Luxembourg, oct.11st

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How to speed-up sports recovery?

Impact of whole-body cryo and others methods

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How to introduce our topic?

- **Training sessions** induce severe physiological adaptations.
- However, in athletes, high levels of training do not necessarily **lead to performance**.
- A complex set of central and peripheral events can **lead to significant drops** in performance in the period following intense training.
- Thus, when **recovery periods are insufficient**, fatigue can reach such a degree that only complete rest can be effective.

WHAT ABOUT RECOVERY?

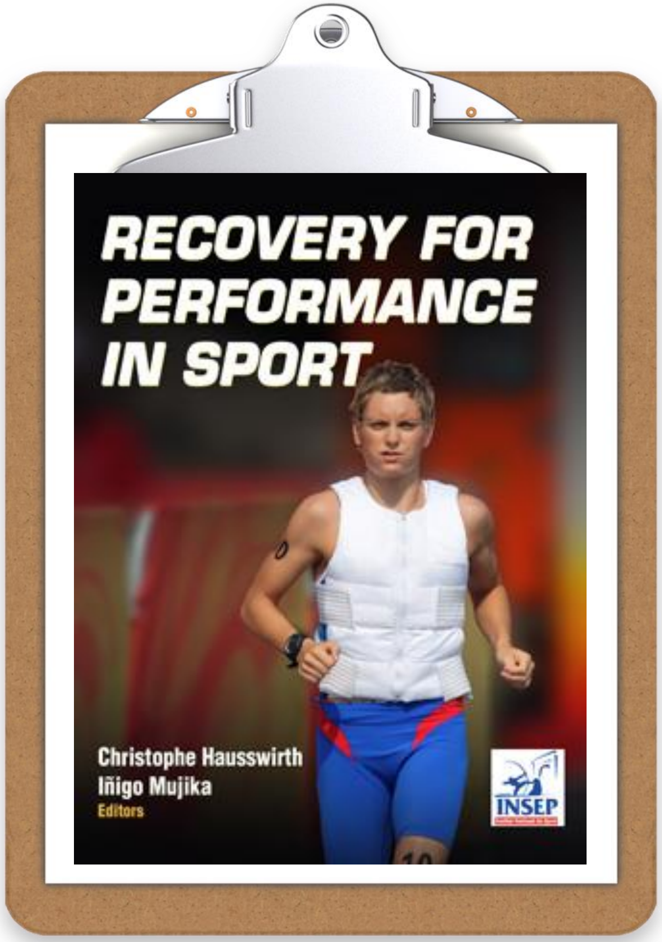
- Training is therefore inseparable **from fatigue**, a normal physiological phenomenon in everyday life.
- However, this must be recognized, analyzed and linked to **appropriate recovery times**, coupled with **practical recovery methods** in line with the training load.
- It is therefore important to recognize the signs of fatigue and to associate early and recurrent recovery periods with **effective recovery methods**!

PRSENTATION OUTLINE

1. Why do we need to recover?
2. The main categories of sports recovery
3. The different roles of recovery
   - A. The **development** stage
   - B. The **competition** window
   - C. The **tapering** period
4. Towards a synthesis of sports recovery programming.

MULTI-FACTORIAL APPROACH TO RECOVERY

- From a practical perspective, we define recovery as the whole set of processes that result in an **athlete's renewed ability to reach** or exceed a previous performance.
- Furthermore, the recovery period is also defined as the **time necessary** for various physiological parameters, which were modified by exercise, to return to resting values.



Hausswirth et Mujika, 2013

WHY RECOVER?

BEFORE…

…AFTER

WHY RECOVER?

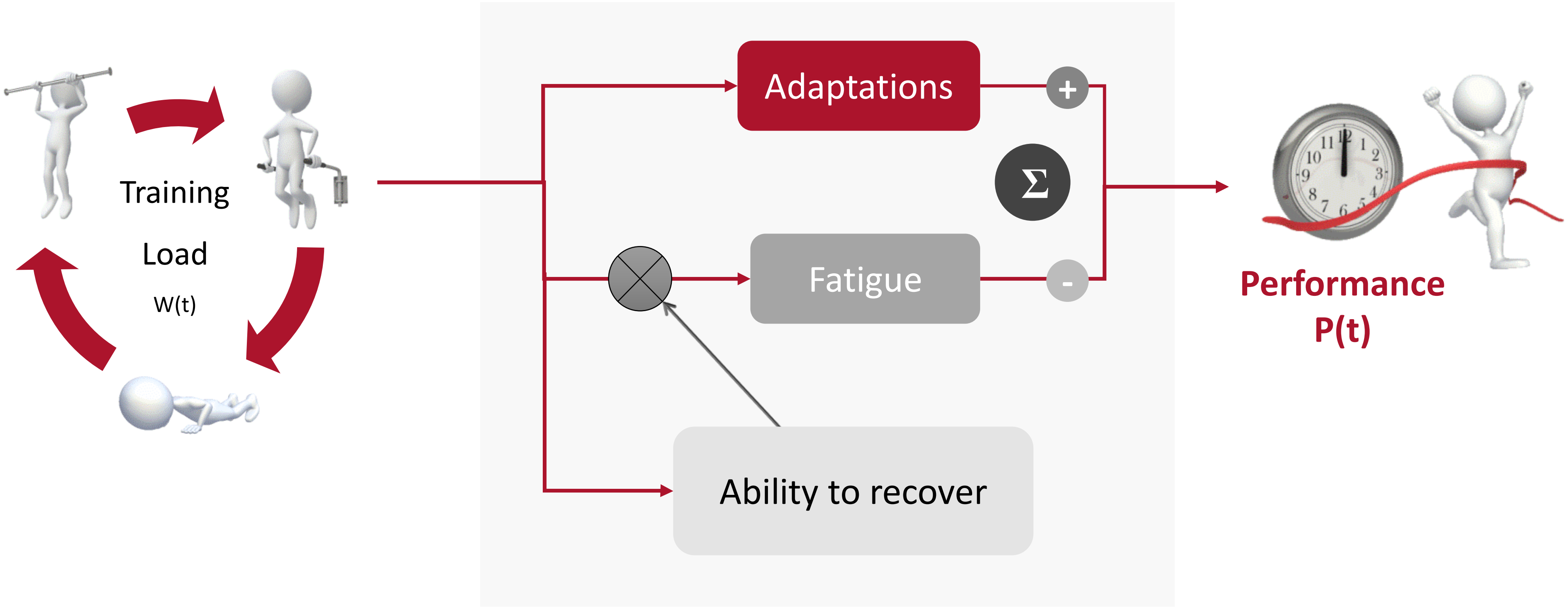
- **Impaired functions:**
  - Mechanical.
  - Metabolism.
  - Cognition.
  - Etc.
- **Dependent on previous exercise …**
  - Duration
  - Intensity
- **… and the following**

Credit photo : FFCK/Julien CROSNIER/DPPI

WHY IMPROVING RECOVERY?

- **Facilitate adaptations** to high training loads
- **Decrease risk** of overload
- **Reduce risk** of injuries
- **Improve** the repeatability of performance

TRAINING MODELIZATION



Training

Load

W(t)

Adaptations

+

Σ

Fatigue

-

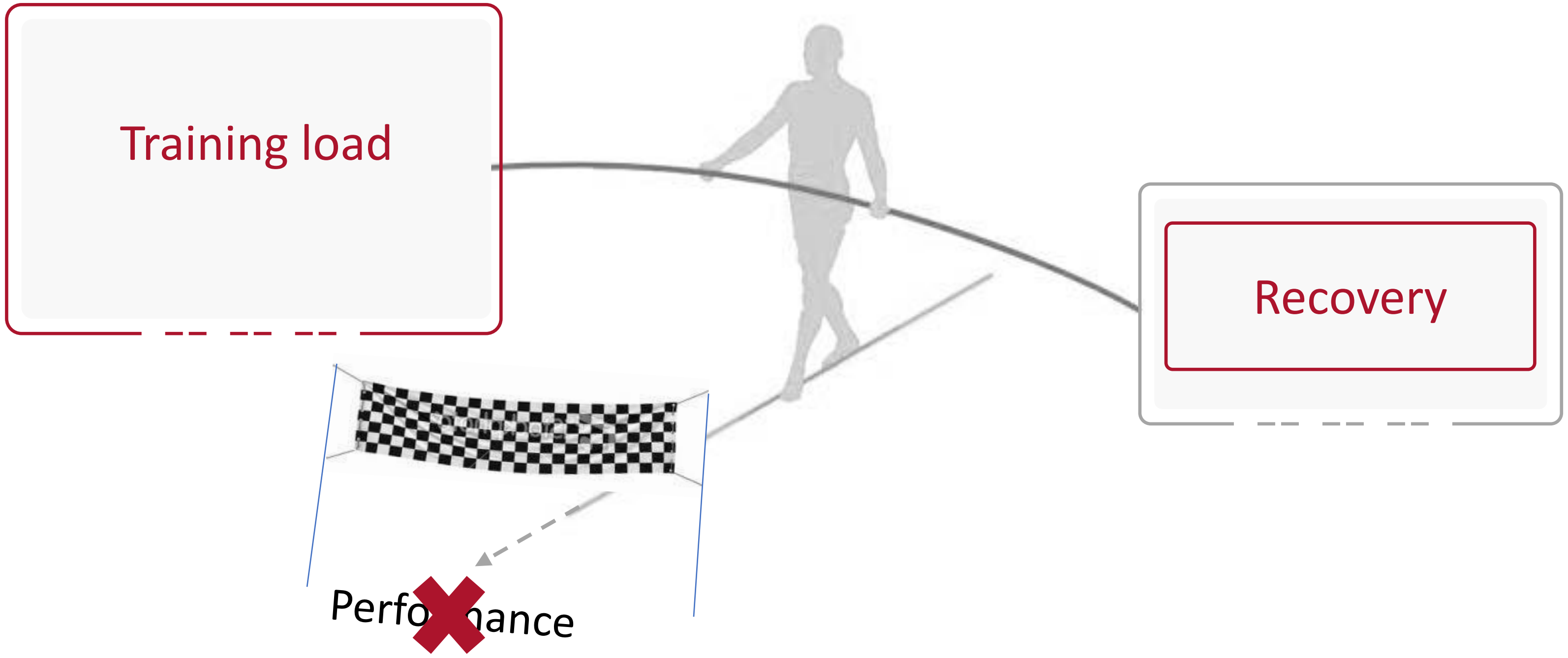
Ability to recover

Performance

P(t)

Bannister 1975

THE TRAINING BALANCE



Training load

Recovery

Performance

Hausswirth C. Eds Vigot 2013

SUPPORT TRAINING LOAD

- Reduced performance.
- Intense and persistent perceived fatigue.
- Mood disorders.
- Increased prevalence of infections.

High Training Load **X** **Poor recovery** **=** **Drop in performance**

Meeusen et al. Med. Sci. Sport Exerc 2013

RECOVERY METHODS FOR THE ATHLETES…

- Active recovery
- Rest
- Electromyostimulation
- Hydration
- Passive streching
- Temp. immersion
- WBC
- Andrews-Pilates method
- Contrasted immersion
- Sleep
- Ice-vest
- Muscle chain method
- Circulatory massage
- Warm application
- Relaxing massage
- Stretching
- Local Cryotherapy
- Aromatherapy
- Far infrared
- Hot immersion
- Mechanical massages
- Sauna
- Hydrojet massage
- Joint mobilization
- Jones technique
- Sophrology
- Hammam
- Ultrasounds
- …

3 KEY CATEGORIES

NATURALS

- Rest
- Active
- Hydration
- Nutrition
- Sleep

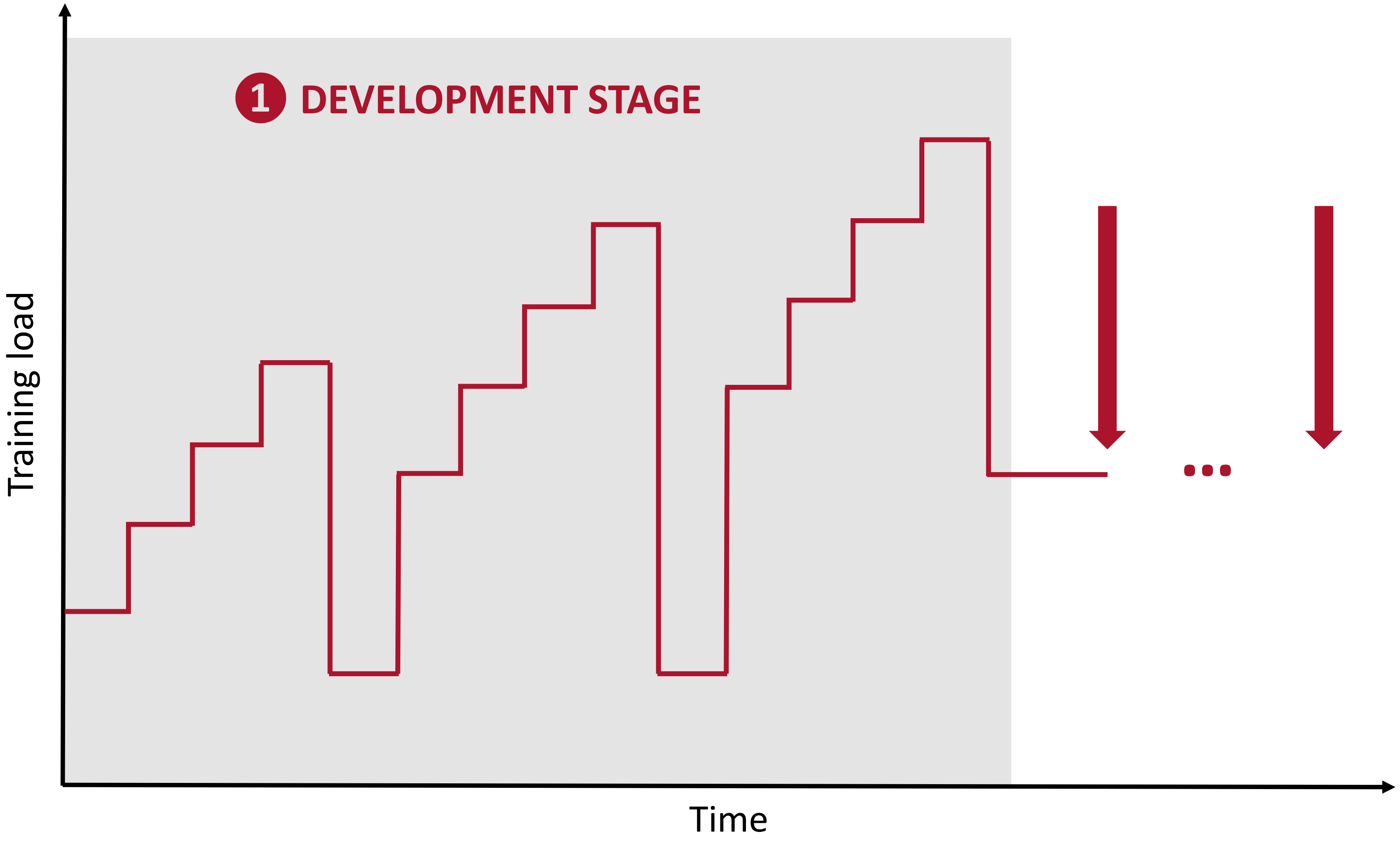
PHYSIO-THERAPEUTICS

- Massage
- **Whole-Body Cryotherapy (WBC)**
- Immersion
- Electromyo-stimulation
- Compression
- Oxygeno-therapy
- Ultrasouds
- Etc.

