin, Aerospace Med 42:489-493, 1971

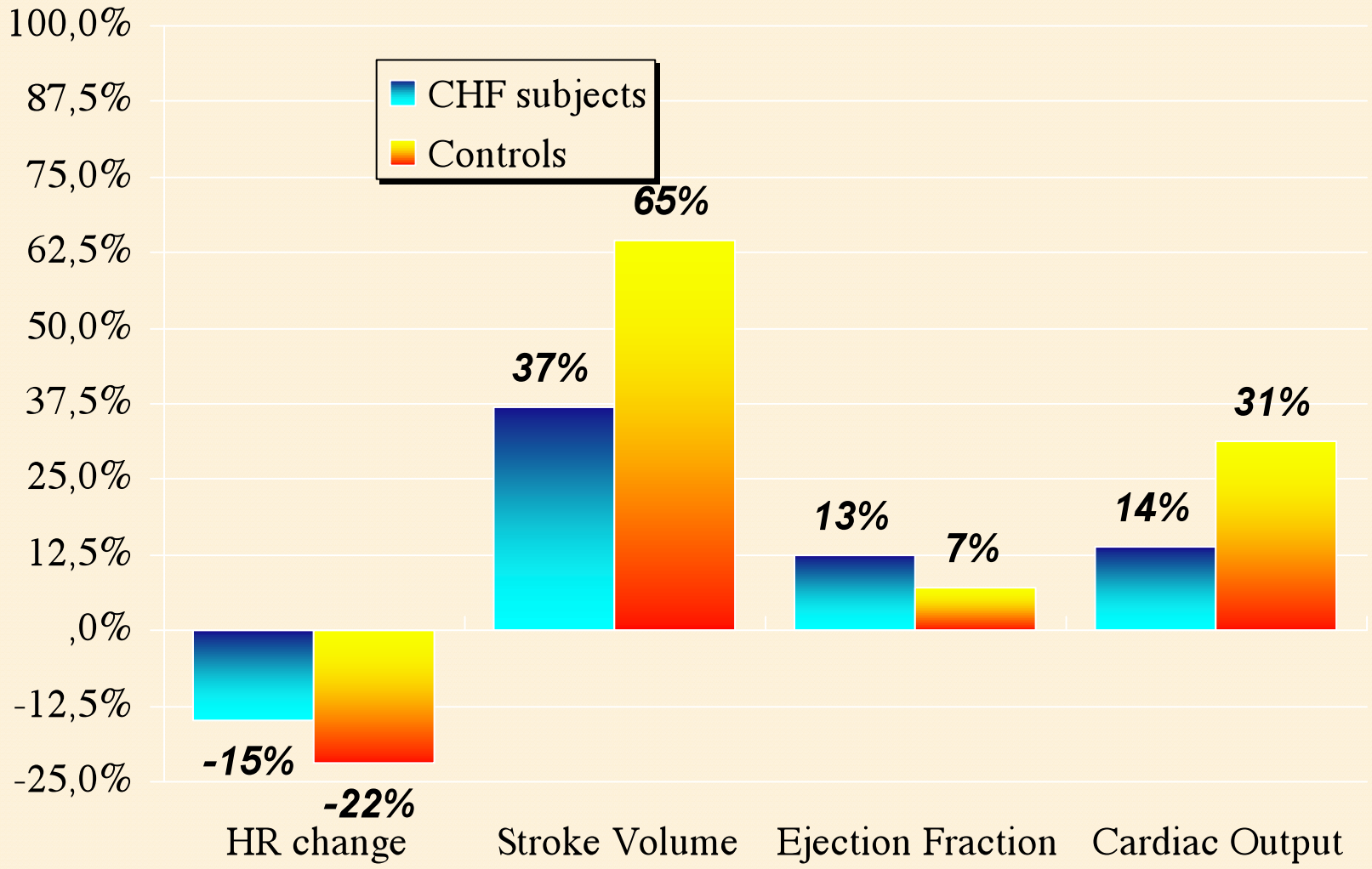
Aquatic Therapy Effects on CHF

Neck depth immersion at 41° C (105.8° F)



Tei & Tanaka, J Cardiol 1996:27:29-30

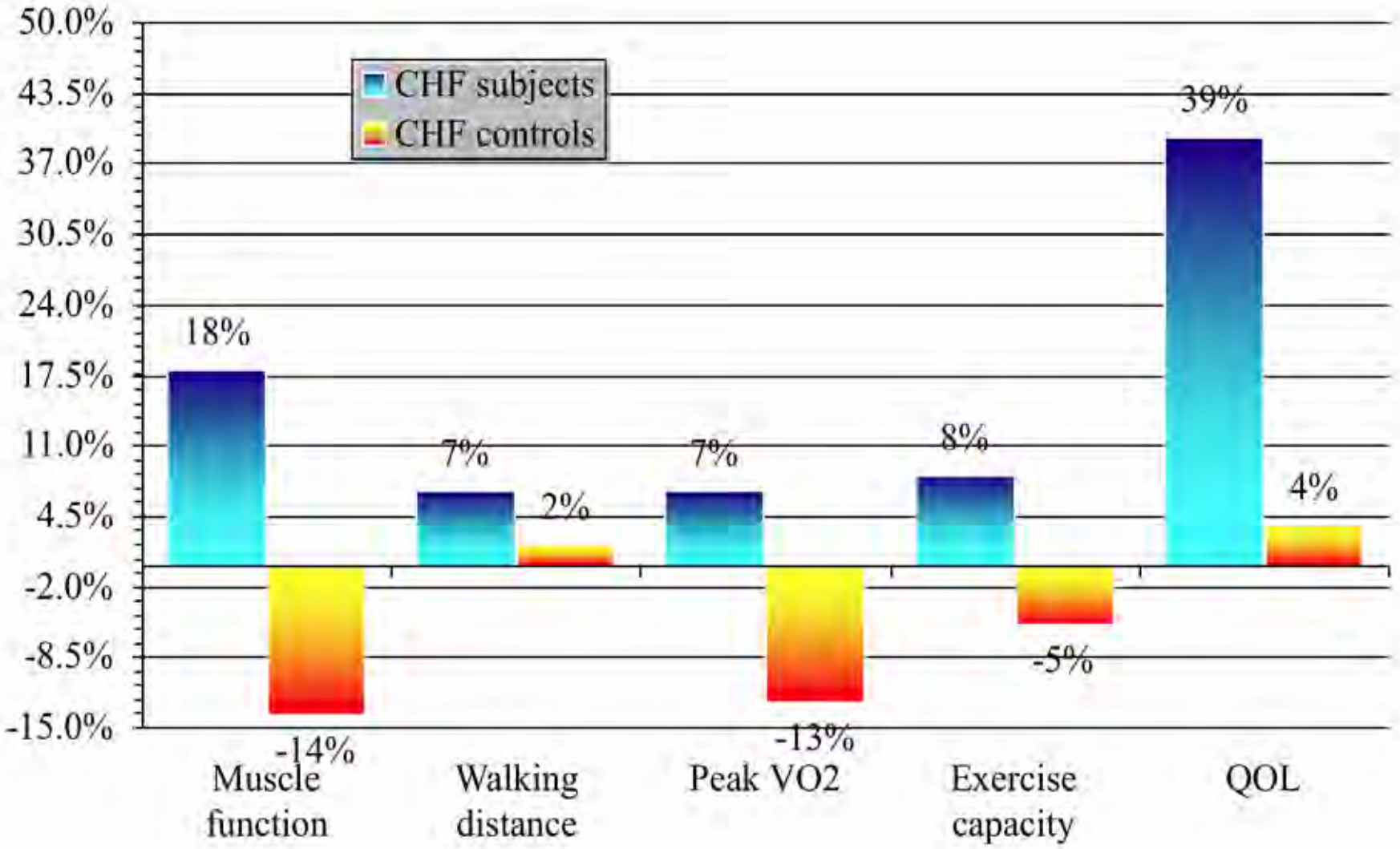
Warm Water Immersion in CHF



Cider A, Svealv BG, Tang MS, Eur J Heart Failure, 8:3, 308-313, 2006

Aquatic Exercise in CHF

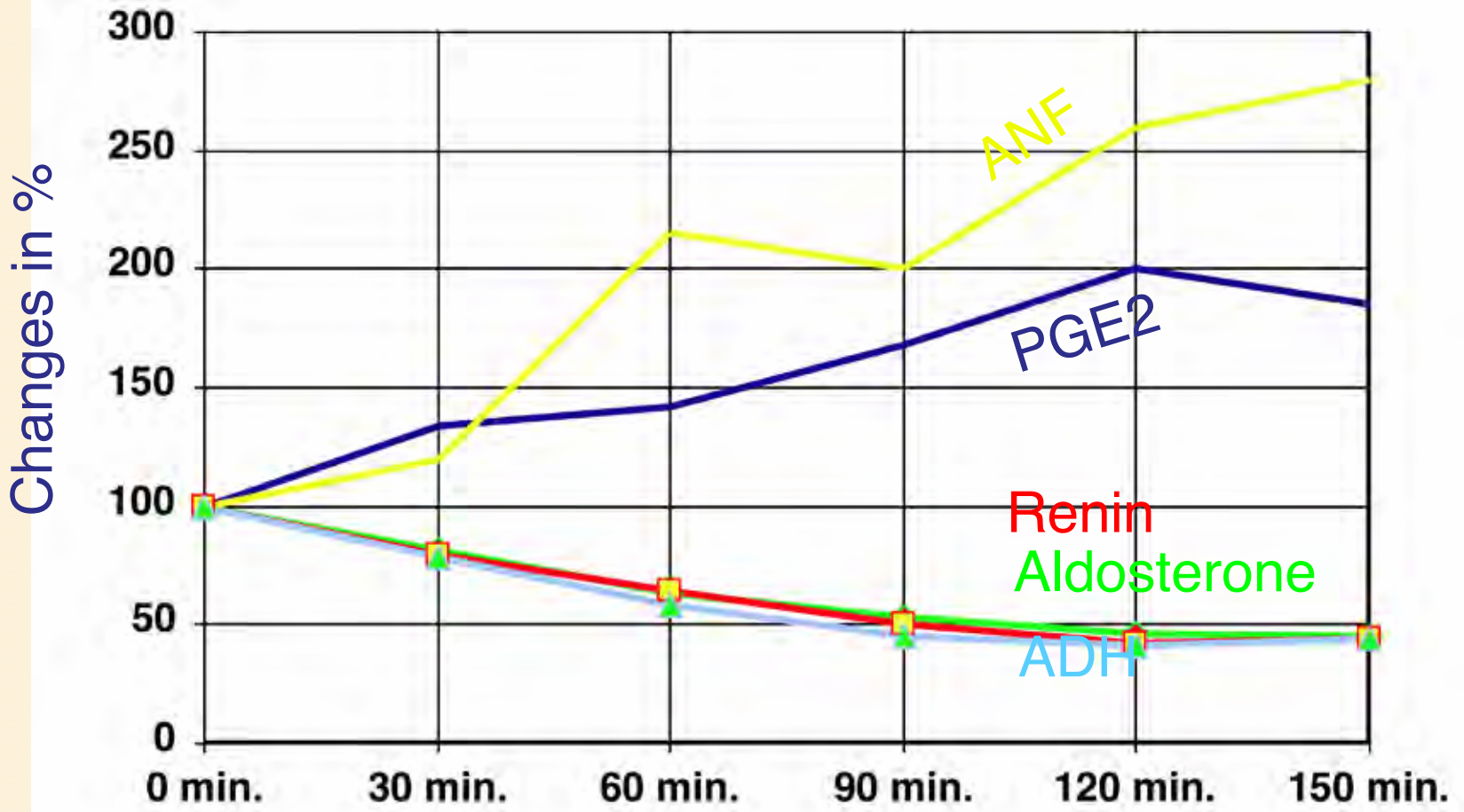
25 pts with CHF, 8 weeks training at 3 times per week