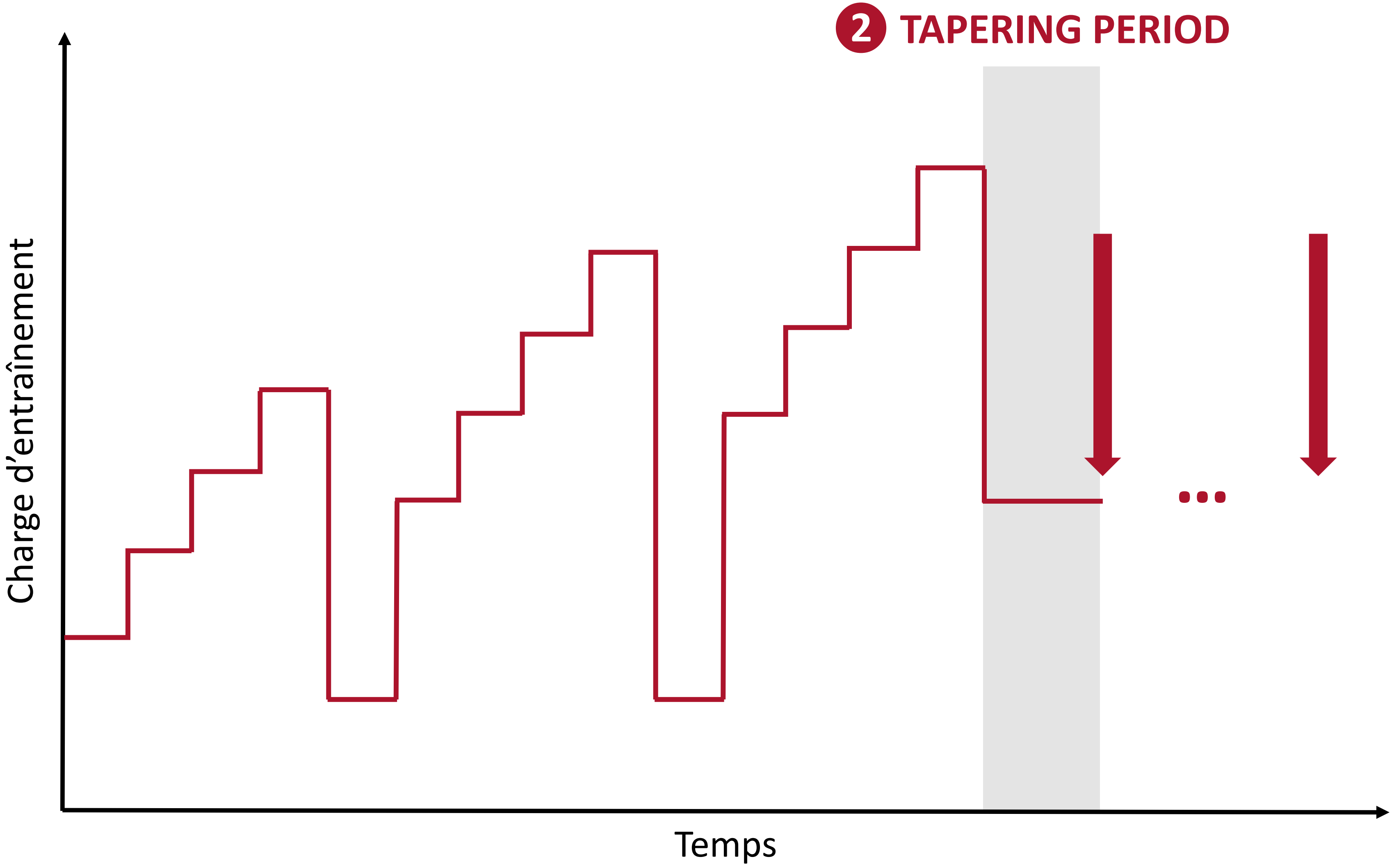
PSYCHOLOGIQUES

- Relaxation techniques
- Stretching
- Etc.

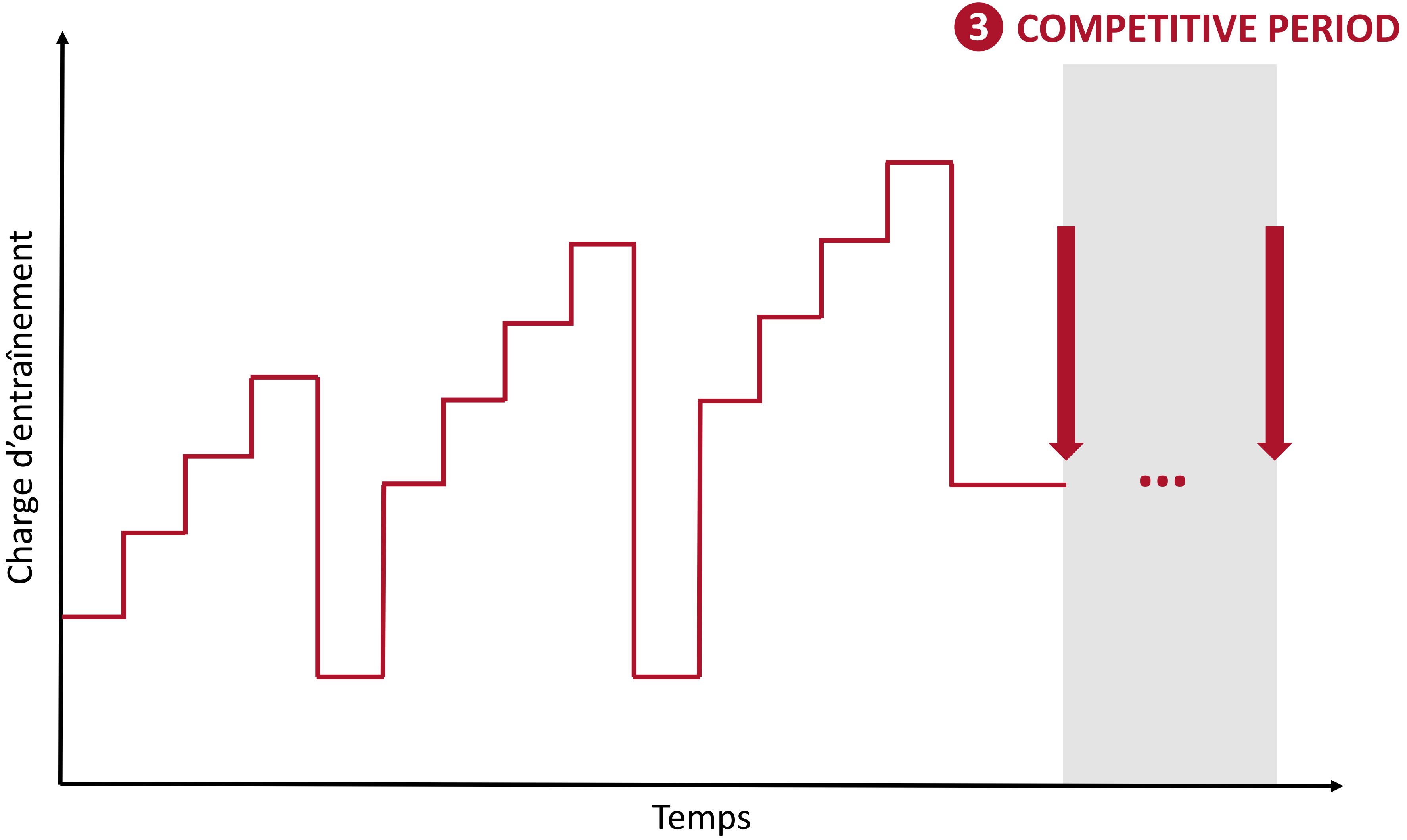
THE VARIOUS ROLES OF RECOVERY



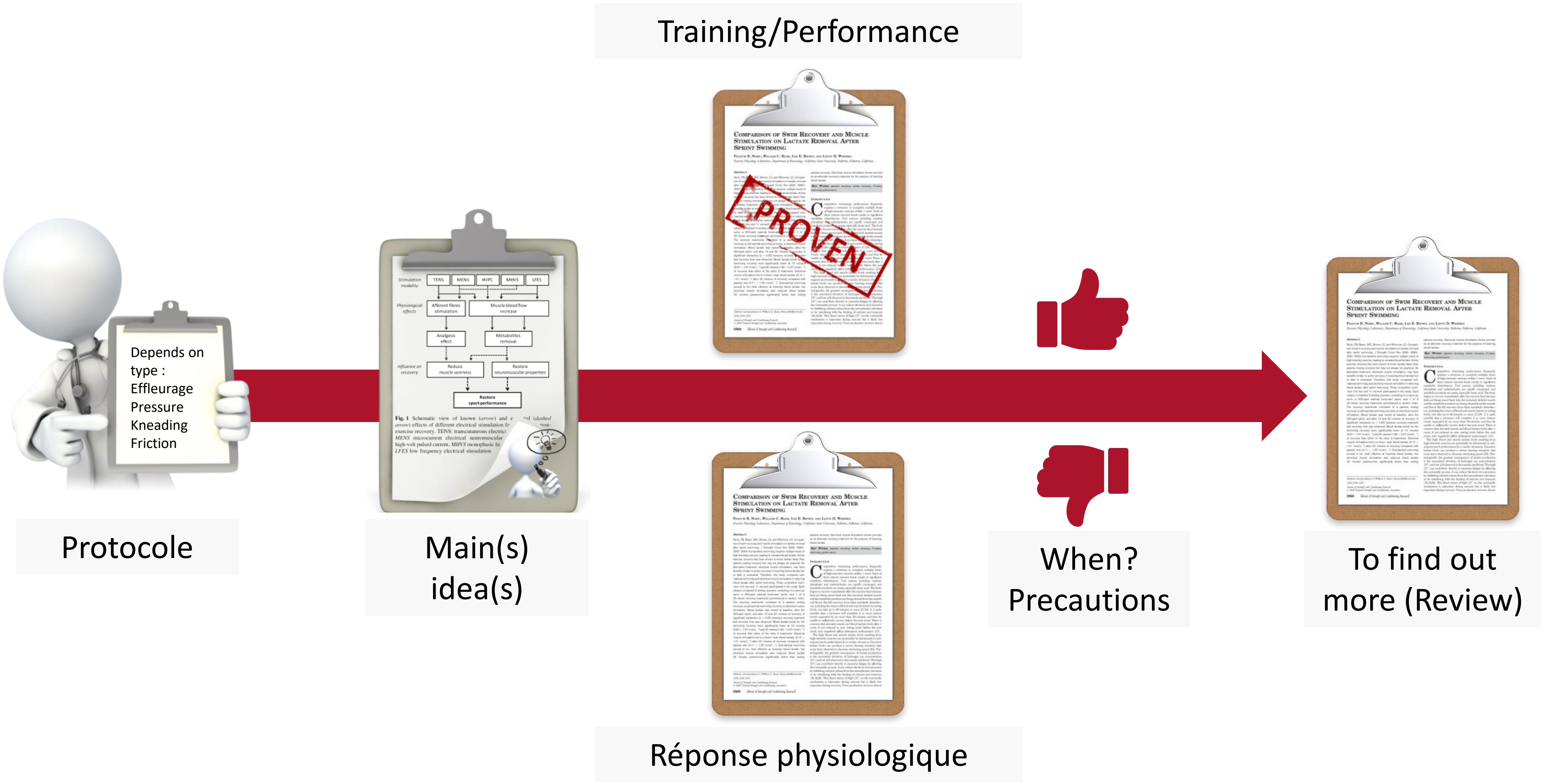
THE VARIOUS ROLES OF RECOVERY



THE VARIOUS ROLES OF RECOVERY



SUPPORTING MODEL



Training/Performance

Comparison of Swim Recovery and Muscle Stimulation on Lactate Removal After Sprint Swimming

Depends on type :
Effleurage
Pressure
Kneading
Friction

Fig. 1 Schematic view of known (*arrow*) and e ted (*dashed arrow*) effects of different electrical stimulation fe post-exercise recovery. TENS: transcutaneous electric *MENS* microcurrent electrical neuromuscular high-volt pulsed current, *MHVS* monophasic hi *LFES* low frequency electrical stimulation

Protocole

Main(s) idea(s)

When? Precautions

Comparison of Swim Recovery and Muscle Stimulation on Lactate Removal After Sprint Swimming

To find out more (Review)

Comparison of Swim Recovery and Muscle Stimulation on Lactate Removal After Sprint Swimming

Réponse physiologique

MANAGING RECOVERY USING WBC

10%

Sport, training, performance

Recovery

- -Muscle strength
- -Inflammation
- -Oxidative stress
- -Cardiodeceleration
- -Muscle damage/DOMS

(Hausswirth et al.2011, 2013; Pournot et al. 2011)

Whole-Body Cryotherapy (3min at -110°C ; -160°C)

Medical domain

Rheumatismal & inflammatory pathologies

-Rheumatoid arthritis,
-Ankylosing Spondylitis
(Wichmann et Fricke 1997; Metzger et al. 2000)

Dermatological pathologies
-Psoriasis
(Fricke, 1989)

Depressive symptoms
(Rymaszewska et al. 2003)

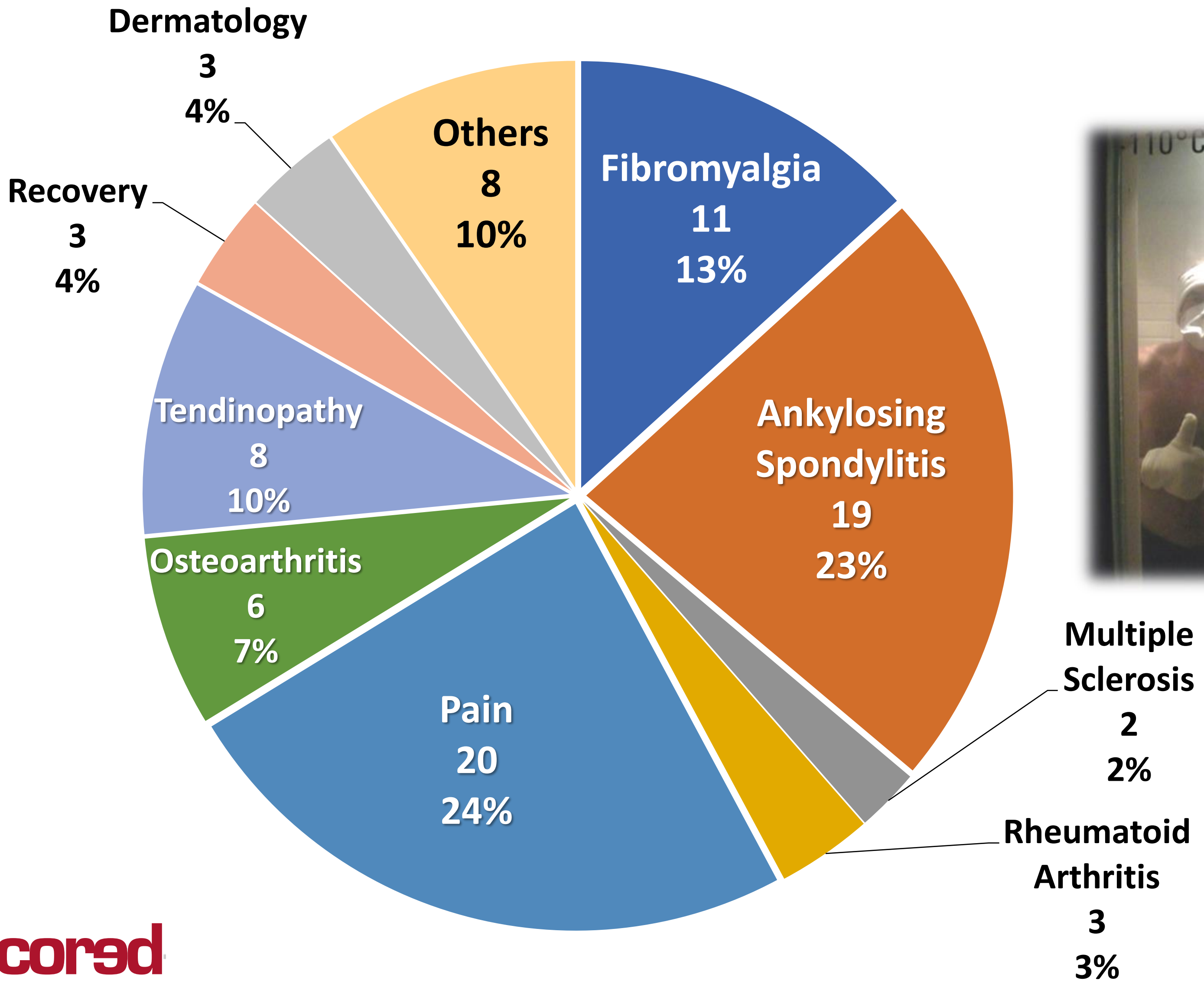
Sports medicine

Injuries & joint and tendons overuse syndrome

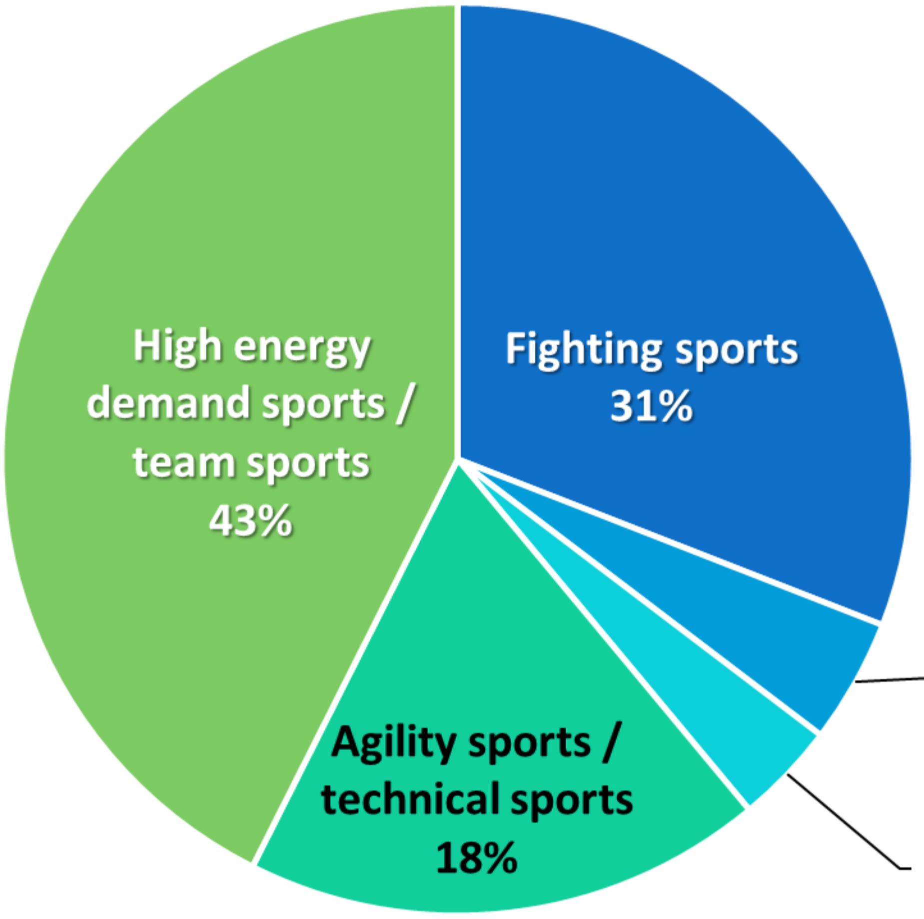
(Barbiche, 2006; Westerlund, 2009)

Distribution of WBC sessions per pathologies

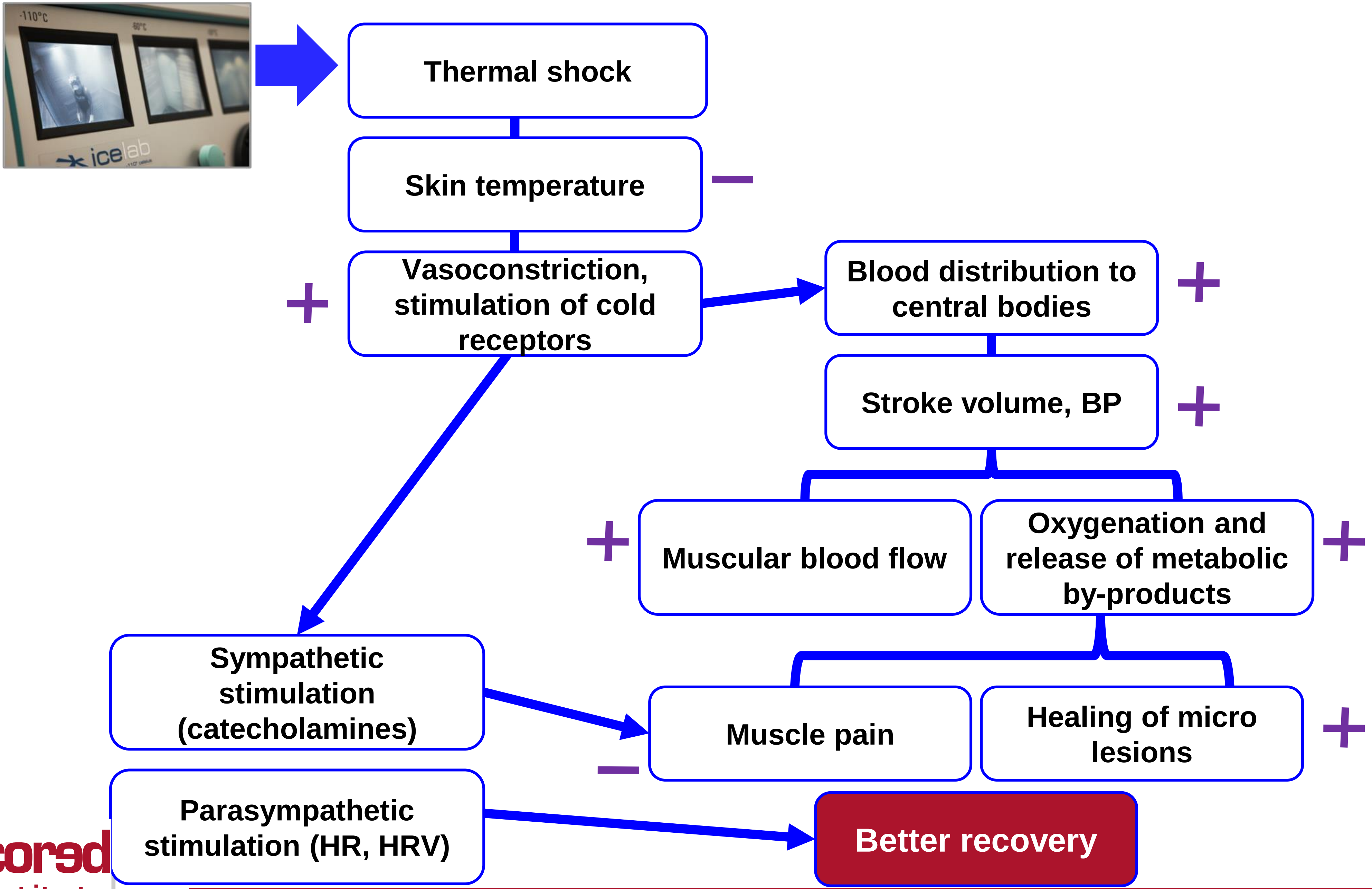
- INSEP-



Distribution of WBC sessions per sport



PHYSIOLOGICAL EFFECTS OF WBC



Thermal shock

Skin temperature −

\+ Vasoconstriction, stimulation of cold receptors

Blood distribution to central bodies +

Stroke volume, BP +

\+ Muscular blood flow

Oxygenation and release of metabolic by-products +

Sympathetic stimulation (catecholamines)

− Muscle pain

Healing of micro lesions +

Parasympathetic stimulation (HR, HRV)

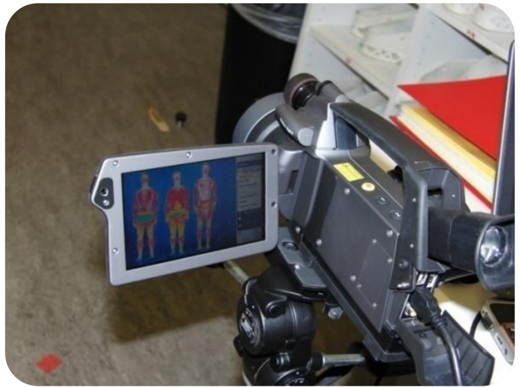
Better recovery

Expected effects of WBC

⇨

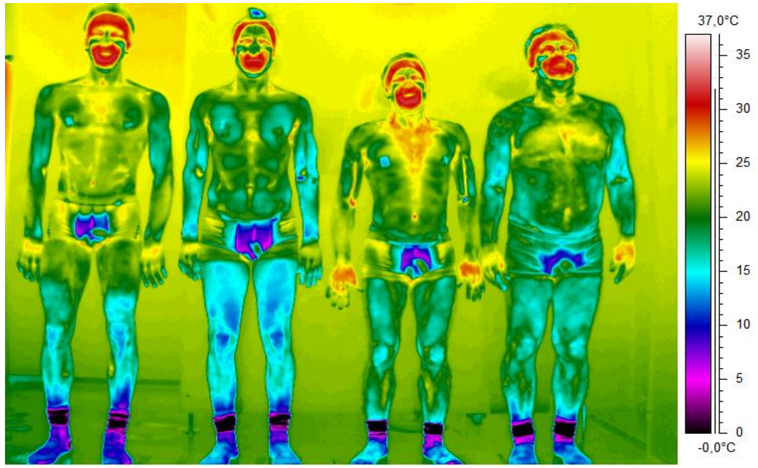
Thermal shock

Skin temperature ↓



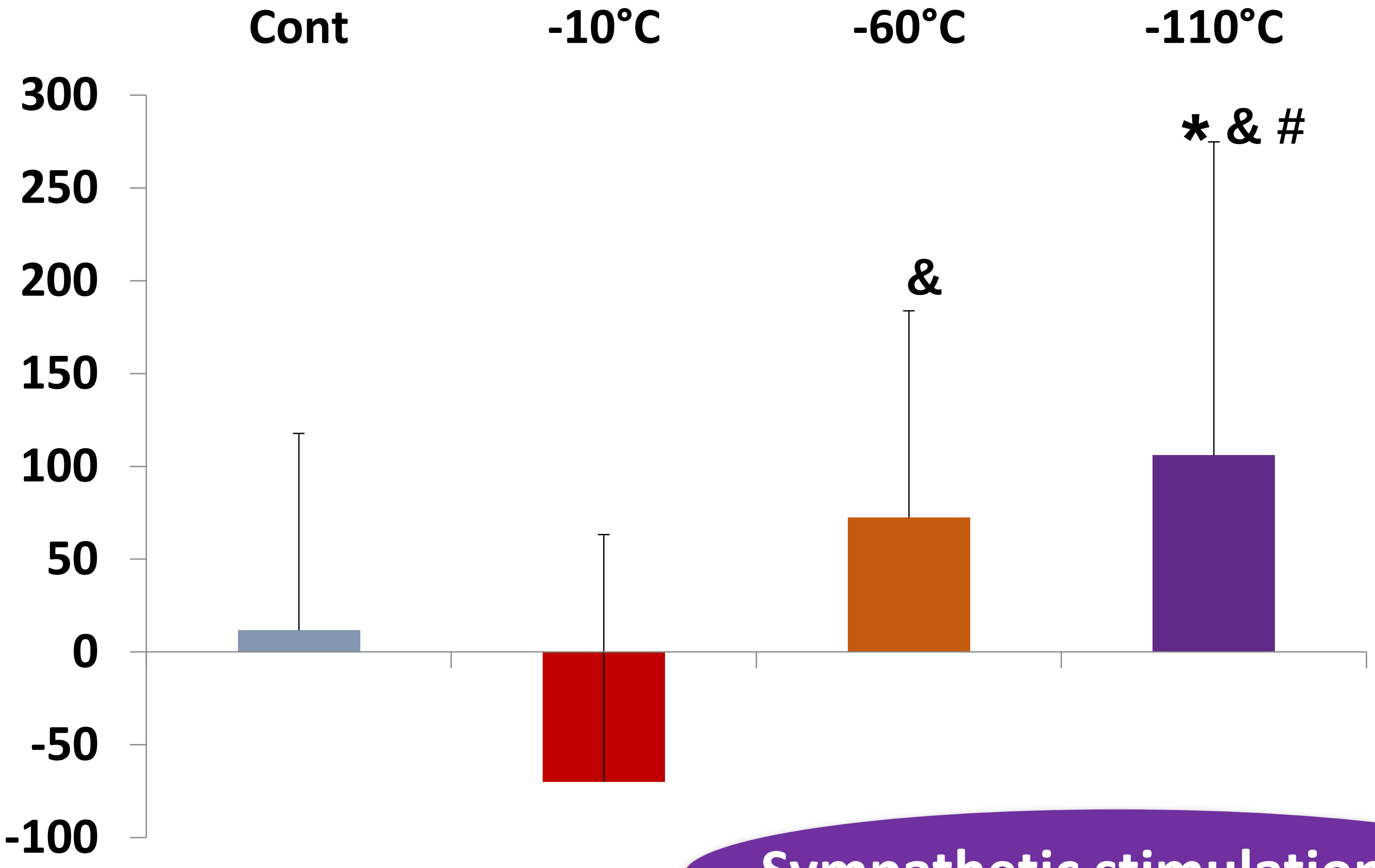
Pre -110°C

Post -110°C



Infra-red Thermal Camera (Flirs system, Sweden)

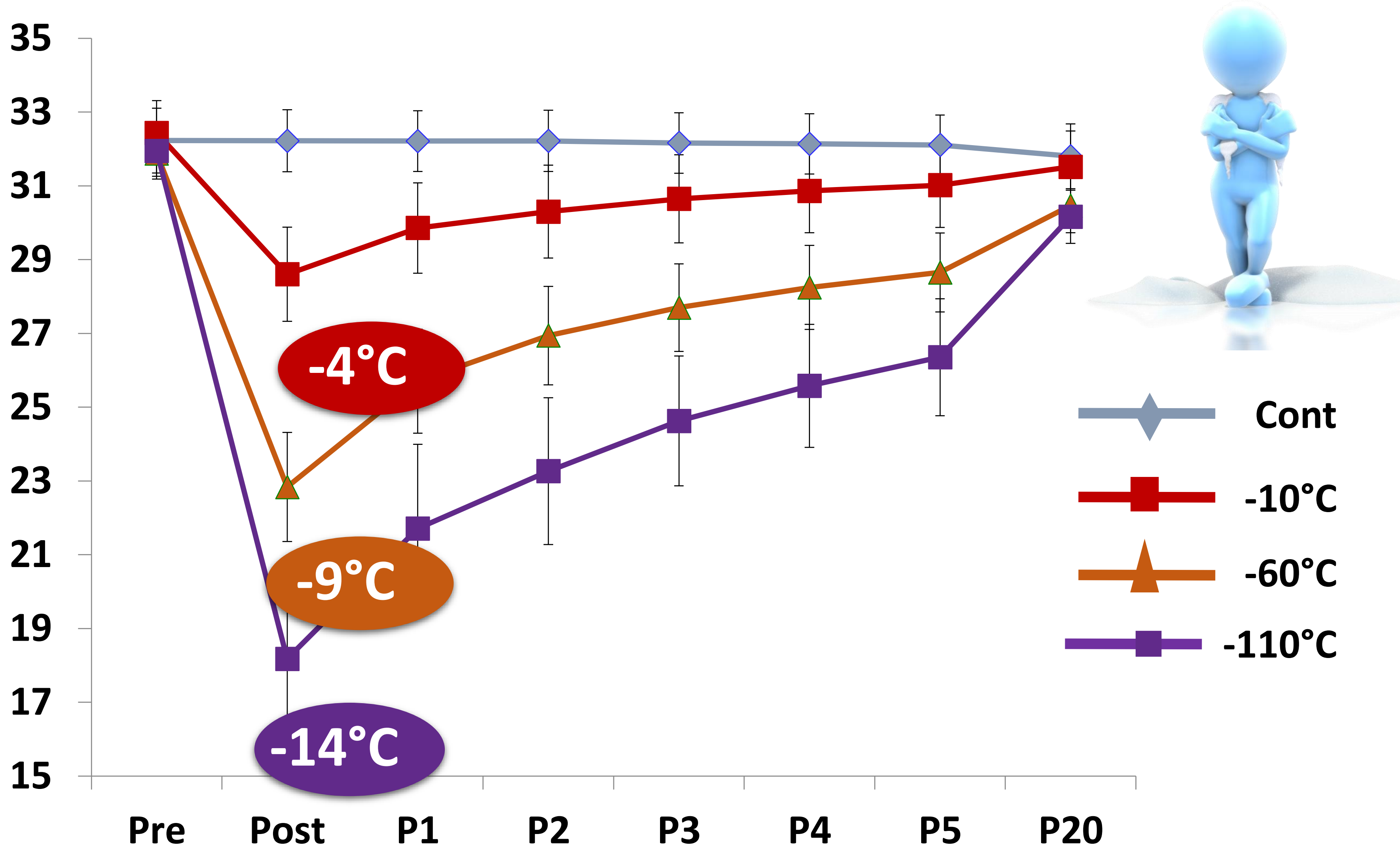
Noradrenaline / Cold intensity



Sympathetic stimulation

* Different from Pre, & from -10°C, # from control

Skin temperature (whole-body)