Cider A, Schaufelberger M, Sunnerhagen KS, Andersson B, Eu J Heart Failure 5 (2003) 527-535

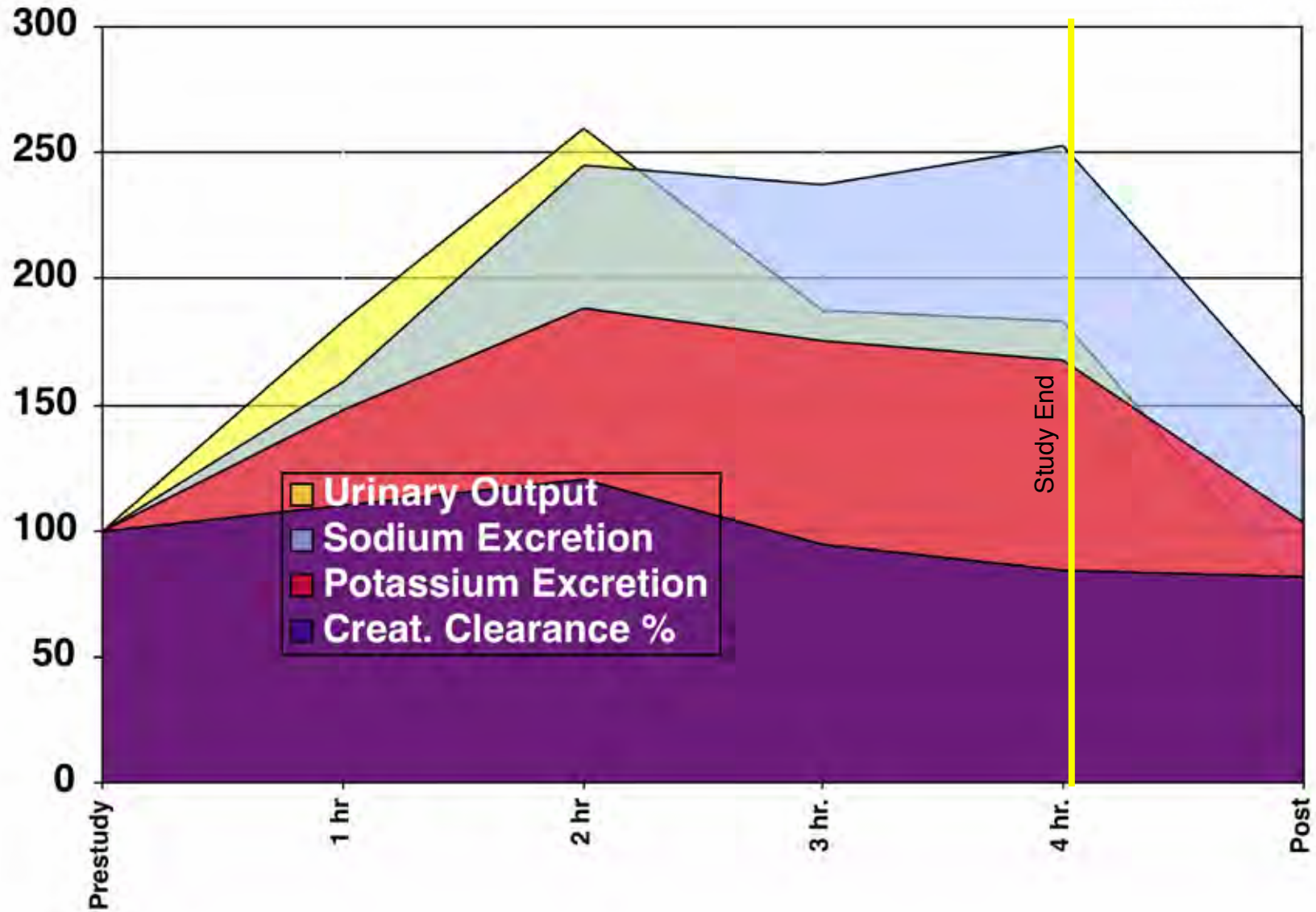
Renal Hormone Changes with Immersion

Thermoneutral temperature



Epstein, Murray; Renal effects of head out immersion in humans: a 15-year update; Physiological Reviews. 1992

Renal Function Changes with Immersion



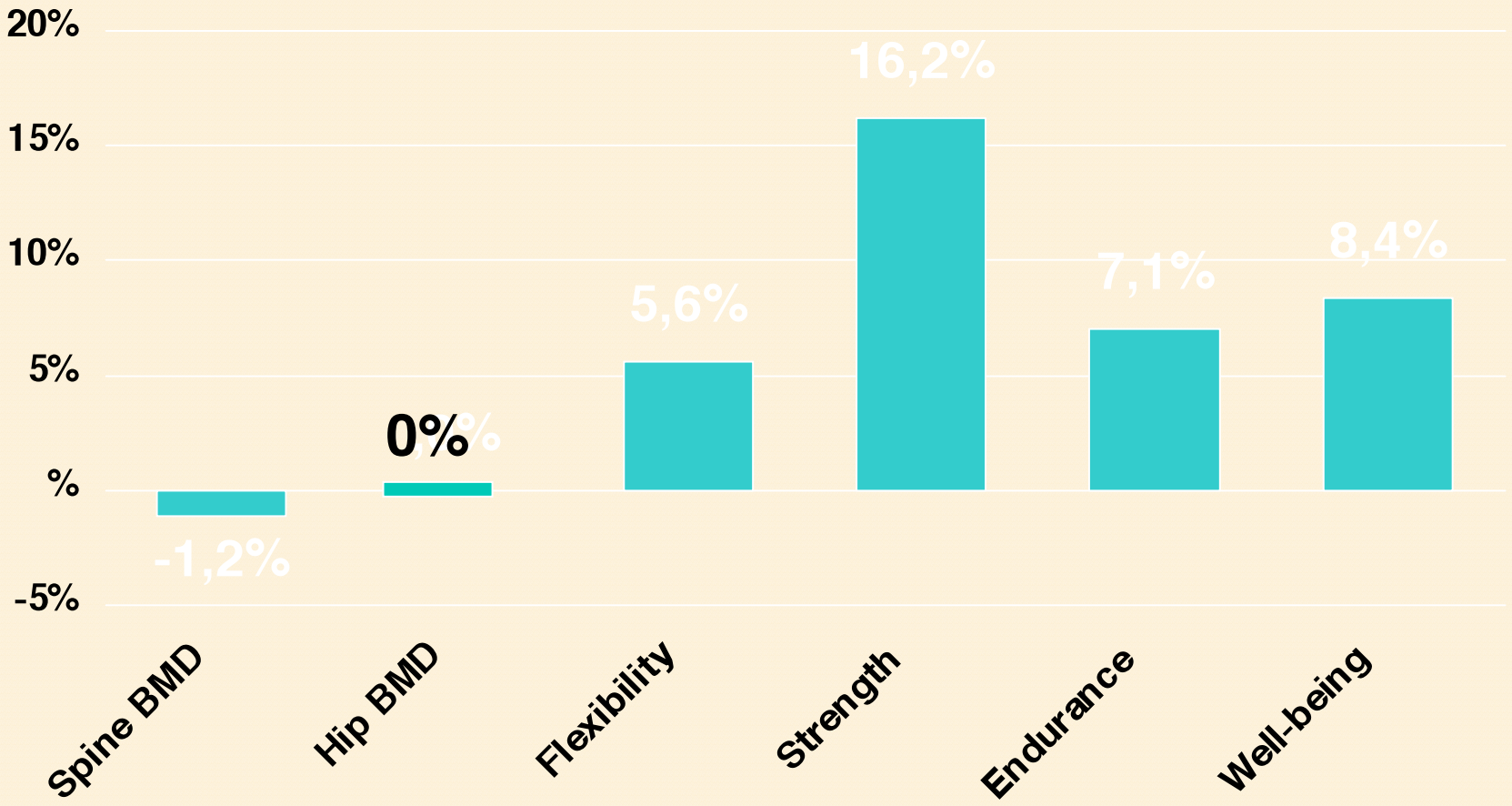
Epstein, Physiol Rev 72:577, 1992

Aquatics & Bone Density

- In older male Masters swimmers, increased bone density has been found.
- In older female Masters swimmers, no effect has been noted.
- In younger individuals, swimming did not add bone mineral content as effectively as weight-bearing exercise.