Louis & Hausswirth 2013

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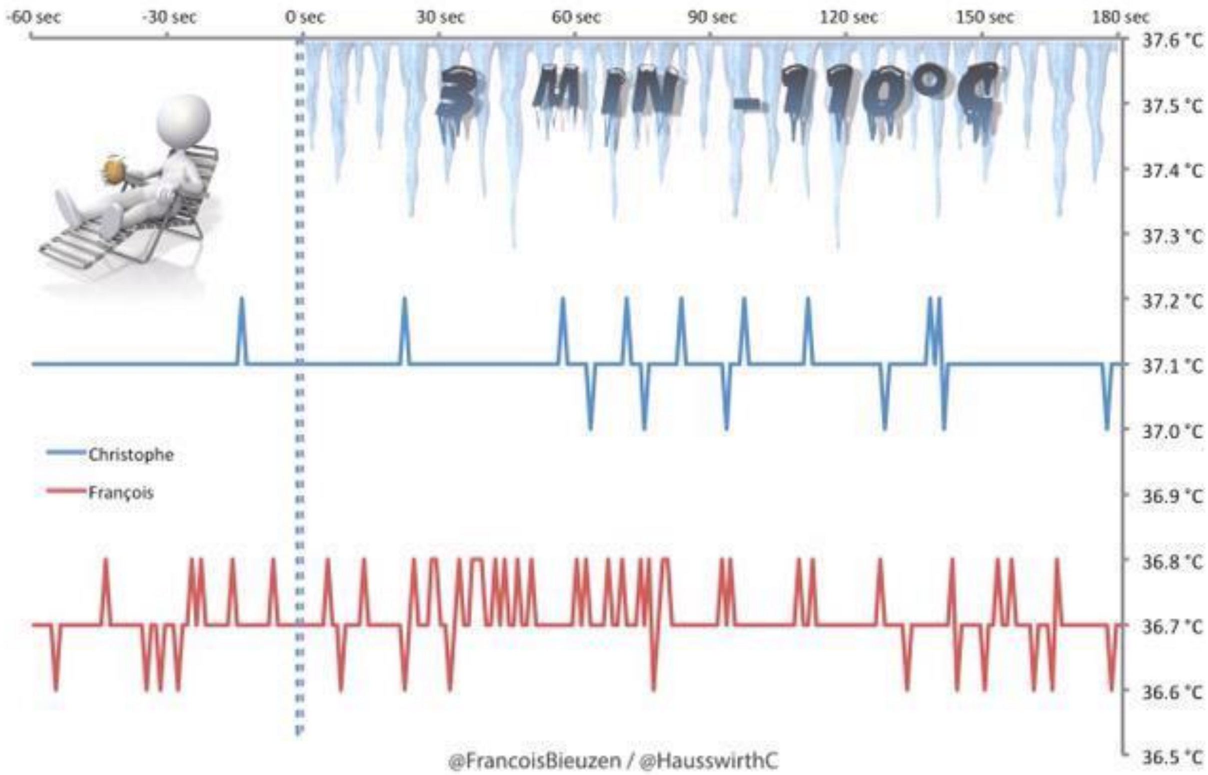
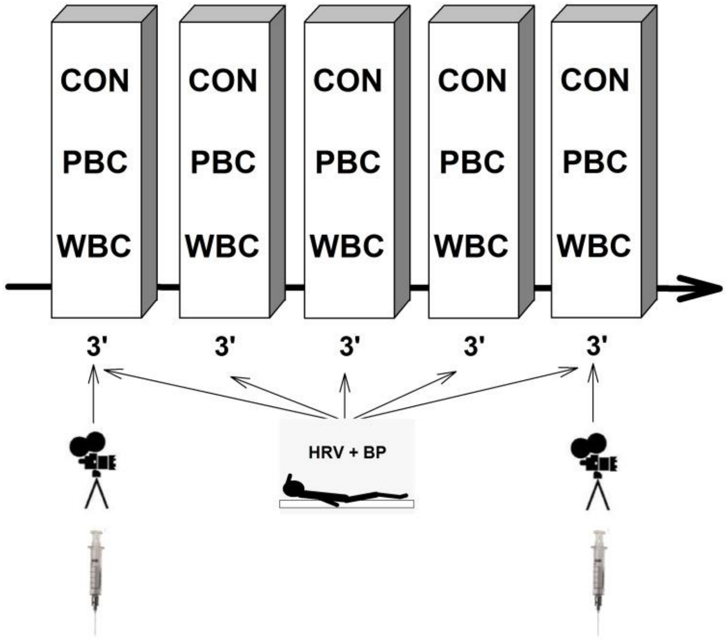
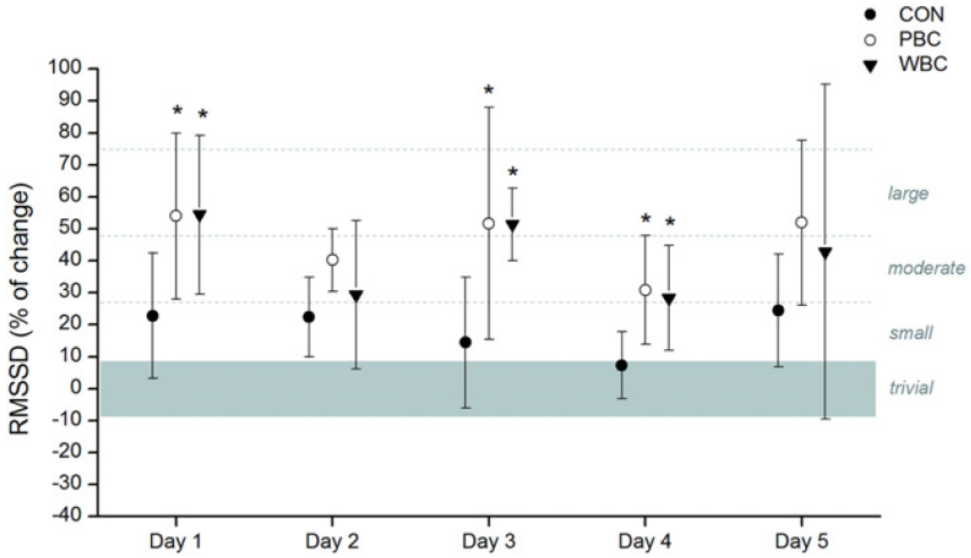
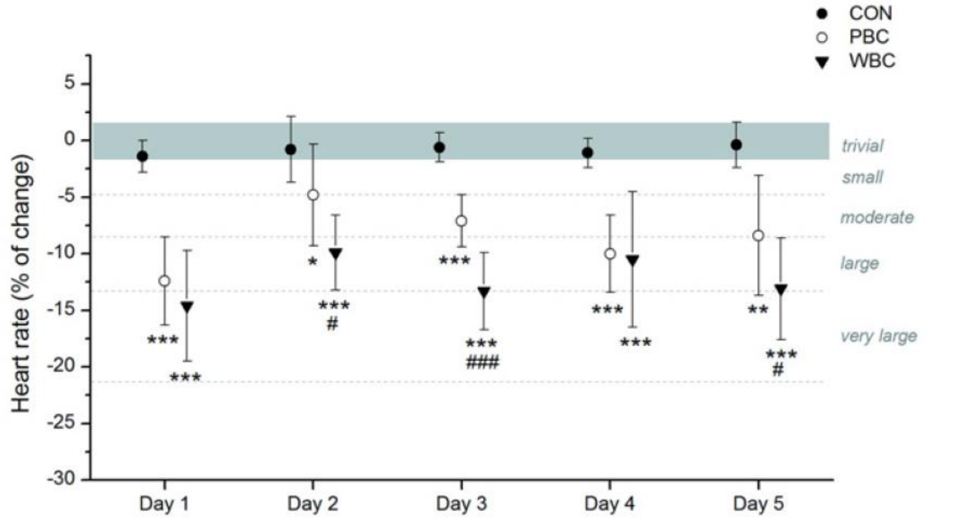
Core temperature during WBC



Multi-exposures to WBC

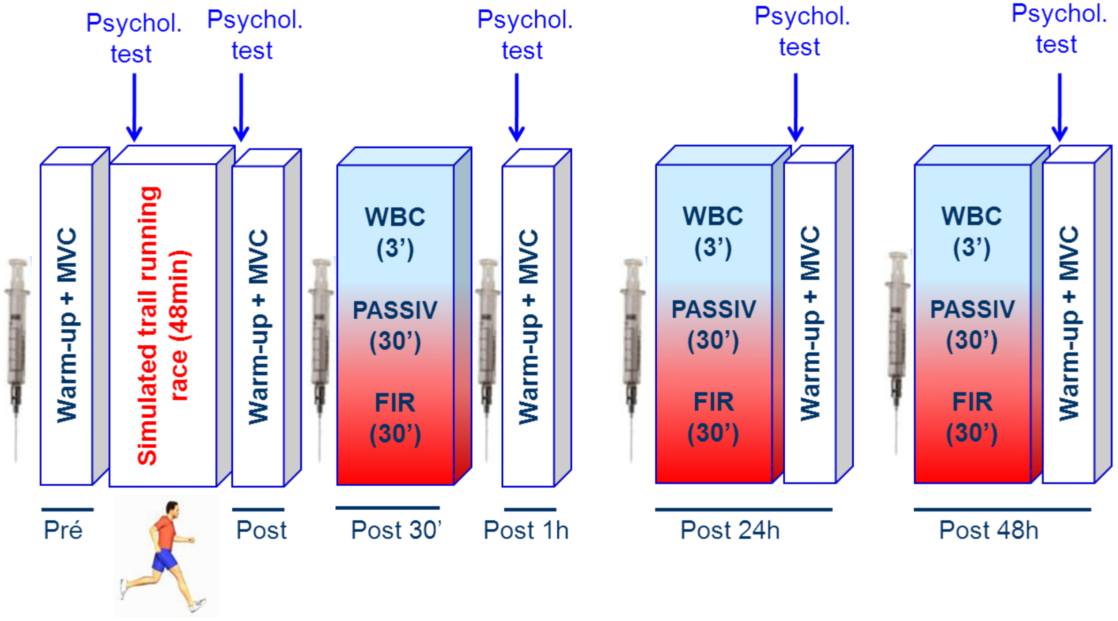






Louis et al. PlosOne, 2015

MUSCLE SORENESS, DAMAGE AND WBC


Psychol. test
Psychol. test
Psychol. test
Psychol. test
Psychol. test
Warm-up + MVC
Simulated trail running race (48min)
Warm-up + MVC
WBC (3')
PASSIV (30')
FIR (30')
Warm-up + MVC
WBC (3')
PASSIV (30')
FIR (30')
Warm-up + MVC
WBC (3')
PASSIV (30')
FIR (30')
Warm-up + MVC
Pré
Post
Post 30'
Post 1h
Post 24h
Post 48h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PLoS one

Effects of Whole-Body Cryotherapy vs. Far-Infrared vs. Passive Modalities on Recovery from Exercise-Induced Muscle Damage in Highly-Trained Runners

Christophe Hausswirth[1*], Julien Louis[1,2], François Bieuzen[1], Hervé Pournot[1,2], Jean Fournier[1], Jean-Robert Filliard[3], Jeanick Brisswalter[2]

1 Research Department, National Institute of Sport, Expertise and Performance (INSEP), Paris, France, 2 Laboratory of Human Motricity, Education and Health, University of Nice Sophia-Antipolis, Nice, France, 3 Medical Department, National Institute of Sport, Expertise and Performance (INSEP), Paris, France

Abstract

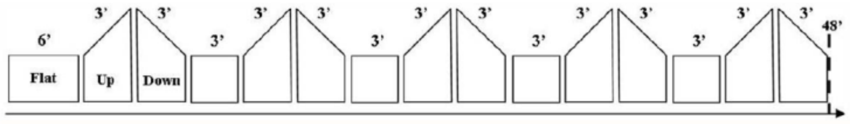
Enhanced recovery following physical activity and exercise-induced muscle damage (EIMD) has become a priority for athletes. Consequently, a number of post-exercise recovery strategies are used, often without scientific evidence of their benefits. Within this framework, the purpose of this study was to test the efficacy of whole body cryotherapy (WBC), far infrared (FIR) or passive (PAS) modalities in hastening muscular recovery within the 48 hours after a simulated trail running race. In 3 non-adjoining weeks, 9 well-trained runners performed 3 repetitions of a simulated trail run on a motorized treadmill, designed to induce muscle damage. Immediately (post), post 24 h, and post 48 h after exercise, all participants tested three different recovery modalities (WBC, FIR, PAS) in a random order over the three separate weeks. Markers of muscle damage (maximal isometric muscle strength, plasma creatine kinase [CK] activity and perceived sensations [i.e. pain, tiredness, well-being]) were recorded before, immediately after (post), post 1 h, post 24 h, and post 48 h after exercise. In all testing sessions, the simulated 48 min trail run induced a similar, significant amount of muscle damage. Maximal muscle strength and perceived sensations were recovered after the first WBC session (post 1 h), while recovery took 24 h with FIR, and was not attained through the PAS recovery modality. No differences in plasma CK activity were recorded between conditions. Three WBC sessions performed within the 48 hours after a damaging running exercise accelerate recovery from EIMD to a greater extent than FIR or PAS modalities.

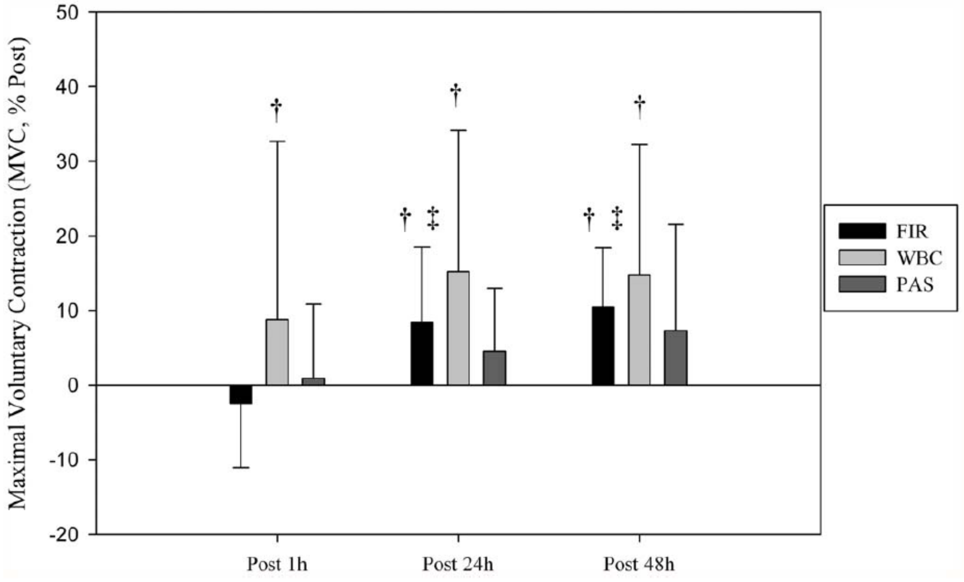
APPROVED

Hausswirth et al. PlosOne, 2011

MUSCLE PERFORMANCE

~ 9.6% MVC decline following the running session ($p<0.05$)





DOMS values decreased after **WBC (post 1h, 24h and 48h)** and after 48h for FIR.

Subjective fatigue decreased after **WBC (post 1h, 24h and 48h)**

WB increased after **WBC de 24h à 48h**, and after 48h for FIR

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Effects of Whole-Body Cryotherapy vs. Far-Infrared vs. Passive Modalities on Recovery from Exercise-Induced Muscle Damage in Highly-Trained Runners

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Citation: Hausswirth [illegible] Louis J, Bieuzen F, Pourno[illegible] Fournier J, et al. (2011) Effects of Whole-Body Cryotherapy vs. Far-Infrared vs. Passive Modalities on Recovery from Exerci[illegible] Muscle Damage in Highl[illegible] Trained Runners. PLoS ONE 6(12): e27749. doi:10.1371/journal.pone.0027749

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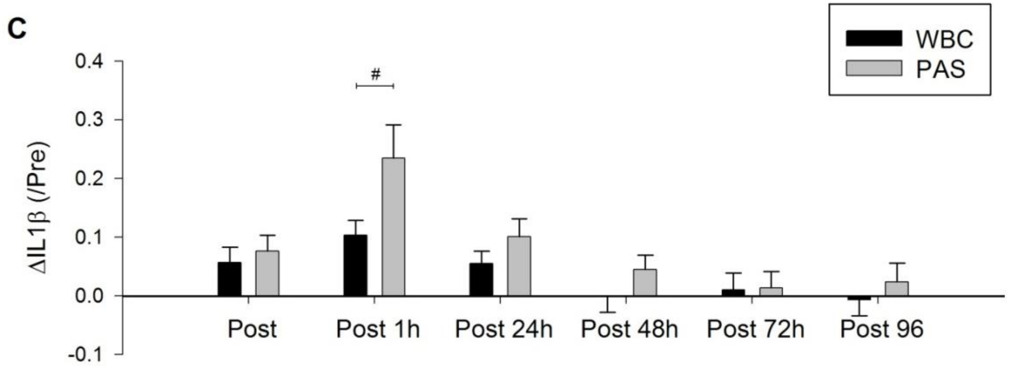
Competing Interests: The autho[illegible] no com[illegible] exist.

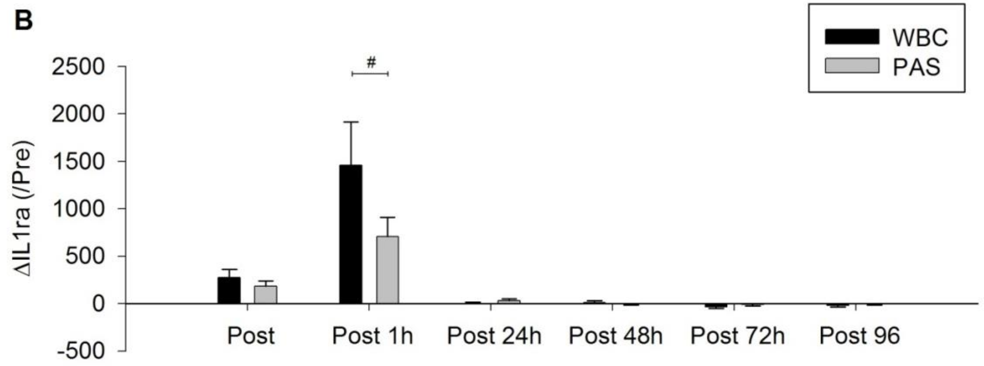
Introduction

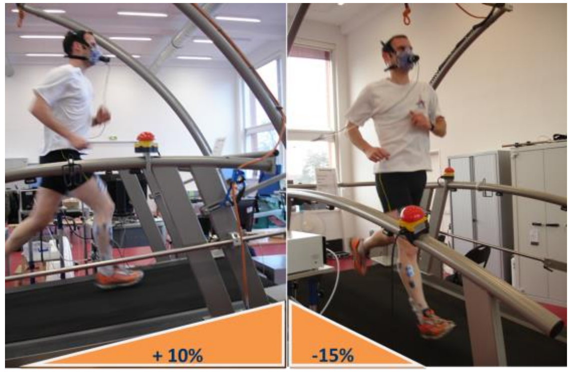
PLoS ONE | www.plosone.org 1 December 2011 | Volume 6 | Issue 12 | e27749

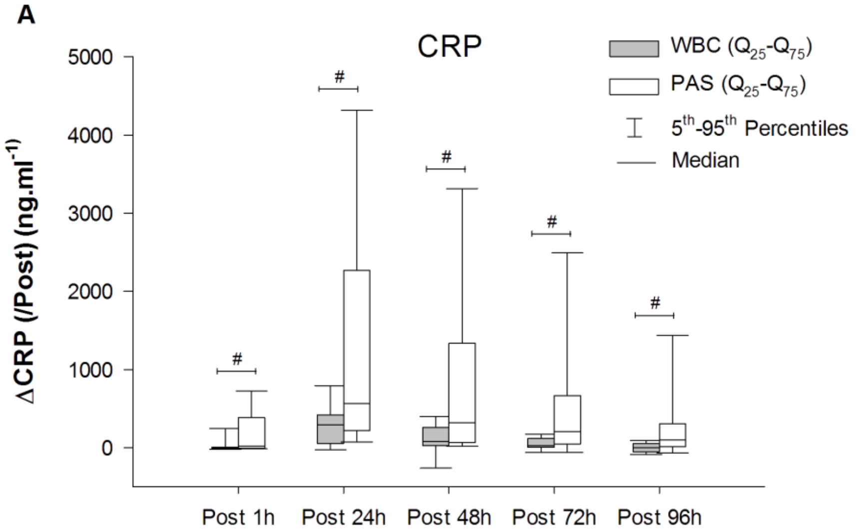
Hausswirth et al. Plos One 2011

INFLAMMATION AND WBC EXPOSURES



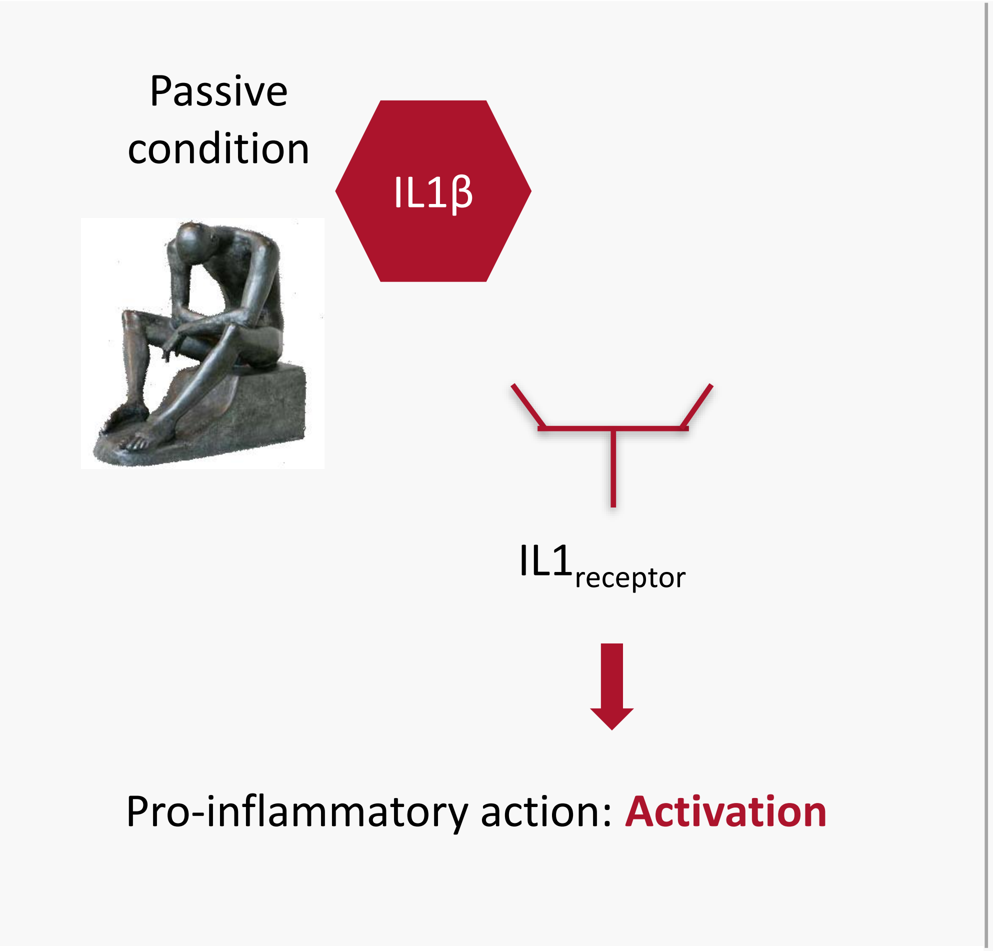






Pournot et al. PlosOne 2011

WBC: PHYSIOLOGICAL RESPONSE

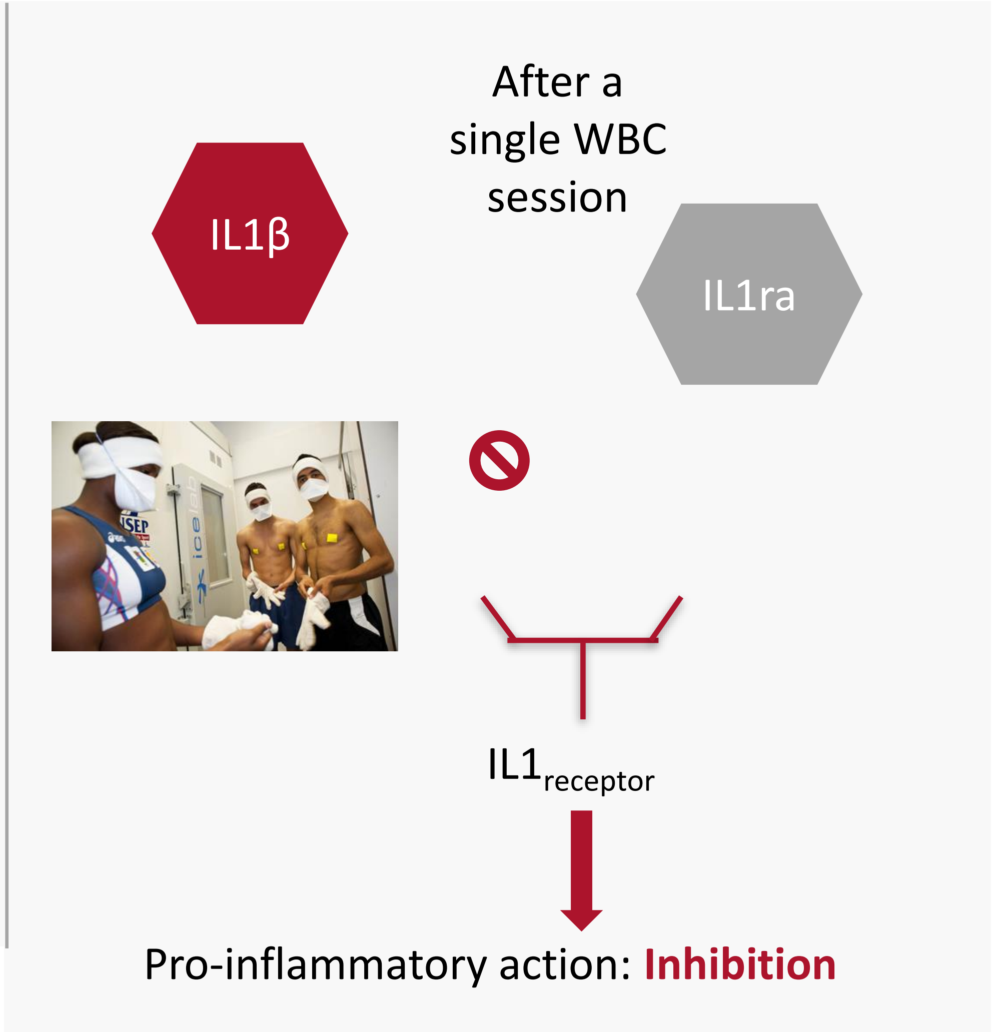


Passive condition

IL1β

IL1$_{receptor}$

Pro-inflammatory action: **Activation**



After a single WBC session

IL1β

IL1ra

IL1$_{receptor}$

Pro-inflammatory action: **Inhibition**

Pournot et al. PlosOne 2011

WBC VS. CWI VS. CWT

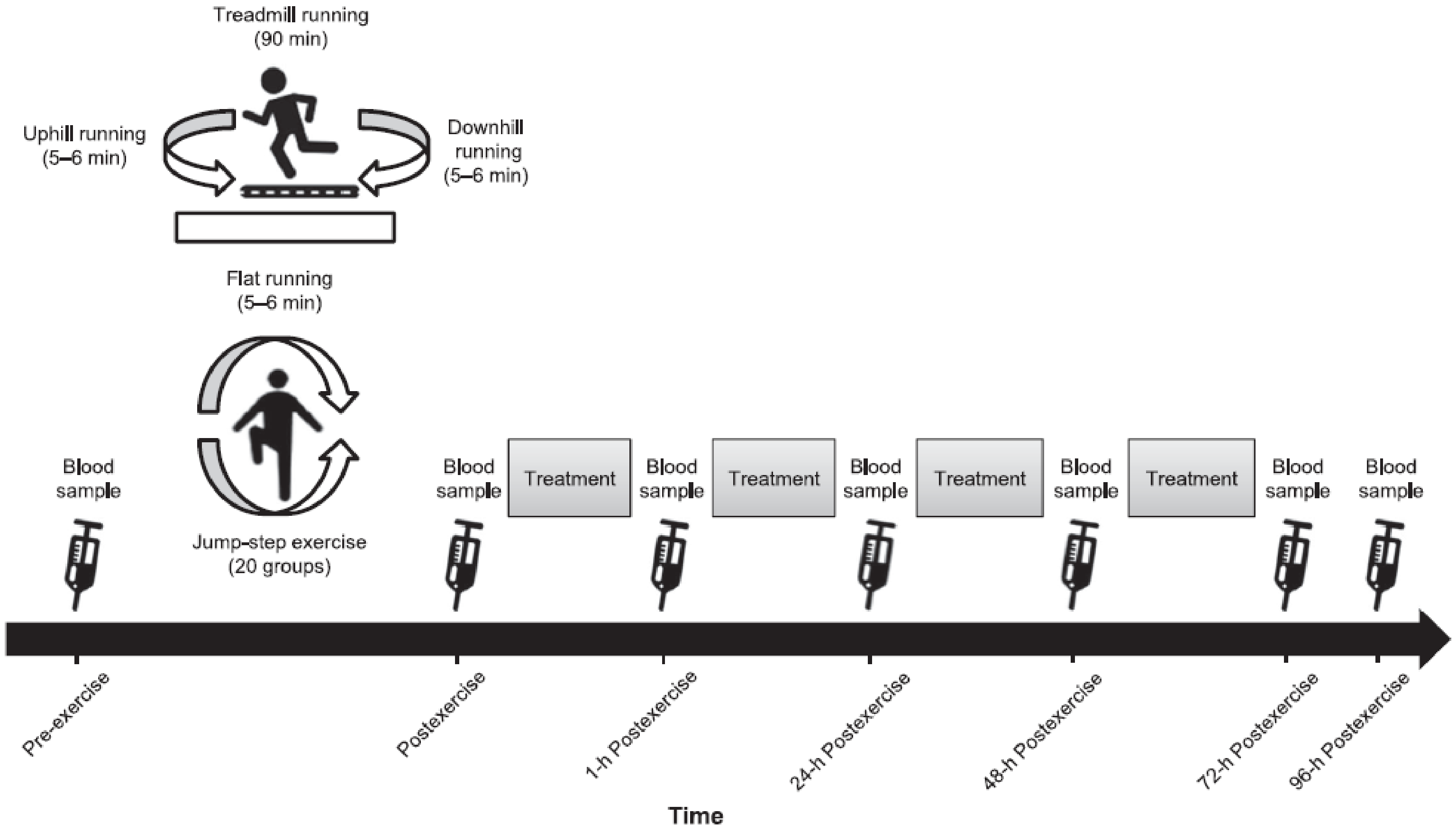


Figure 1. Study design for the 4 interventions: control, cold-water immersion, contrast-water therapy, and whole-body cryotherapy.