Aquarobic Effect on BMD, Fitness & Well-being @1 year

77 females, ages 50-70, 1 hour/day, 3 days per week, 12 months



Bravo, Gauthier et al, Arch PMR, 78, 1375-80,1997

Osteoporosis and Aquatic Therapy

- The aquatic environment is a very appropriate place to begin a strengthening and endurance program
- The pool will probably not provide a major bone-deposition stimulus, or reverse loss of bone mineralization
- Transitioning to land-based impact activities is the goal for osteoporosis

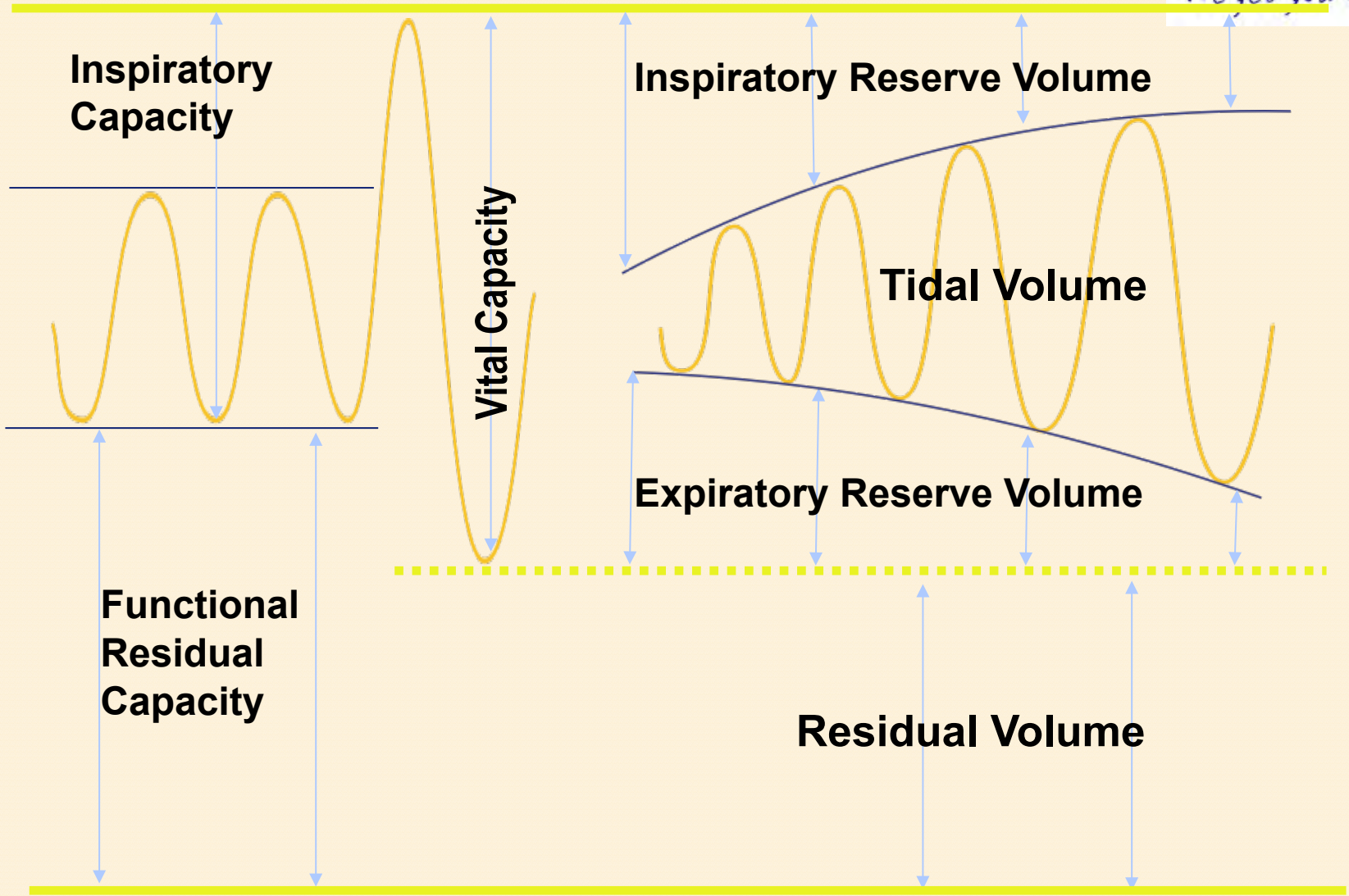
Respiratory Motor System:

- Neck muscles, incl. Scalenes, SCM
- Diaphragm
- Intercostal muscles
- Abdominal muscles

Impairment seen in:

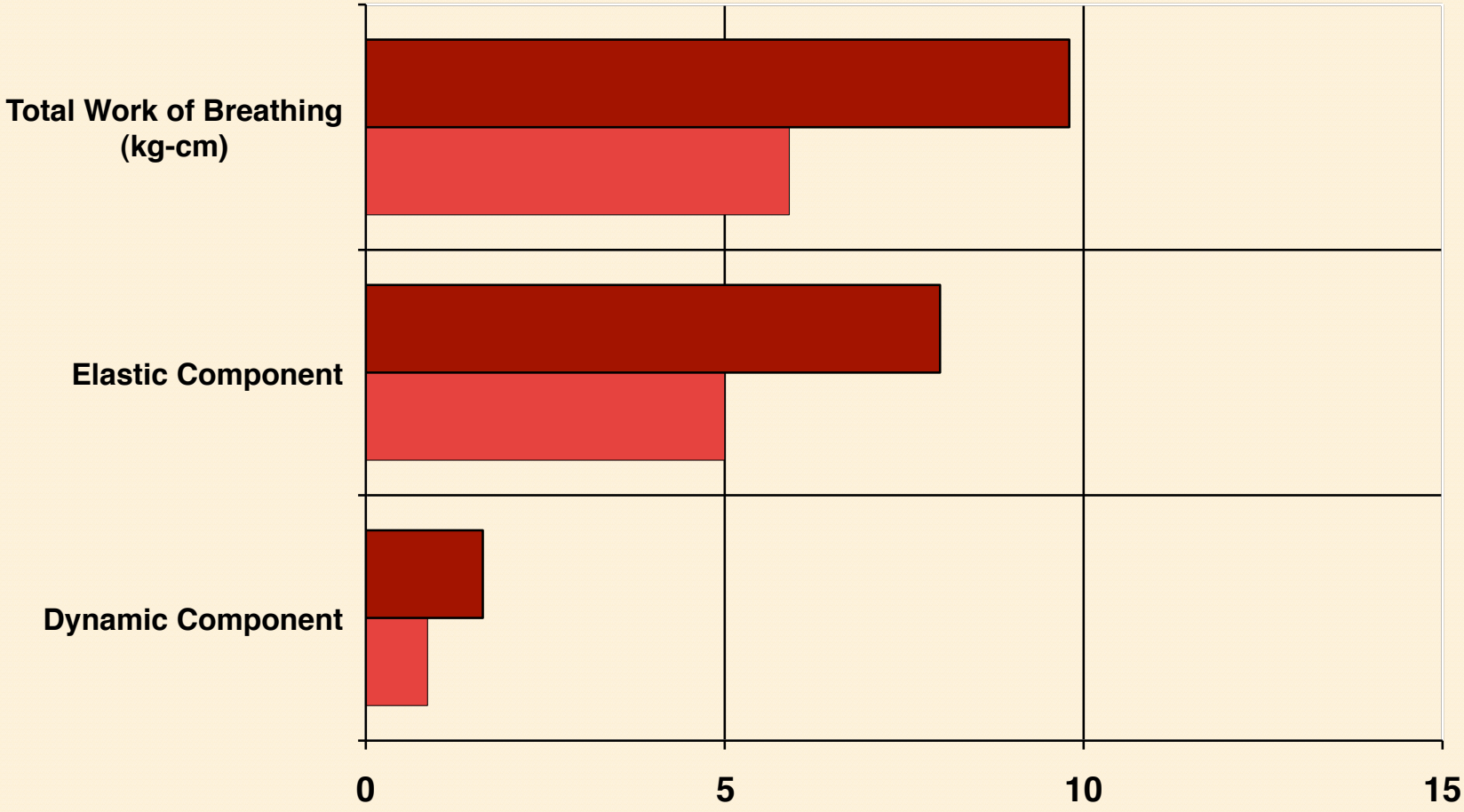
- Congestive Heart Failure
- Neuromuscular Disease
- Malnutrition & General Debilitation

Pulmonary Function Divisions



Energy Costs of Immersed Breathing

Neck depth immersion at thermoneutral temperature



Work in Kg/cm.

Hong, J Appl Physiol 27:535-538, 1969

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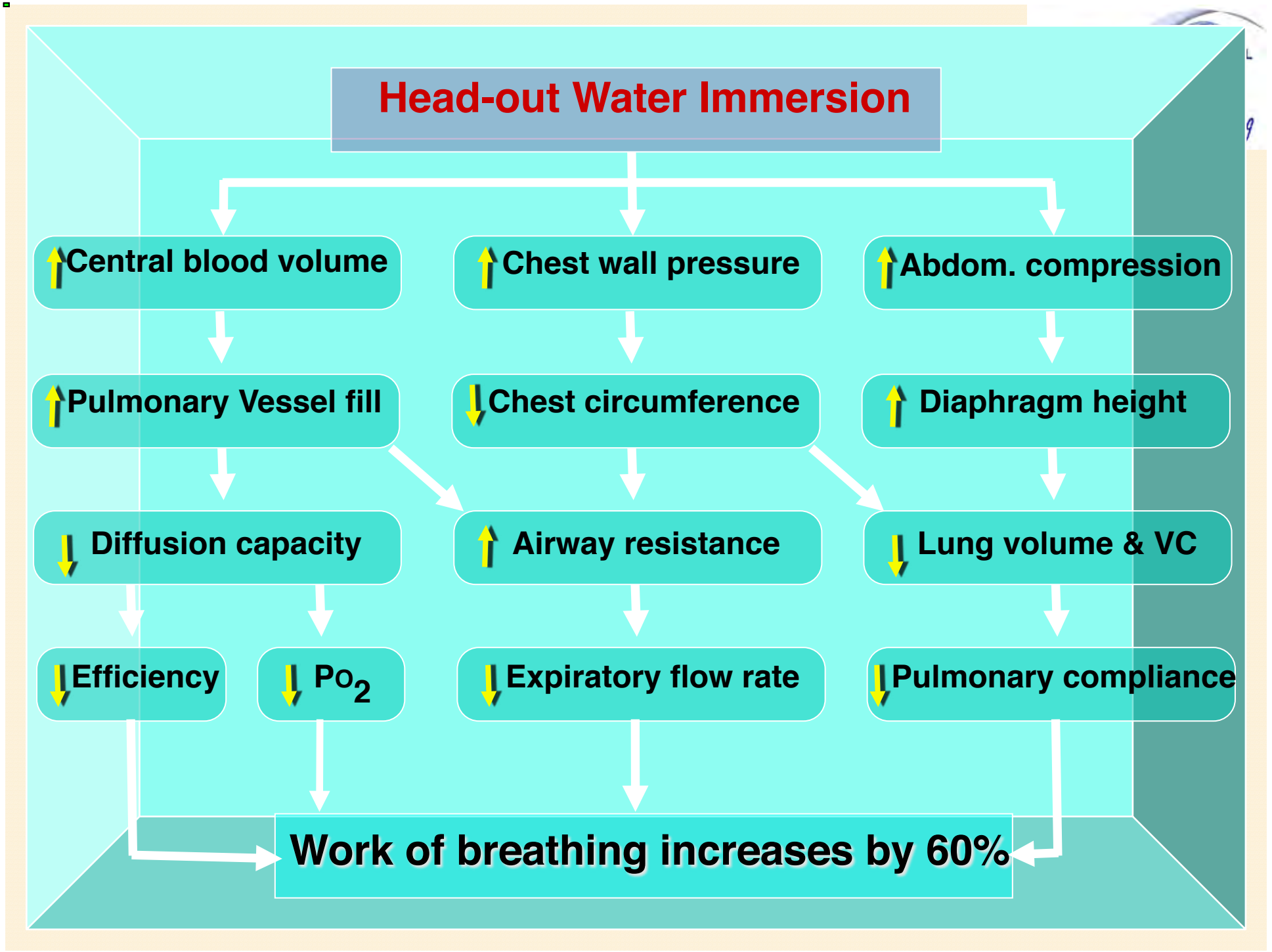
Dramatic increase in work of breathing