Qu Chaoyi et al. J Ath Training 2020

WBC VS. CWI VS. CWT

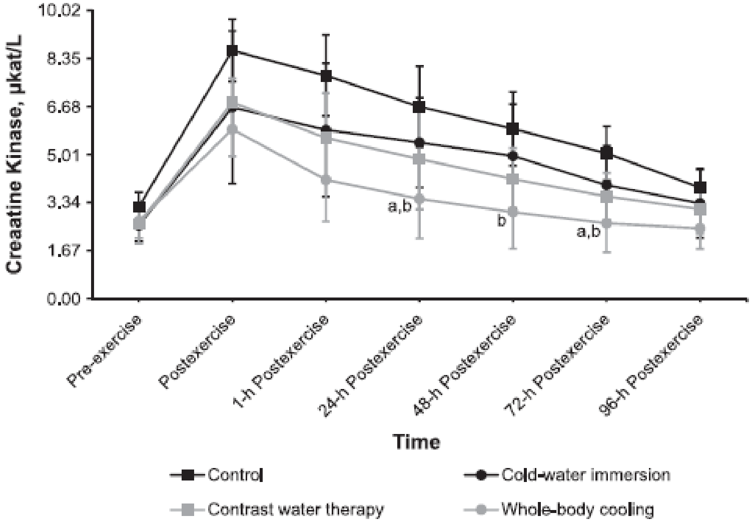


Figure 4. Effects of different cryotherapy models on plasma creatine kinase activity at 7 time points. ^{a} Different from the control intervention ($P < .05$). ^{b} Different from the cold-water–immersion intervention ($P < .05$).

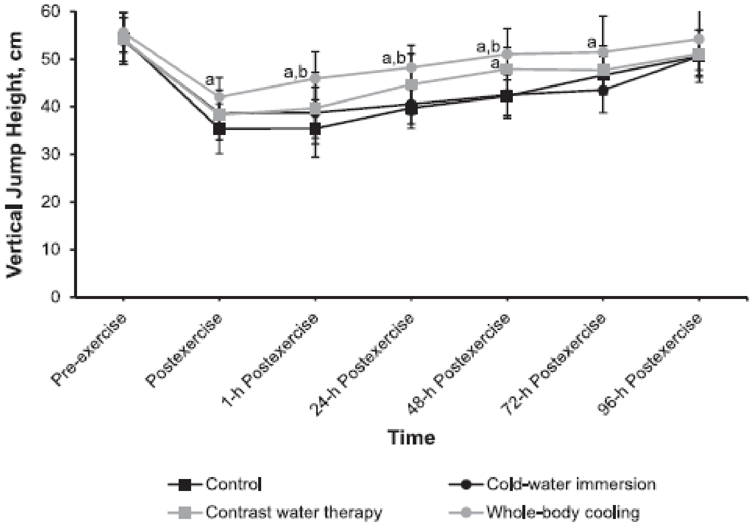


Figure 6. Effects of different cryotherapy models on vertical jump height at 7 time points. ^{a} Different from the control intervention ($P < .05$). ^{b} Different from the cold-water–immersion intervention ($P < .05$).

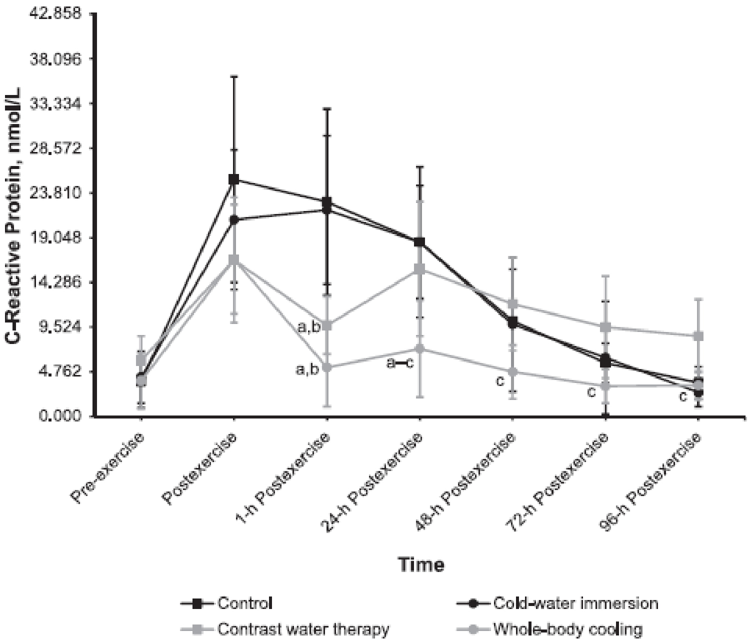
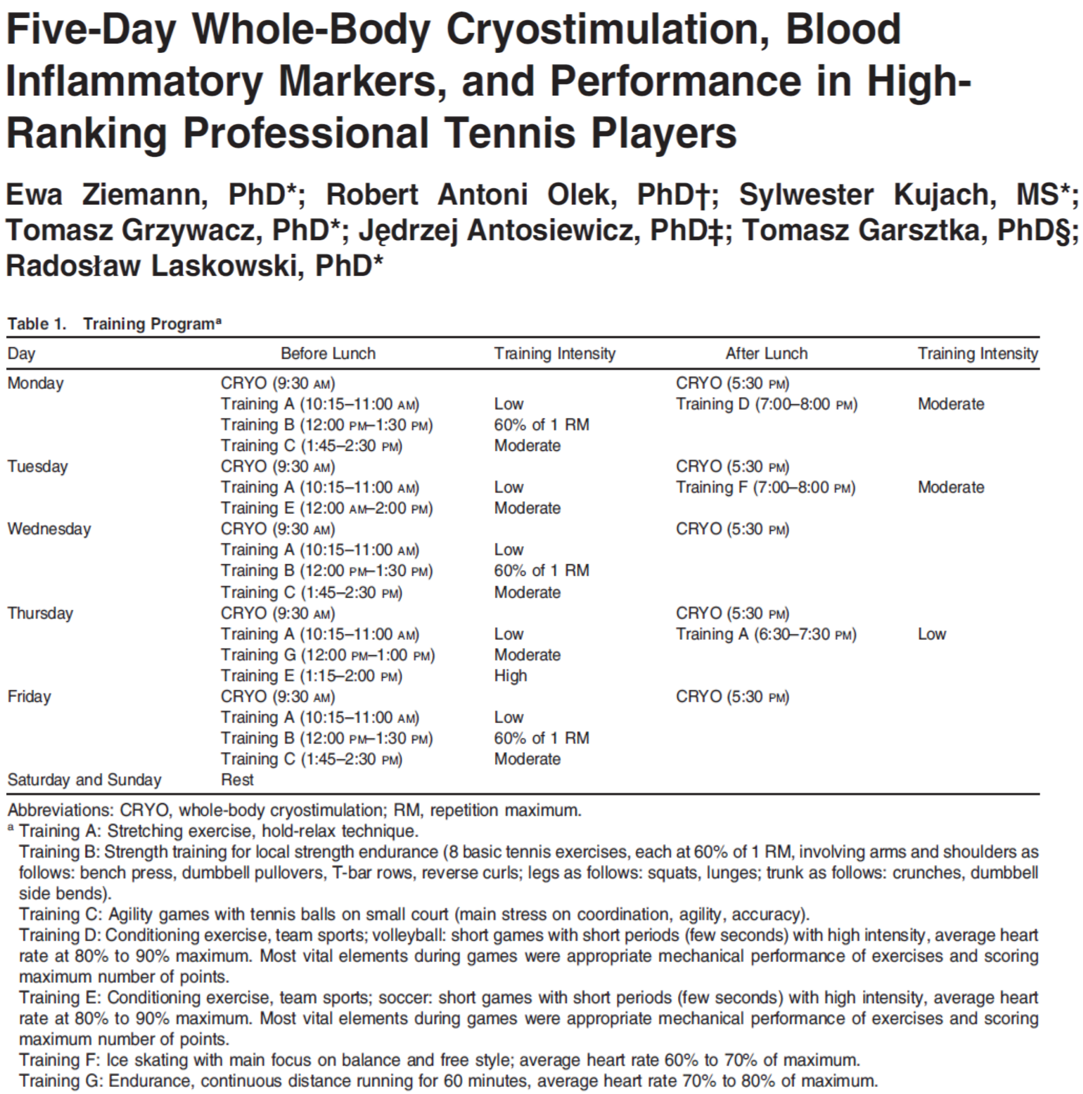


Figure 5. Effects of different cryotherapy models on plasma C-reactive protein activity at 7 time points. ^{a} Different from the control intervention ($P < .05$). ^{b} Different from the cold-water–immersion intervention ($P < .05$). ^{c} Different from the contrast-water–therapy intervention ($P < .05$).

Qu Chaoyi et al. J Ath Training 2020

INFLAMMATORY MARKERS AND TENNIS: WBC



Five-Day Whole-Body Cryostimulation, Blood Inflammatory Markers, and Performance in High-Ranking Professional Tennis Players

Ewa Ziemann, PhD*; Robert Antoni Olek, PhD†; Sylwester Kujach, MS*; Tomasz Grzywacz, PhD*; Jędrzej Antosiewicz, PhD‡; Tomasz Garsztka, PhD§; Radosław Laskowski, PhD*

Table 1. Training Program[a]

Day	Before Lunch	Training Intensity	After Lunch	Training Intensity
Monday	CRYO (9:30 AM)		CRYO (5:30 PM)	
	Training A (10:15–11:00 AM)	Low	Training D (7:00–8:00 PM)	Moderate
	Training B (12:00 PM–1:30 PM)	60% of 1 RM		
	Training C (1:45–2:30 PM)	Moderate		
Tuesday	CRYO (9:30 AM)		CRYO (5:30 PM)	
	Training A (10:15–11:00 AM)	Low	Training F (7:00–8:00 PM)	Moderate
	Training E (12:00 AM–2:00 PM)	Moderate		
Wednesday	CRYO (9:30 AM)		CRYO (5:30 PM)	
	Training A (10:15–11:00 AM)	Low		
	Training B (12:00 PM–1:30 PM)	60% of 1 RM		
	Training C (1:45–2:30 PM)	Moderate		
Thursday	CRYO (9:30 AM)		CRYO (5:30 PM)	
	Training A (10:15–11:00 AM)	Low	Training A (6:30–7:30 PM)	Low
	Training G (12:00 PM–1:00 PM)	Moderate		
	Training E (1:15–2:00 PM)	High		
Friday	CRYO (9:30 AM)		CRYO (5:30 PM)	
	Training A (10:15–11:00 AM)	Low		
	Training B (12:00 PM–1:30 PM)	60% of 1 RM		
	Training C (1:45–2:30 PM)	Moderate		
Saturday and Sunday	Rest			

Abbreviations: CRYO, whole-body cryostimulation; RM, repetition maximum.

[a] Training A: Stretching exercise, hold-relax technique.

Training B: Strength training for local strength endurance (8 basic tennis exercises, each at 60% of 1 RM, involving arms and shoulders as follows: bench press, dumbbell pullovers, T-bar rows, reverse curls; legs as follows: squats, lunges; trunk as follows: crunches, dumbbell side bends).

Training C: Agility games with tennis balls on small court (main stress on coordination, agility, accuracy).

Training D: Conditioning exercise, team sports; volleyball: short games with short periods (few seconds) with high intensity, average heart rate at 80% to 90% maximum. Most vital elements during games were appropriate mechanical performance of exercises and scoring maximum number of points.

Training E: Conditioning exercise, team sports; soccer: short games with short periods (few seconds) with high intensity, average heart rate at 80% to 90% maximum. Most vital elements during games were appropriate mechanical performance of exercises and scoring maximum number of points.

Training F: Ice skating with main focus on balance and free style; average heart rate 60% to 70% of maximum.

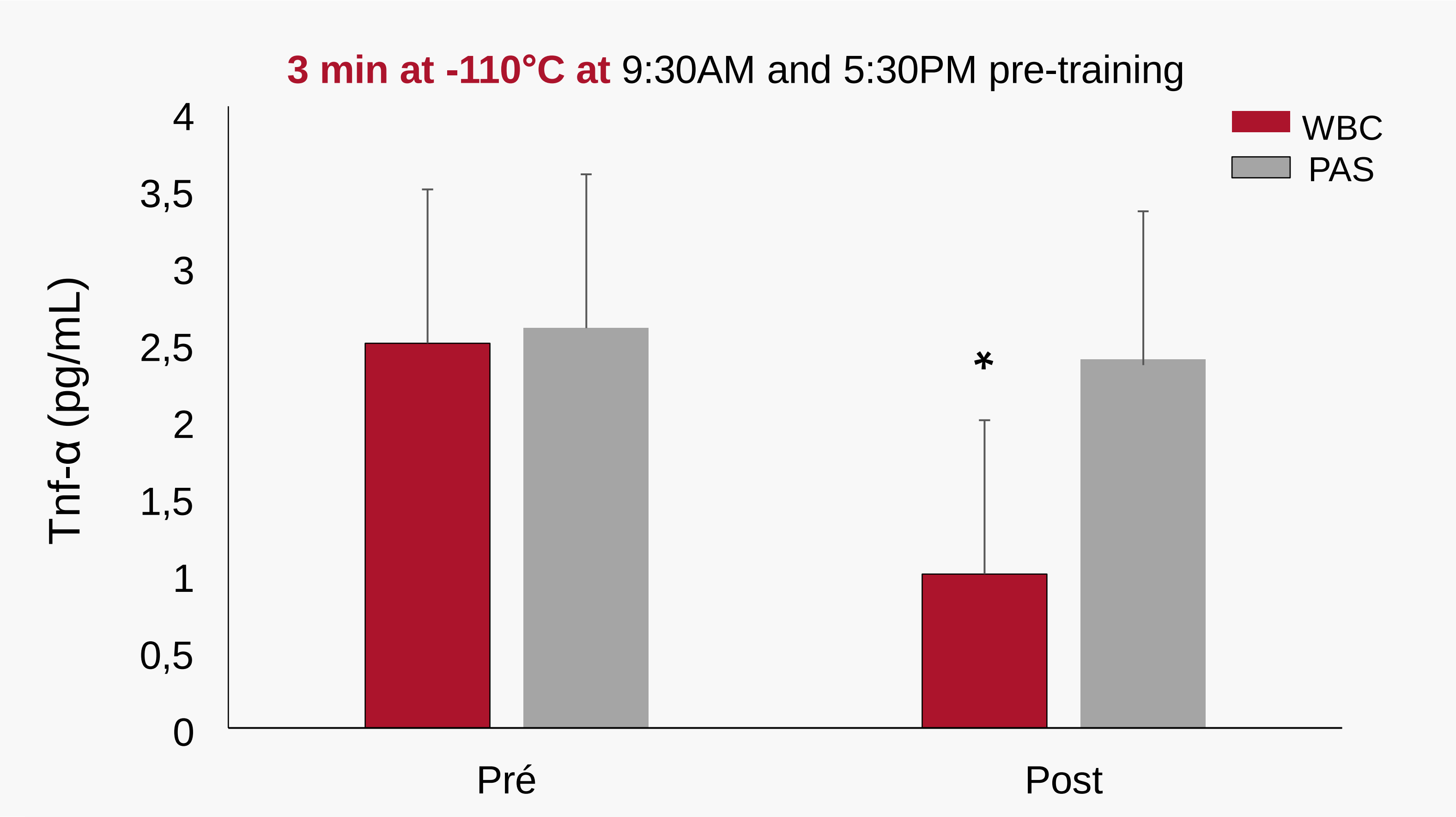
Training G: Endurance, continuous distance running for 60 minutes, average heart rate 70% to 80% of maximum.

- **12 players ATP**
- **10 sessions of 3 min,**
- **2 sessions per day**
- **Training programme « tennis & Physical »**
- **4200 Cal per day**

Ziemann et al. J Athle Tr 2012

INFLAMMATORY PROCESS & TENNIS: WBC

⚠ 10 sessions of WBC over 5 days help reduce inflammation during a tennis training camp.

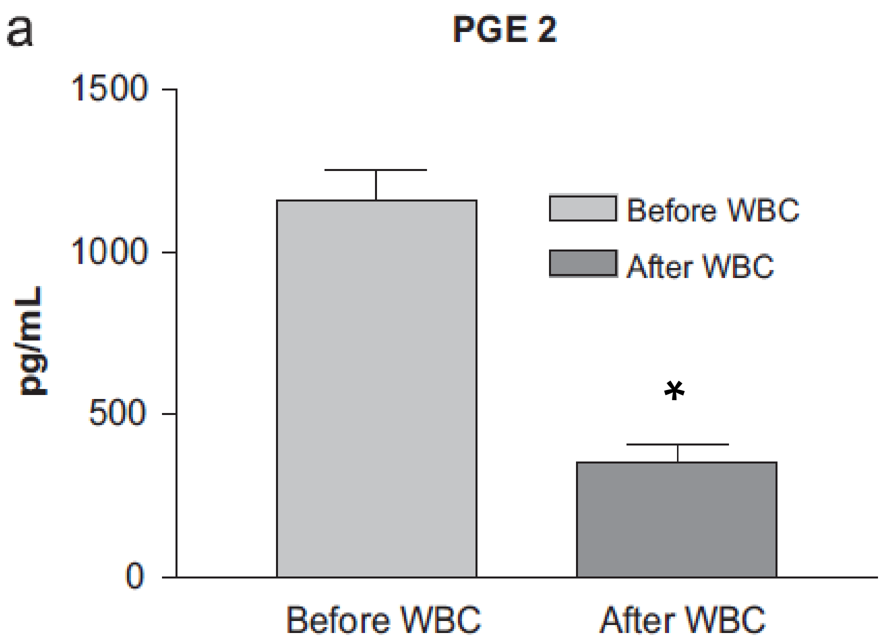


Ziemann et al. J Athle Tr 2012

INFLAMMATORY PROCESS & RUGBY: WBC

Effects of whole-body cryotherapy on serum mediators of inflammation and serum muscle enzymes in athletes

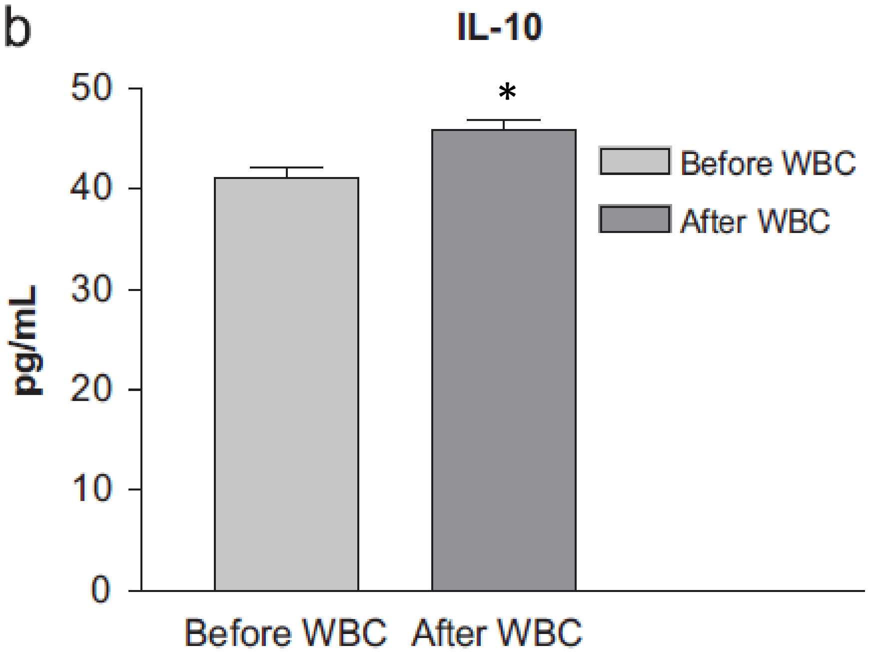
Giuseppe Banfi [a,b], Gianluca Melegati [a,c], Alessandra Barassi [d], Giada Dogliotti [e],
Gianvico Melzi d'Eril [d], Benoit Dugué [f], Massimiliano M. Corsi [a,e,*]

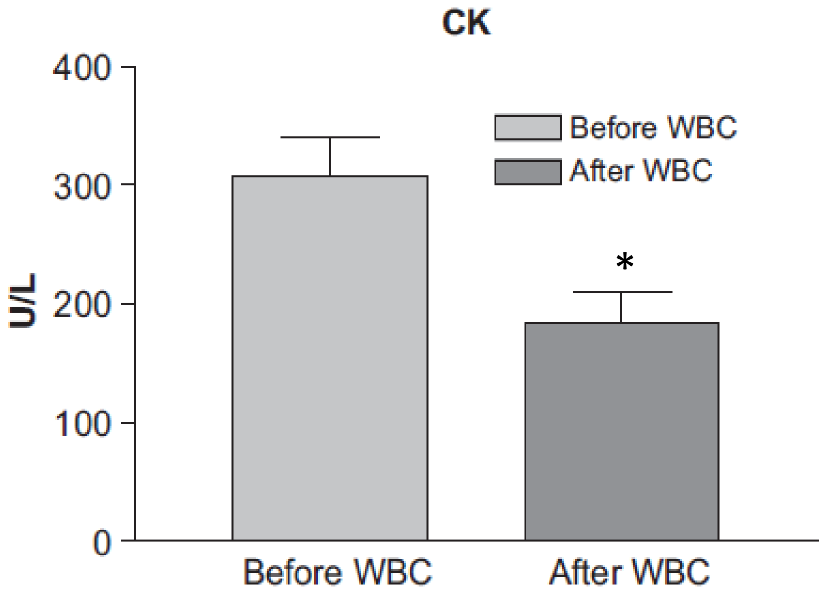


- 10 Elite Rugby players
- 5 sessions; one per day
- Training: rugby match.
- Cytokines and PGE2.

Banfi et al, 2008

INFLAMMATORY PROCESS & RUGBY: WBC

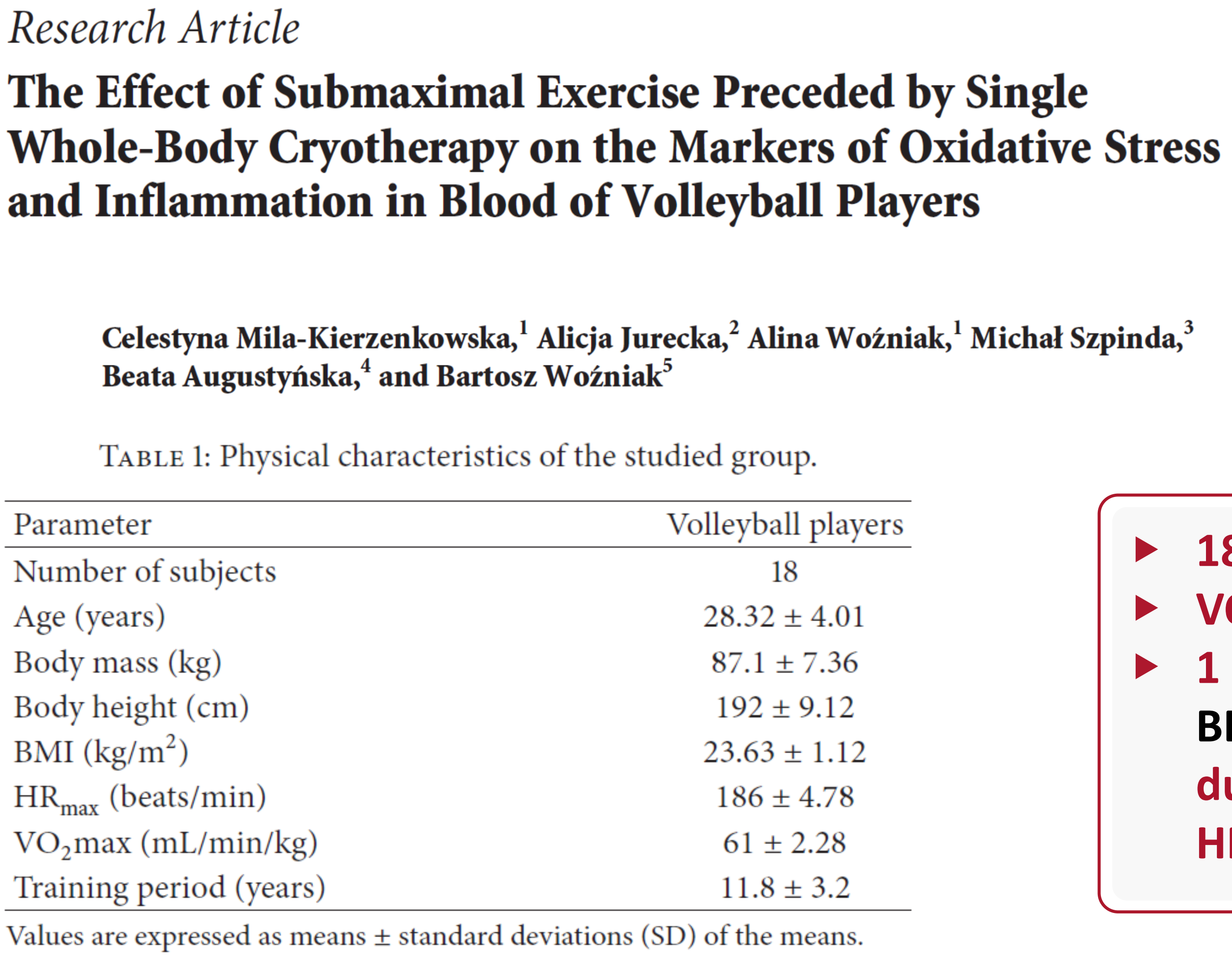




IL-10: anti-inflammatory cytokine (+++)
→ macrophage- and T-cell-mediated inflammation.

Banfi et al., 2008

INFLAMMATION IN VOLLEY-BALL



Research Article

The Effect of Submaximal Exercise Preceded by Single Whole-Body Cryotherapy on the Markers of Oxidative Stress and Inflammation in Blood of Volleyball Players

Celestyna Mila-Kierzenkowska,[1] Alicja Jurecka,[2] Alina Woźniak,[1] Michał Szpinda,[3] Beata Augustyńska,[4] and Bartosz Woźniak[5]

Table 1: Physical characteristics of the studied group.

Parameter	Volleyball players
Number of subjects	18
Age (years)	28.32 ± 4.01
Body mass (kg)	87.1 ± 7.36
Body height (cm)	192 ± 9.12
BMI (kg/m^2)	23.63 ± 1.12
HR$_{max}$ (beats/min)	186 ± 4.78
VO$_2$max (mL/min/kg)	61 ± 2.28
Training period (years)	11.8 ± 3.2

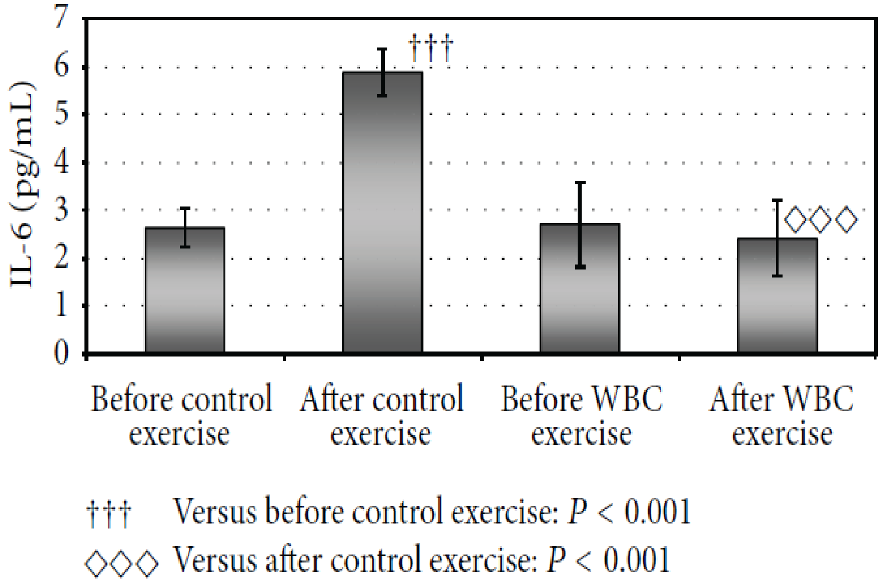
Values are expressed as means ± standard deviations (SD) of the means.

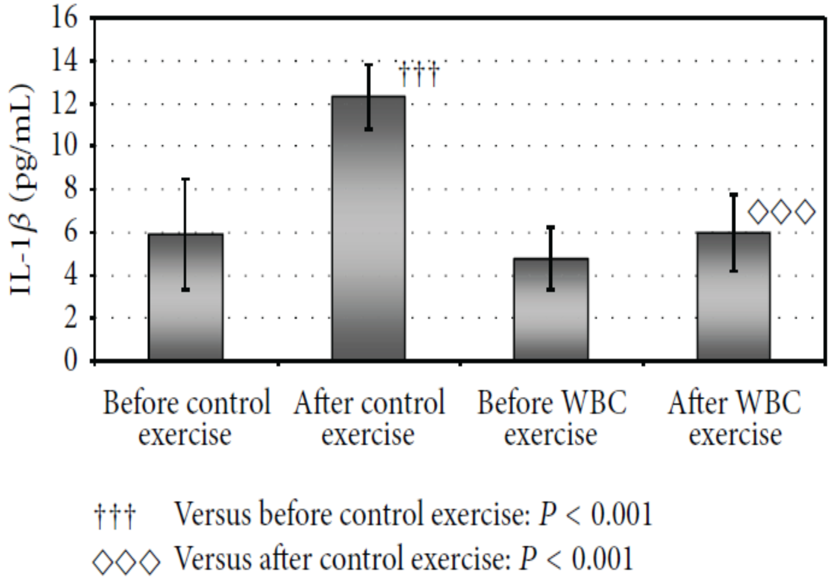
- **18 athletes;**
- **VO$_{2max}$: 61 ml.O$_2$/min/kg;**
- **1 session of 2 min at -130°C BEFORE ergocycling (160W during 40min, *i.e.* 85% HRmax).**

Mila-Kierzenkowska et al. Oxid Med Cell Longev 2013.