Hydrostatic Pressure

Hydrostatic Pressure

Incr.
Intra-abd
Pressure

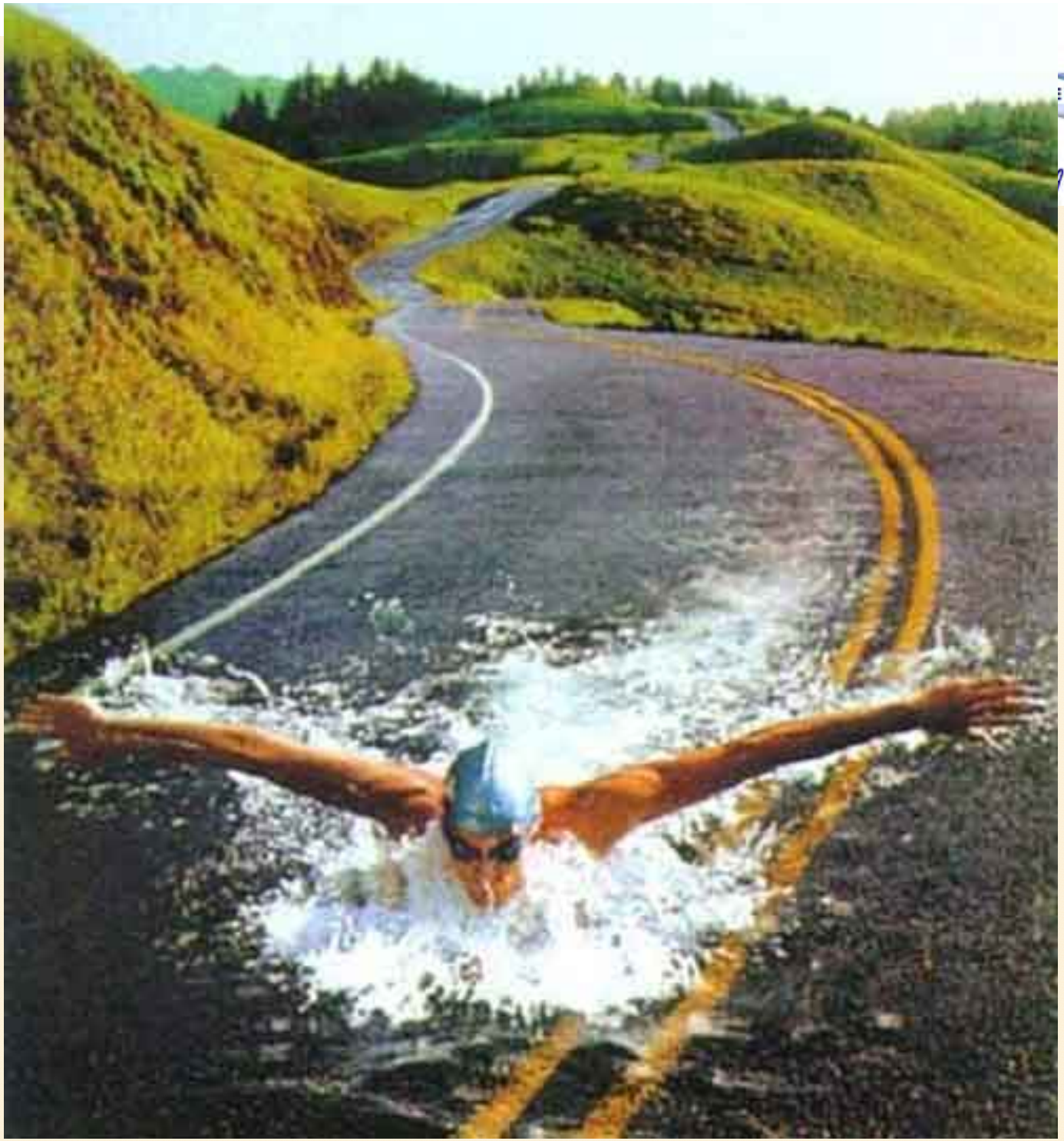

Head-out Water Immersion
Central blood volume
Chest wall pressure
Abdom. compression
Pulmonary Vessel fill
Chest circumference
Diaphragm height
Diffusion capacity
Airway resistance
Lung volume & VC
Efficiency
Po_2
Expiratory flow rate
Pulmonary compliance
Work of breathing increases by 60%

Inspiratory Muscle Training

6 weeks of daily training

- Attenuates blood lactate formation
- Improves exercise recovery time in repetitive sprint activity
- Improves perceptual response to exertion
- Improves time trial performance, especially in longer events (4 to 5%)

Romer et al, Int j sports Med 23(5) 2002, MSSE 34(5) 2002



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NSPF / WSU Respiratory Study

- 100 college students, 50 per group
  - Group 1: Deep water exercise, 50 minutes/ session 3 times per week at RPE 15
  - Group 2: Land aerobics, 50 minutes / session 3 times per week at RPE 15
- Data points: prestudy, week 8 and week 15
  - PImax, PImax-VL curves, PFTs
  - % body fat via BodPod
  - Treadmill VO2 max

Exercise Programming

- Exercise sessions between groups were designed to be similar in all aspects
- Warm-up, aerobic exercise, and cool-down times were the same between groups
- Choreography was similar and in the same order between groups
- Instructor supervision, motivation and feedback was similar
- Students were instructed to maintain a desired RPE of 15. An RPE of 15 is considered “Hard”

Study Methods

Initial Assessment

- All subjects were tested first for resting heart rate and bp, then body fat percentage, followed by spirometry, and then finally maximal oxygen consumption.
- There was no difference between groups on testing times.
- Subjects self selected their testing time for peak performance.

Lung Measurements Assessed

- Peak inspiratory pressure (PI_{max})
- Peak expiratory pressure (PE_{max})
- Mean airway pressure (MAP)
- Mean inspiratory pressure (MIP)
- Tidal volume (V_t)
- Forced vital capacity (FVC)
- Maximal inspiratory flow (MIF)
- Maximal inspiratory minute volume (VI_{atph})
- Maximal expiratory minute volume (VE_{atph})
- Maximal expiratory flow (MEF)

Starting Group Comparisons

Variable	Water	Land
Age	22.34	21.04
Gender M/F	26/25	30/20
Active (≥3 days/wk)	68%	62%
% Body Fat	24.25	23.67
Weight (Kg)	79.85	77.12
BP_{sys}	122.8	123.33
BP_{dia}	67.82	69.43
HR_{rest}	90.43	88.78
$VO2_{max}$	42.17	42.96

Study Results between Groups

Variable	Water	Land	Significance
PI_{max}	183.39	185.73	p=0.522
PE_{max}	194.83	193.2	p=0.658
MIP	15.08	15.68	p=0.802
V_t	2.73	2.67	p=0.686
FVC	3.04	2.90	p=0.468
MIF	89.46	88.14	p=0.802
MEF	401.87	396.31	p=0.812
MAP	14.71	14.21	p=0.604

Max Expiratory Vital Capacity (FVC)

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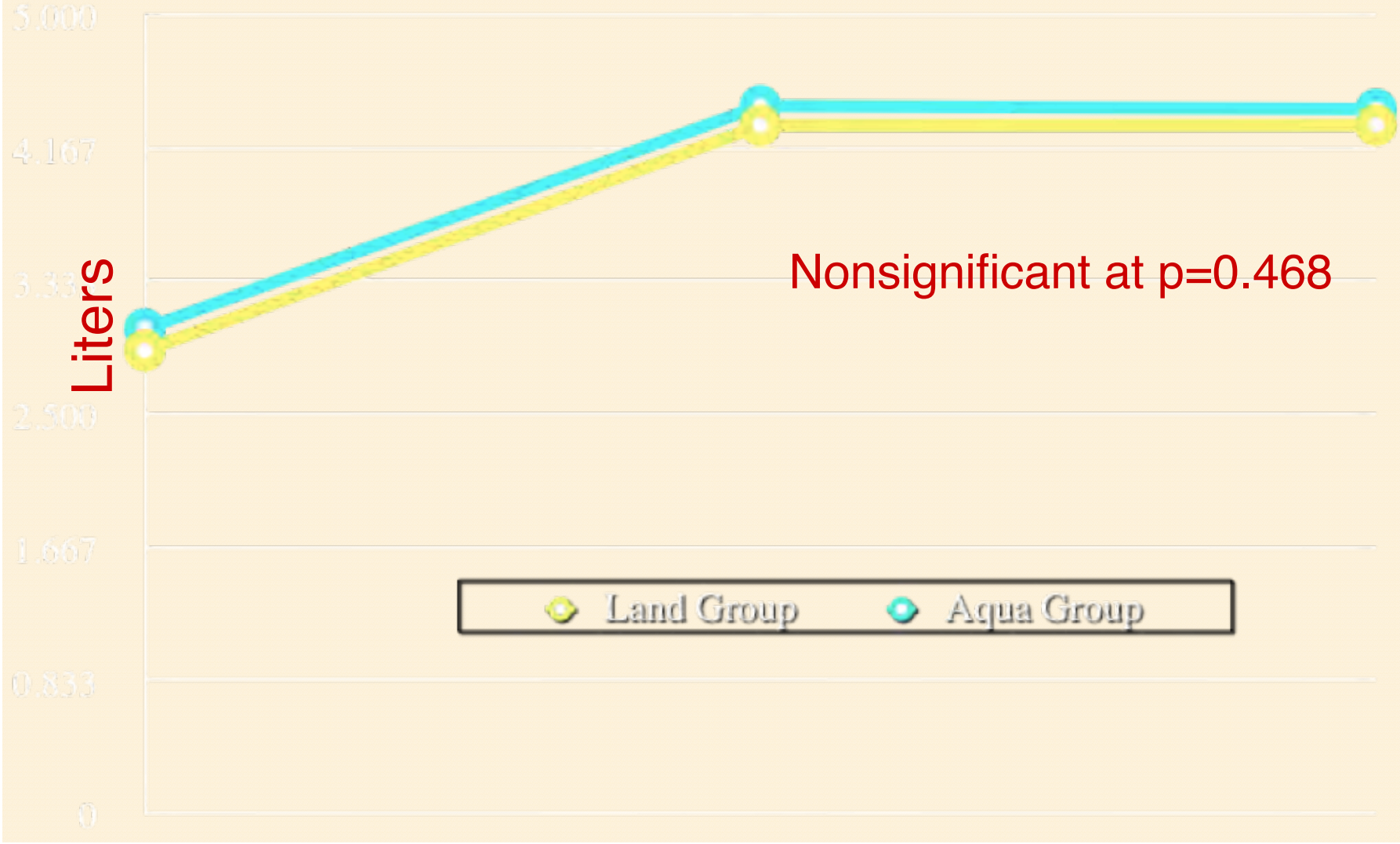
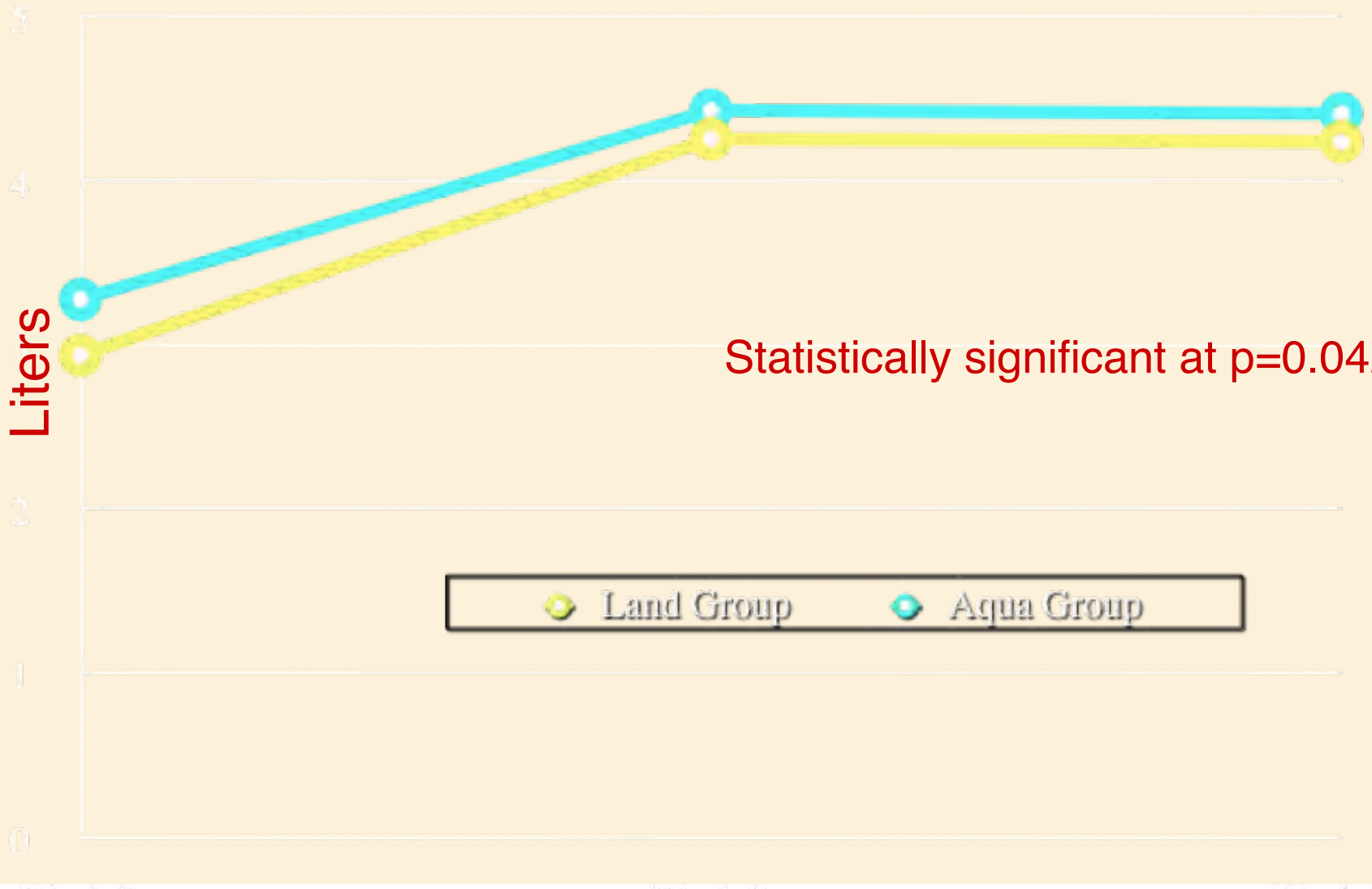
Changes between groups across study interval



Nonsignificant at p=0.468

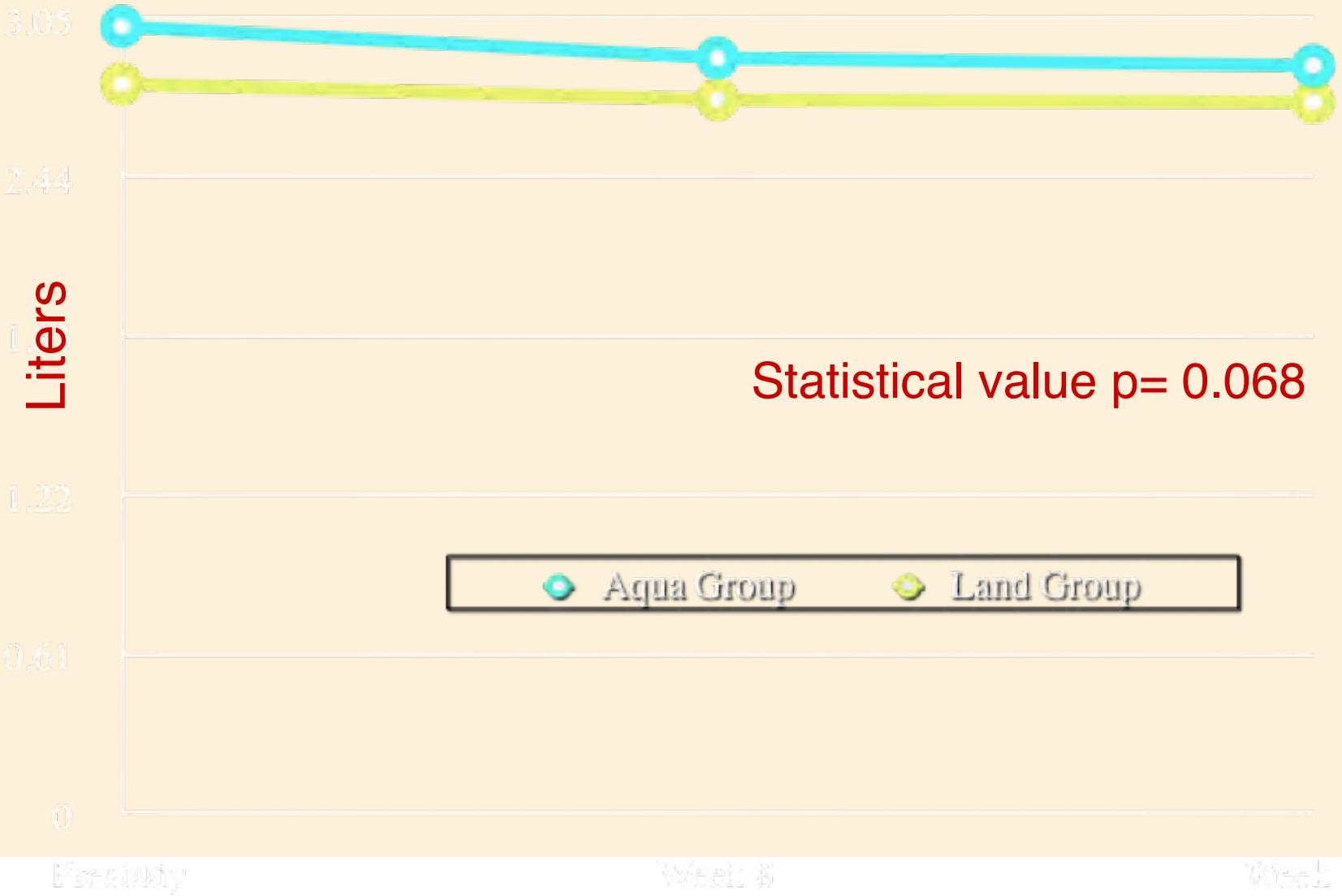
Max Inspiratory Vital Capacity (FIVC)

Changes between groups across study interval



Statistically significant at p=0.042

Tidal Volume at Max Exercise



Study Results: Both Groups

Variable	Week 0	Week 8	Week 15	Significance
Body Weight	77.16	75.1	75.41	0.0001
% Body Fat	24.16	22.47	23.18	0.0001
$VO2_{max}$	42.03	46.2	45.82	0.0001
Vt	1.3	1.26	1.05	0.0001
FVC	2.97	4.38	4.36	0.0001
FIVC	3.11	4.34	4.32	0.0001
PEF	194.11**	503.53	511.37	0.0001
MIF				
VI_{atps}	88.81	93.82	90.29	0.0001
VE_{atps}	108.75	117.16	110.71	0.0001
MEF				

Preliminary Study Results

- The aquatic group showed improvement in ventilatory capacity (FIVC) and respiratory endurance ($MVV_{12\ sec}$) compared to the land group.
- Both groups showed statistically significant improvements in:
  - Weight loss and lean body mass
  - % body fat
  - VO2max
  - Resting tidal volume
  - Peak expiratory flow pressures


The Cocoon Effect

Probable Causes

- Autonomic Nervous System downregulation
  - Heart Rate Variability changes
  - Catacholamine changes
  - Blood Pressure changes
  - EEG changes
  - Muscle tone changes

The WSU Research Questions:

1. What are the effects, potential health benefits and risks of aquatic immersion at various temperatures?
2. What aquatic temperatures produce the maximum positive effects??
3. What is the time course of these changes?

Our Lab

- 3 Prodigy™ tubs, donated by Hot Spring Spas.
  - Cool tub maintained at 88° F (31.1°C)
  - Neutral maintained at 98° F (36.7°C)
  - Warm tub maintained at 102° F (38.9°C)
- CorTemp™ telemetry system
- BioPac™ monitoring system
  - ECG
  - Blood flow measurement through laser doppler
  - EEG
  - Core temperature
- Blood pressure monitoring
- Body fat percentage (BodPod™)

Study Methodology

- Subjects recruited, consent signed
- CoreTemp pill swallowed
- Subjects then connected to our research hardware
- Sat at tubside for 6 minutes, immersed in cool tub for 24 min, rest out for 12 minutes, neutral immersion for 24 min, rest out for 12 min, warm tub for 24 min, recovery for 12 min.

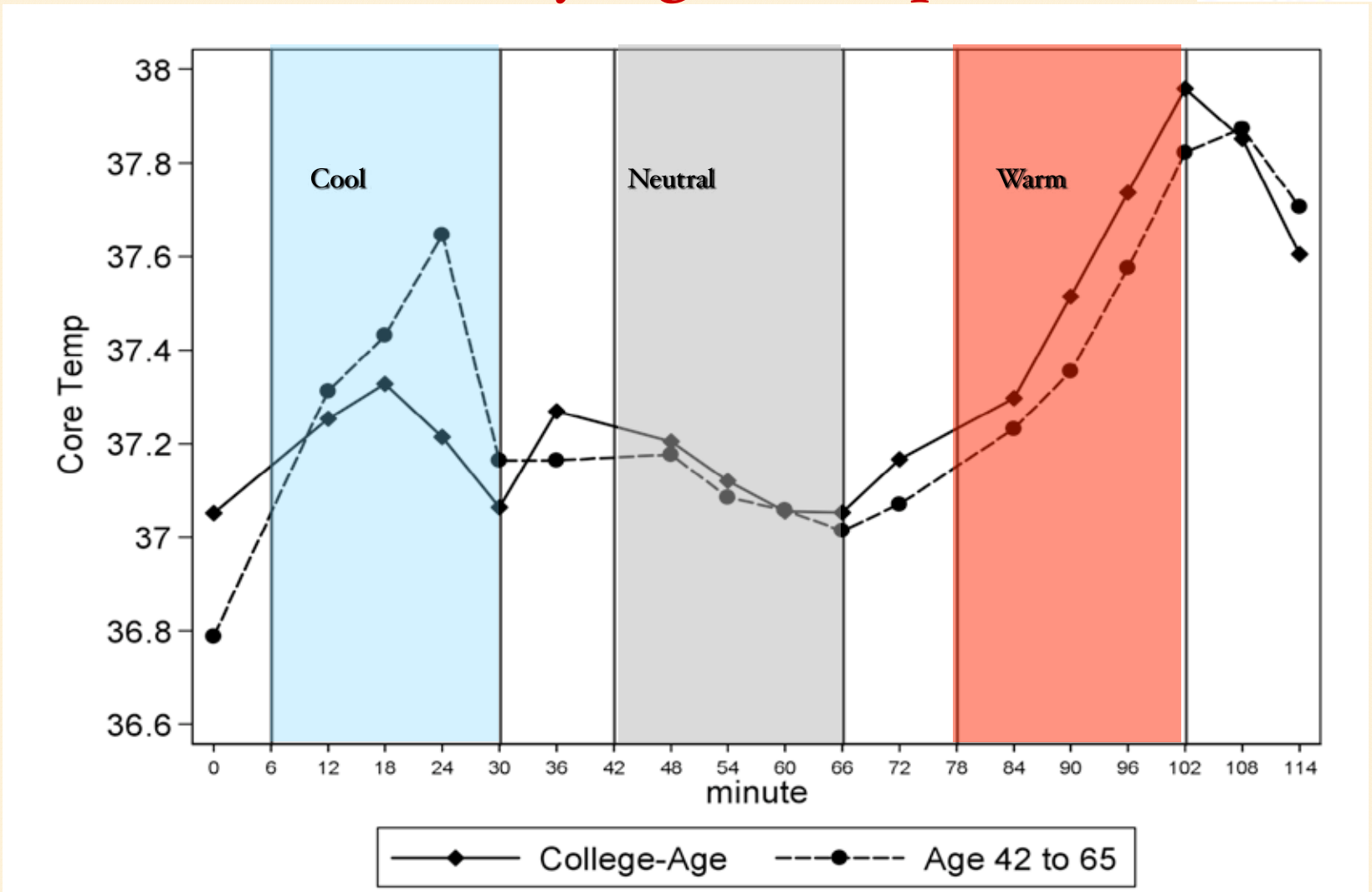
HRV & Health

- Autonomic imbalance has been suggested to be the final common pathway in many diseases
- Highly correlated with cardiovascular health
- Associated with diabetes, inflammatory processes, and immune dysfunction
- An increase in parasympathetic tone decreases release of inflammatory cytokines, & increased sympathetic tone increases them

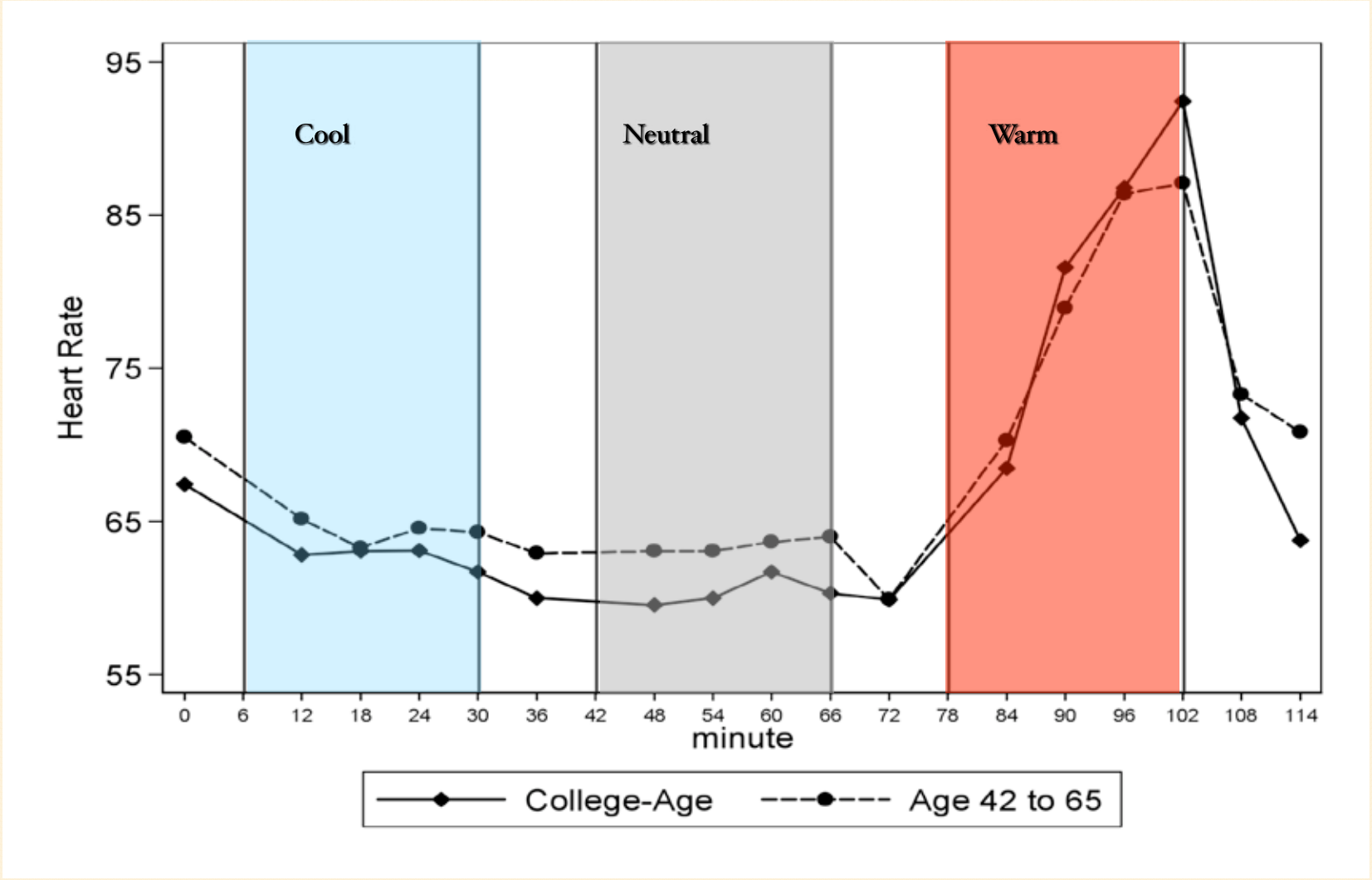
HRV Analysis

- Computerized breakdown into frequency spectra via fast Fourier Transformation:
  - Ultra-low frequency (<0.04 HZ) (respiratory)
  - Very low frequency (0.04HZ) (sympathetic activity)
  - Low frequency (0.04-0.15HZ)(sympathetic &GI)
  - High frequency (0.15-0.4HZ) (parasympathetic activity)
  - Sympathetic
  - Vagal (parasympathetic)
  - Sympathetic / Vagal balance

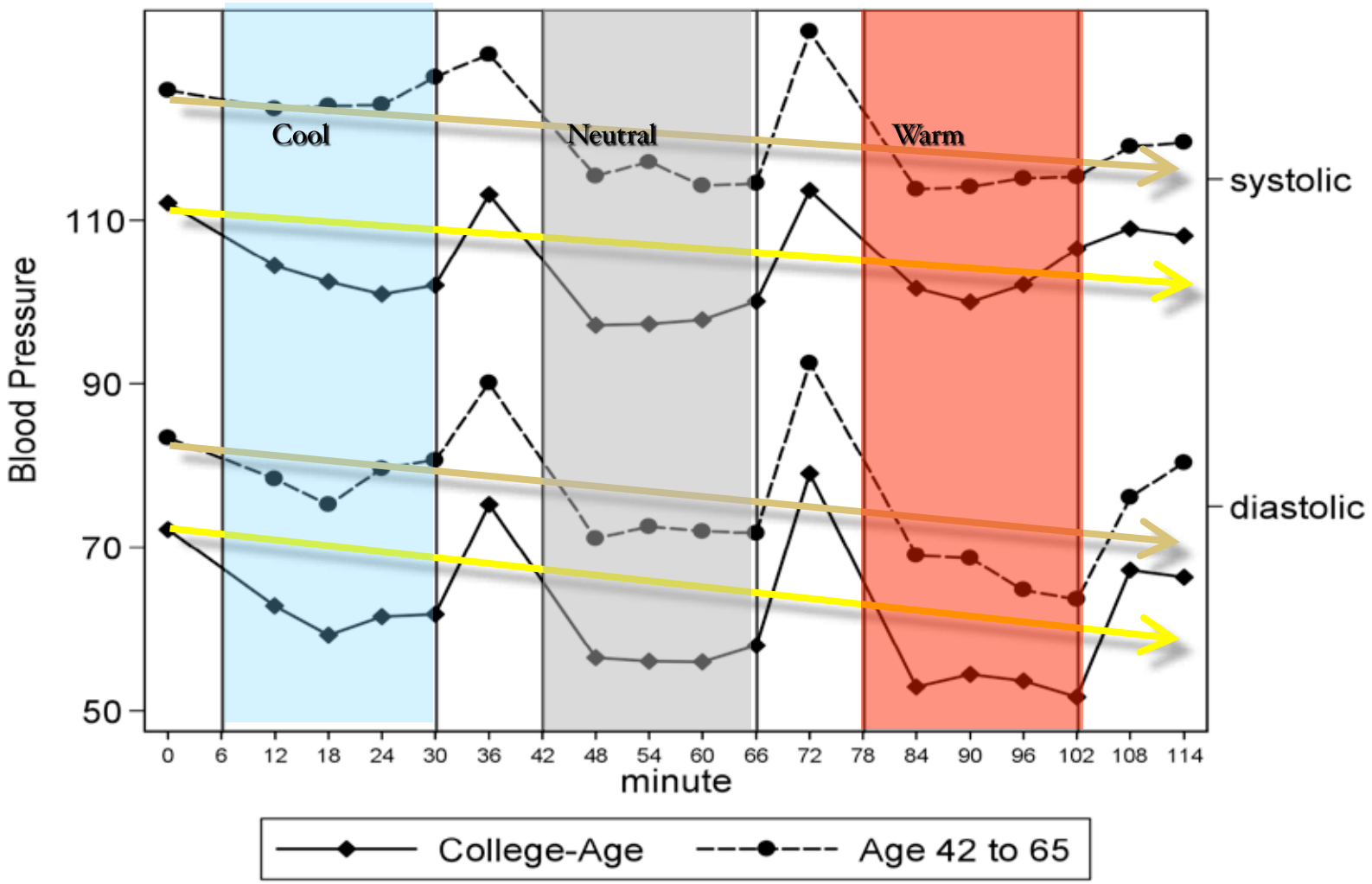
Core Temperature Response by Age Group



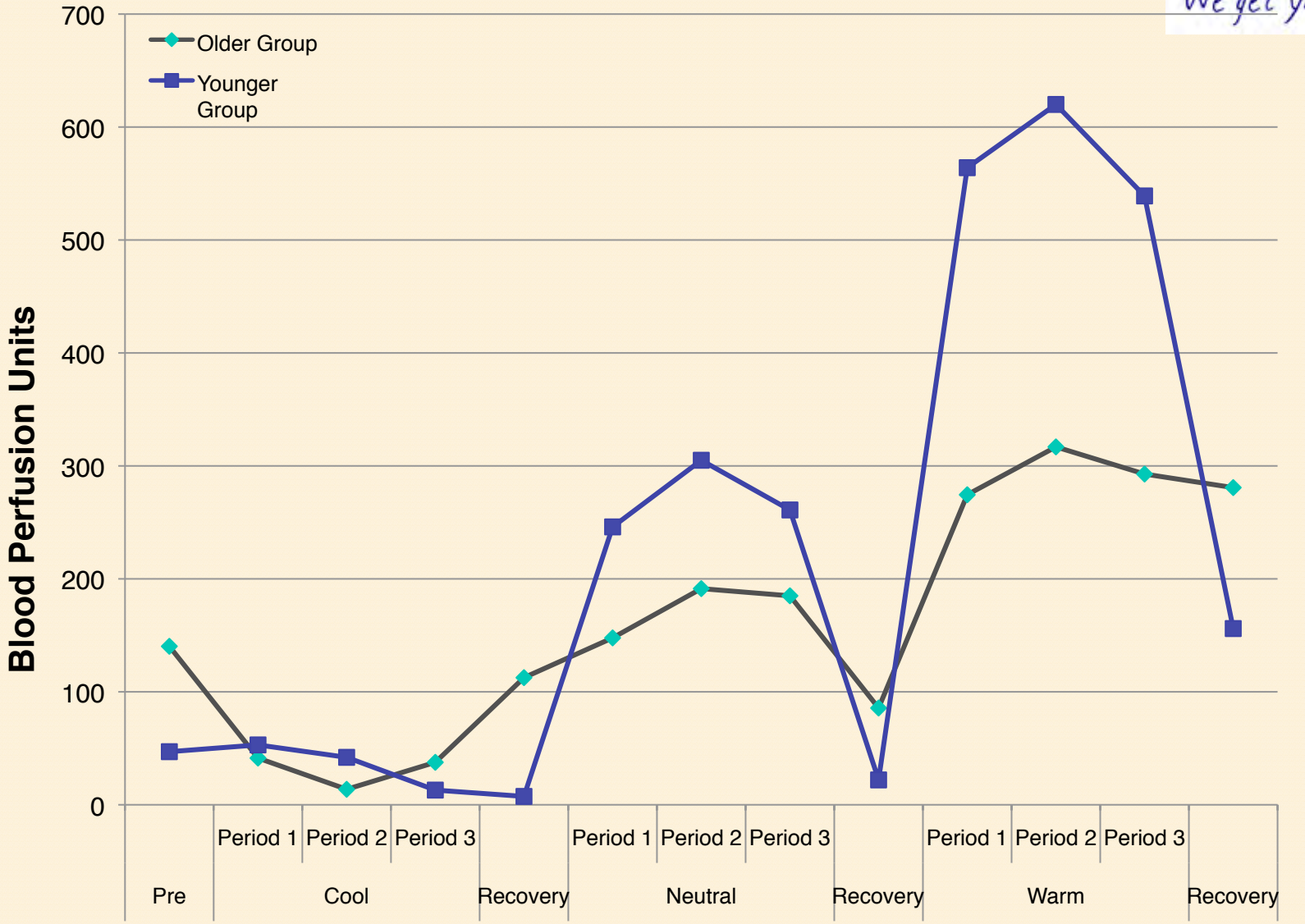
Heart Rate Change during Immersion



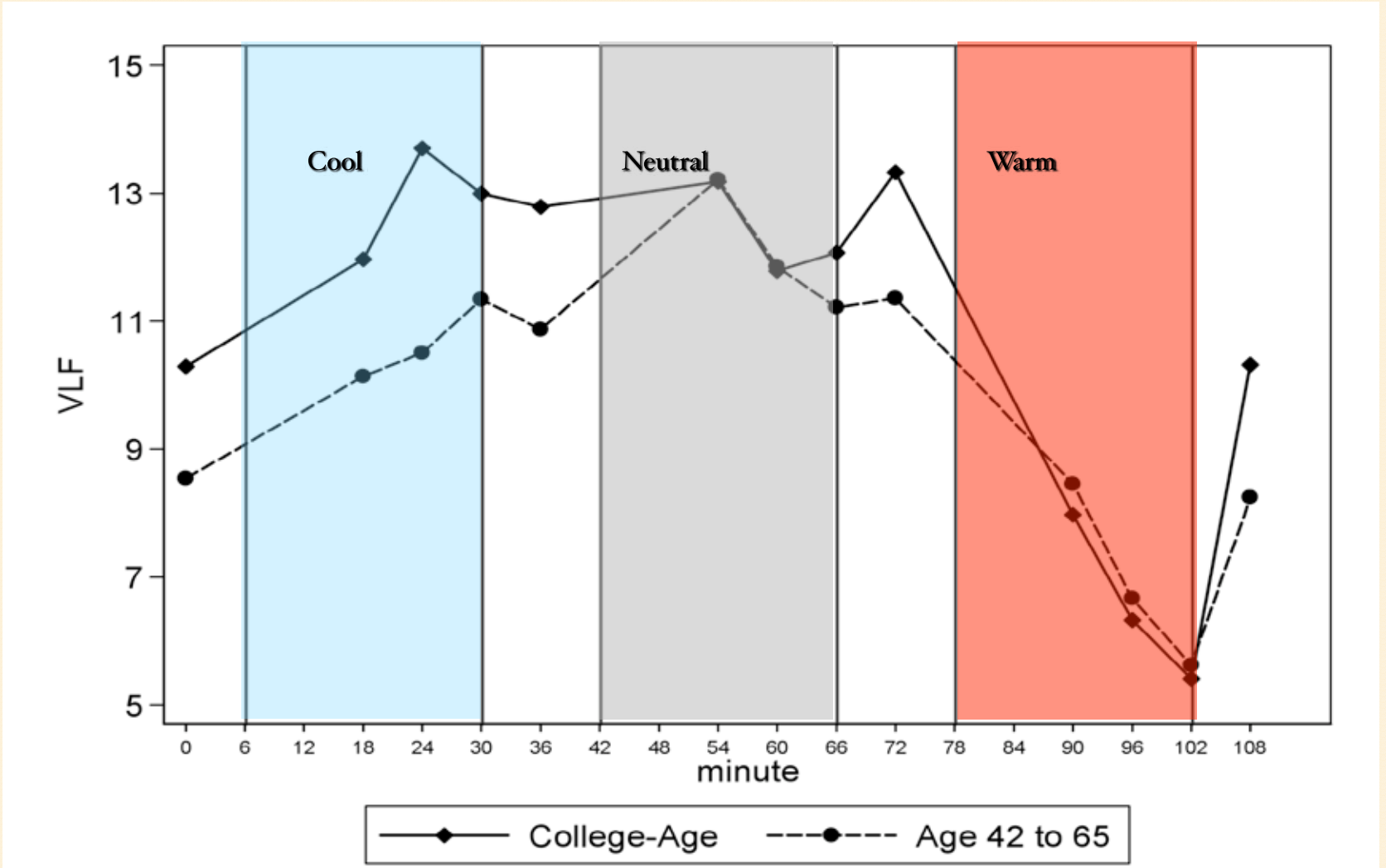
Blood Pressure Response by Age Group



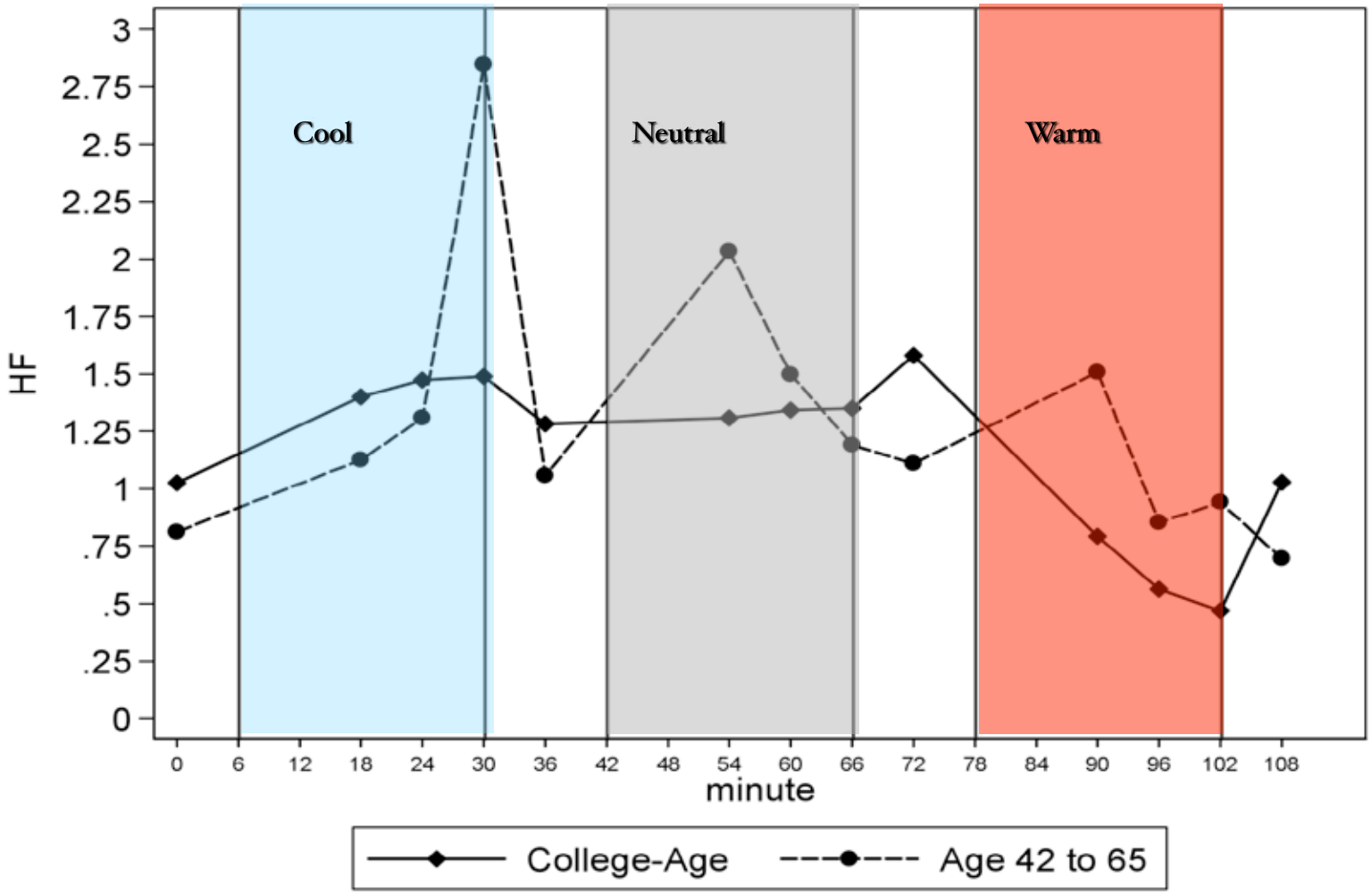
Young vs Older Circulatory Changes



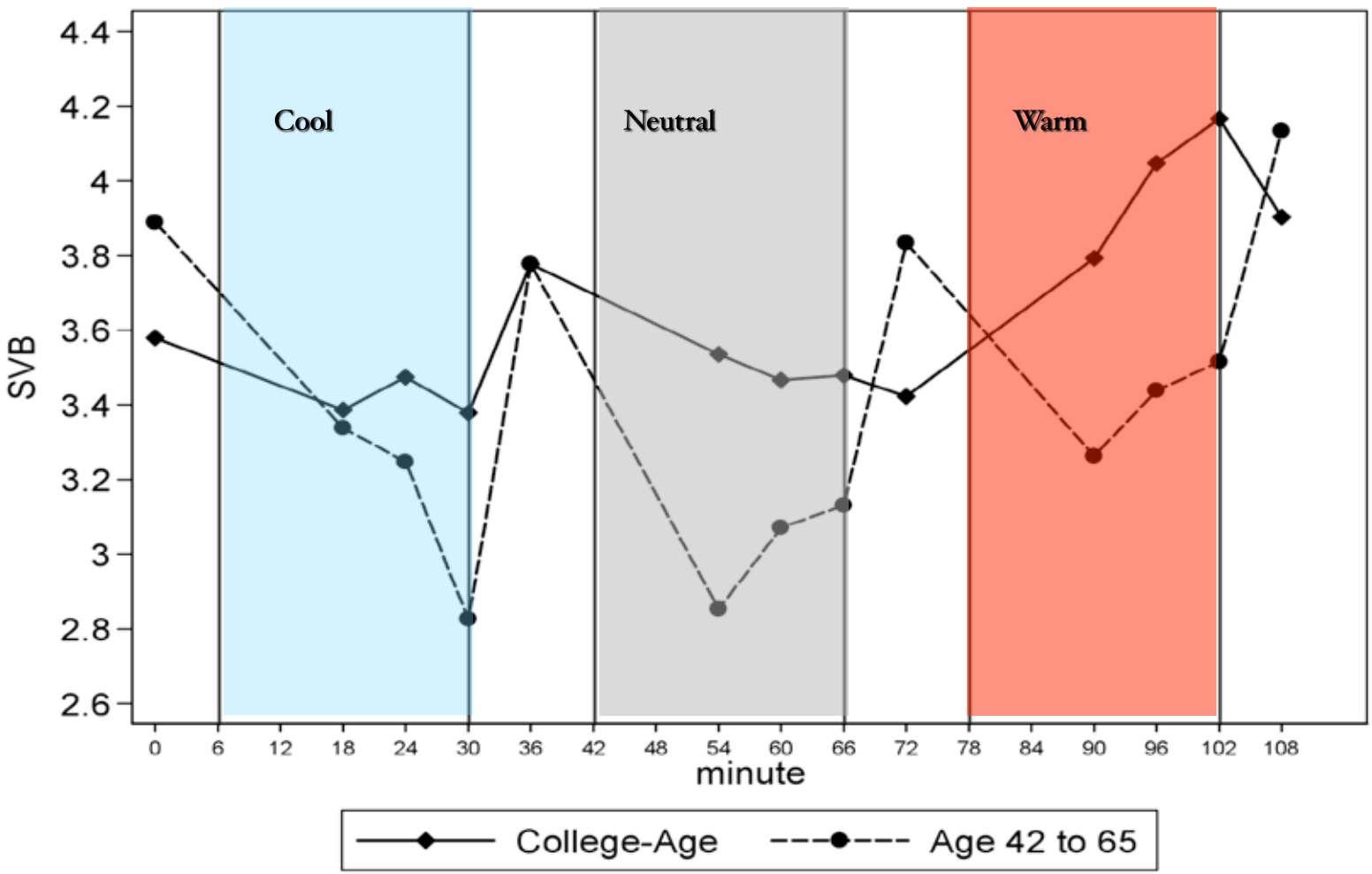
VLF Power Spectral Display by Age Group



HF Power Spectral Display by Age Group



Sympathovagal Balance by Age Group



Study Result Summary

- There seems to be a very significant effect of warm water immersion upon the autonomic nervous system
- That effect seems to enhance the balance between parasympathetic and sympathetic components, and is likely one of the major changes that create the feeling of relaxation in warm water.

Results Summary cont.

- The increase in autonomic balance did not happen in cooler water temperatures
- Sympathetic activation occurred in both cool and neutral temperatures, but not in warm
- The changes noted were quite consistent across all of the subjects tested

Results Summary, con't

- Systolic pressures remained quite constant through all 3 immersion phases
- Diastolic pressures declined through the 3 phases
- Heart rates remained stable until climbing during the mid-point of warm water immersion
- Core temperatures also rose during this latter cycle, but only by less than 1°C on average

Study conclusions thus far

- The data we have analyzed so far indicates that in these healthy subjects there are a number of important ANS changes that occur during warm water immersion.
- There seems to be a dose response (immersion time) relationship
- These changes may well have beneficial public health implications for warm water immersion.

Potential Clinical Applications

- Depression
- Anxiety and panic disorders
- Attention Deficit Disorder
- Autism
- Cardiac Rehabilitation
- Diabetes, both Types I & II

The Unique Effects of Immersion

- Usually lowers blood pressure
- Reduces autonomic imbalance
- Strengthens inspiratory musculature
- Improves kidney function
- Increases muscle perfusion
- Offloads joints, and probably increases circulation to joints
- Enhances cardiovascular efficiency


The National Aquatics & Sports Medicine Institute
Research Team
Washington State University