INFLAMMATION IN VOLLEY-BALL

1 pre-exercise CCE session helps prevent pro-inflammatory cytokine elevation

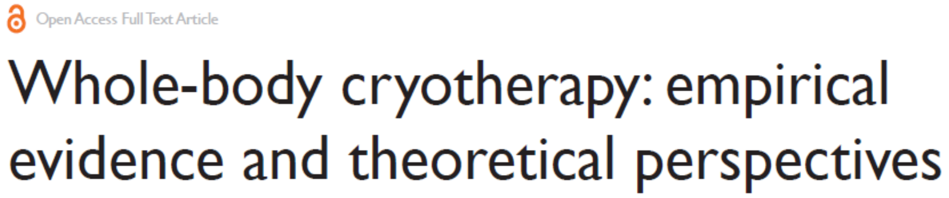




beScored Institute

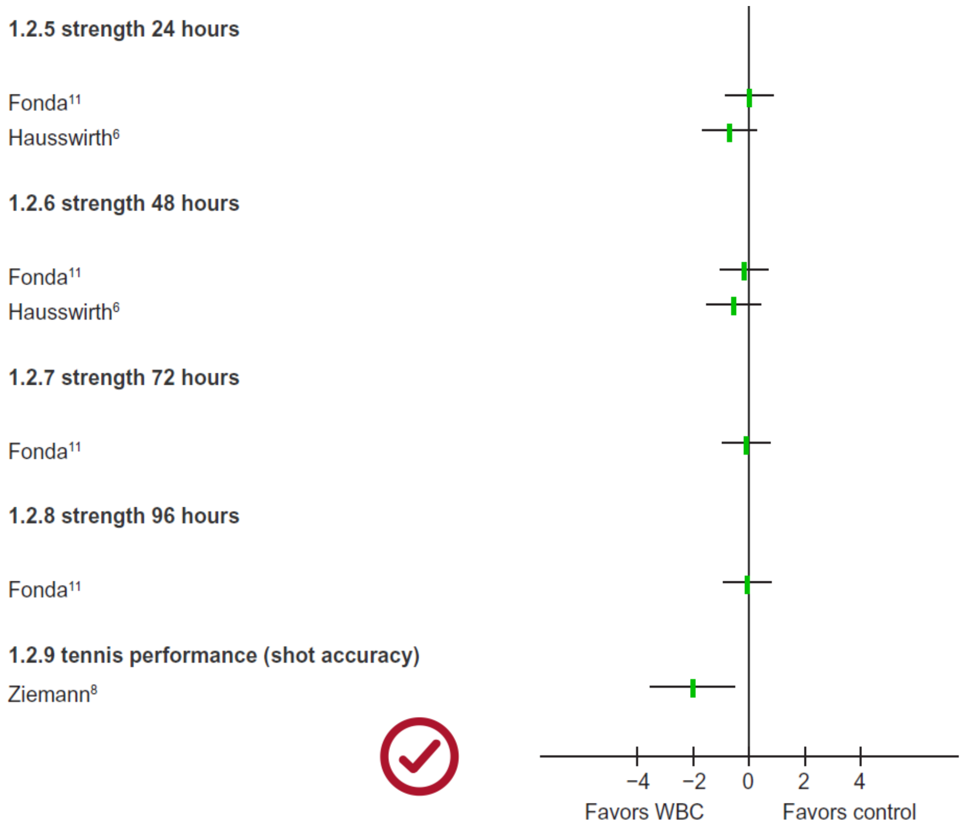
Mila-Kierzenkowska et al. Oxid Med Cell Longev 2013

META-ANALYSIS : WBC and FORCE LEVEL POST-FATIGUE



Open Access Full Text Article

Whole-body cryotherapy: empirical evidence and theoretical perspectives



Beakley et al. Cochrane 2014

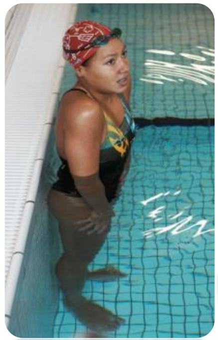
WBC and IN-BETWEEN RECOVERY

In the context of 2 closely scheduled maximal exercise bouts,

to evaluate the effect of 4 recovery techniques including two cooling methods, on:

30min Active recovery (swim & sync. Swim)

Whole-body cryotherapy (3min)



15 min Contrast-Water therapy

30 min Passive recovery

1. Metabolic indicators of recovery and subsequent exercise capacity
2. Postexercise parasympathetic reactivation, as assessed through HRV analysis

1

NRC Research Press

ARTICLE

Effect of recovery mode on postexercise vagal reactivation in elite synchronized swimmers

Karine Schaal, Yann Le Meur, François Bieuzen, Odile Petit, Philippe Hellard, Jean-François Toussaint, and Christophe Hausswirth

Abstract: This study investigated the effect of whole-body cryostimulation (WBC), contrast-water therapy (CWT), active recovery (ACT), and passive condition (PAS) protocols on the parasympathetic reactivation and metabolic parameters of recovery in elite synchronized swimmers who performed 2 simulated competition ballets (B1 and B2) separated by 70 min. After determining maximal oxygen consumption ($\dot{V}O_{2max400}$) and blood lactate concentrations ($[La^-]_{b400}$) during a 400-m swim trial, 11 swimmers performed 1 protocol per week in randomized order. Heart rate variability (HRV) was measured at rest (PreB1), 5 min after B1 (PostB1), before B2 (PreB2), and 5 min after B2 (PostB2). $\dot{V}O_{2peak}$ was measured at PostB1 and PostB2, and $[La^-]_b$ was measured at PostB1, PreB2, and PostB2. PostB1 $\dot{V}O_{2peak}$ and $\dot{V}O_{2max400}$ were similar, but PostB1 $[La^-]_b$ was higher than $[La^-]_{b400}$ ($p = 0.004$). Each ballet caused significant decreases in HRV indices. At PreB2, all HRV indices had returned to PreB1 levels in the CWT, PAS, and ACT protocols, whereas the WBC protocol yielded a 2- to 4-fold increase in vagal-related HRV indices, compared with PreB1. WBC and ACT both increased $[La^-]_b$ recovery, compared with PAS ($p = 0.06$ and $p = 0.04$, respectively), and yielded an increased $\dot{V}O_{2peak}$ from B1 to B2; however, it decreased after PAS (+5.4%, +3.4%, and –3.6%; $p < 0.01$). This study describes the physiological response to repeated maximal work bouts that are highly specific to elite synchronized swimming. In the context of short-term recovery, WBC yields a strong parasympathetic reactivation, and shows similar effectiveness to ACT on the metabolic parameters of recovery and subsequent exercise capacity.

Key words: [illegible] cryotherapy, female athlete, heart rate variability, maximal exercise, water im[illegible] active recovery.

[illegible] : Cette étude analyse l'effet de la cryostimulation de [illegible] entier [illegible] WBC »), de la thérapie [illegible] contraste de température (« CWT »), des protocoles [illegible] (« ACT ») [illegible] (PAS) sur la réactivation sympathique [illegible] paramètres [illegible] de la récupération chez des [illegible] synchronisée de niveau [illegible] réalisant deux chorégraphies (B1 et B2) en compétition simulée [illegible] 70 min d'intervalle. [illegible] l'évaluation [illegible] maximale d'oxygène ($\dot{V}O_{2max400}$) et de la concentration [illegible] de lactate ($[La^-]_{b400}$) [illegible] d'une [illegible] de [illegible] nage, 11 [illegible] participent de façon aléatoire à [illegible] conditions expérimentales à raison d'une par semaine. On évalue la variabilité du rythme cardiaque (HRV) au repos (PreB1), 5 min après B1 (PostB1), avant B2 (PreB2) et [illegible] B2 (PostB2). On évalue le $\dot{V}O_2$ de pointe à PostB1 et à PostB2 de même que la [La⁻]b à PostB1, PreB2 et PostB2. À PostB1, le $\dot{V}O_2$ de pointe est similaire au $\dot{V}O_{2max400}$, mais la [La⁻]b est supérieure à $[La^-]_{b400}$ ($p = 0,004$). Chaque chorégraphie suscite une diminution significative des indices de HRV. À PreB2 dans les conditions [illegible] et ACT, tous les indices de HRV présentent des valeurs observées à PreB1, mais dans la condition WBC, on observe 2 à 4 fois plus d'augmentation de la valeur des indices HRV associés aux fonctions vagales, comparativement à PreB1. Dans les conditions WBC et ACT, on observe une augmentation de la $[La^-]_b$ de récupération comparativement à la condition PAS ($p = 0,06$ et $p = 0,04$); de plus, dans les conditions WBC et ACT, on observe une augmentation du $\dot{V}O_2$ de pointe de B1 à B2, lequel diminue après PAS (+5,4%, +3,4% et –3,6%, $p < 0,01$). Cette étude décrit des ajustements physiologiques à des séances répétées d'exercice maximal spécifique à la ~~nage~~ synchronisée de niveau élite. Dans un contexte de récupération brève, WBC révèle une importante réactivation parasympathique et s'avère aussi efficace qu'ACT dans la récupération des variables métaboliques et de la capacité physique subséquente. [Traduit par la Rédaction]

Mots-clés : cryothérapie globale, athlète féminine, variabilité du rythme cardiaque, exercice maximal, immersion dans l'eau, récupération active.

Introduction

Synchronized swimming is an aesthetic and highly technical judged sport that has become increasingly physically demanding over the past decades. In addition to developing artistic, technical, and acrobatic skills, elite synchronized swimmers must follow a high-volume, high-intensity regimen to optimize strength, flexibility, and aerobic and anaerobic exercise capacity (Liang et al. 2005; Mountjoy 2009) because these physiological parameters are directly correlated to performance scores in elite competition settings (Yamamura et al. 1999).

At the international level, synchronized swimmers usually perform 2 or more training sessions per day, with few days of rest (Liang et al. 2005). Hence, in the practical scheduling of so many training hours, the time spans allotted for physical recovery between training sessions can be fairly short. Likewise, during competitions, the various ballet performances are sometimes closely scheduled, and accelerating the postexercise return to resting physiological levels after each performance is particularly important to maintain a consistent level of execution throughout the competition.

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J.-F. Toussaint. Sports Biomedical and Epidemiological Research Institute (IRMES), National Institute of Sport, Expertise and Performance (INSEP), Paris, France; Paris-Descartes University, Paris, France; Sports Medicine Investigation Center (CIMS), Hôtel-Dieu, Assistance Publique des Hôpitaux de Paris, Paris, France.
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Appl. Physiol. Nutr. Metab. 38: 1–9 (2013) dx.doi.org/10.1139/apnm-2012-0155

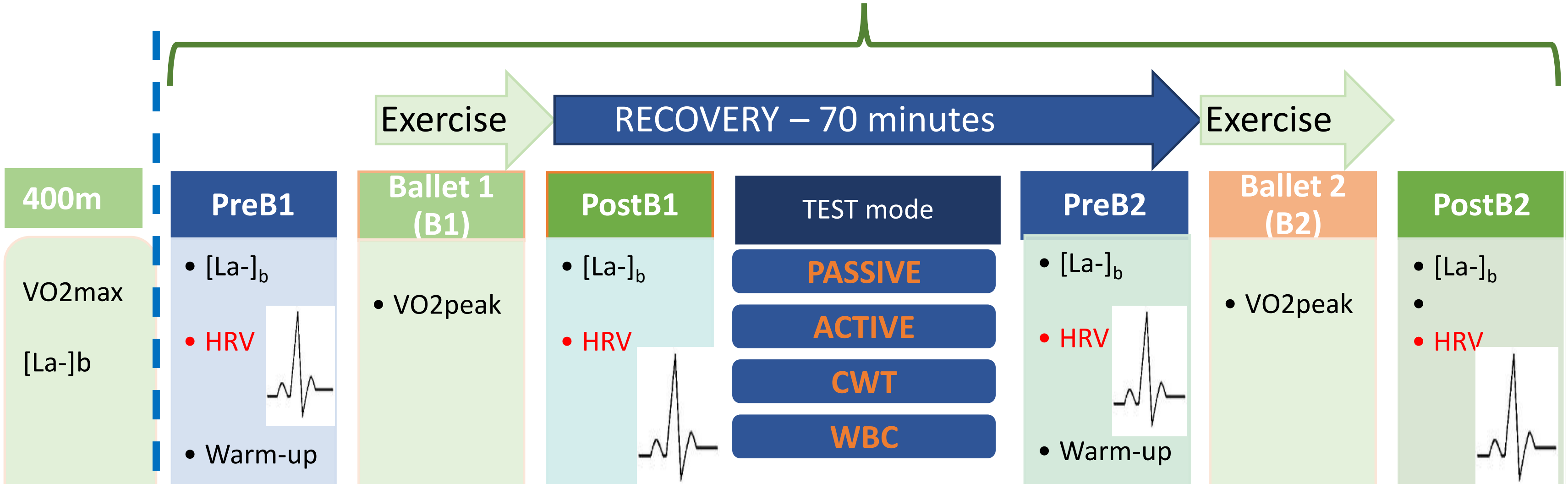
APPROVED

Schaal et al. APNM, 2013

METHODS – Study Design

Participants:
11 elite synchronised swimmers
20.3 ± 1.8 years old
$VO2_{max}$: 62.4 ± mL /min/kg

4 trials, randomised order



Exercise

RECOVERY – 70 minutes

Exercise

400m

VO2max

[La-]b

PreB1

- $[La\text{-}]_b$
- HRV
- Warm-up

Ballet 1 (B1)

- VO2peak

PostB1

- $[La\text{-}]_b$
- HRV

TEST mode

PASSIVE

ACTIVE

CWT

WBC

PreB2

- $[La\text{-}]_b$
- HRV
- Warm-up

Ballet 2 (B2)

- VO2peak

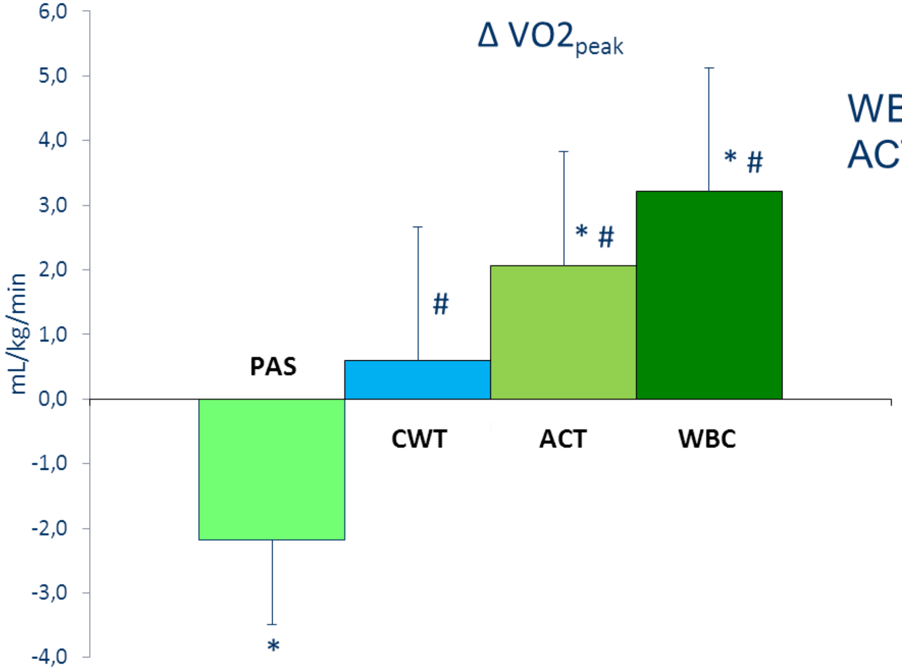
PostB2

- $[La\text{-}]_b$
-
- HRV

VO_2 by retro-extrapolation

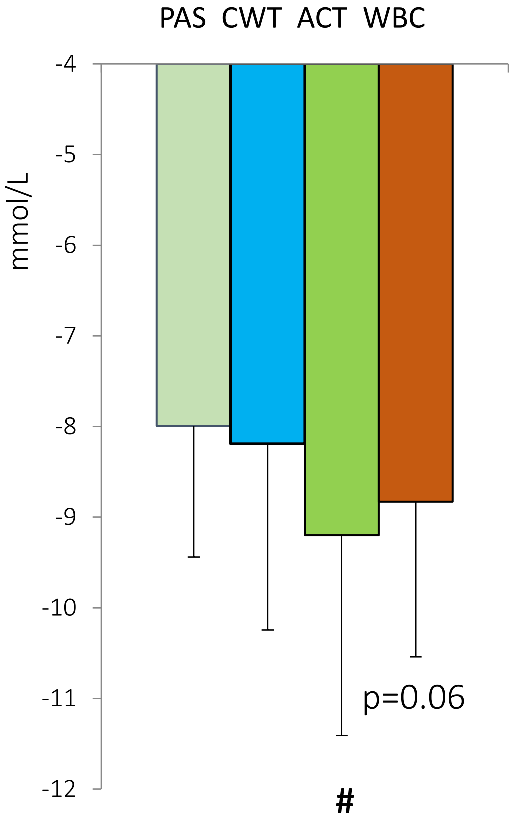
Schaal et al. APNM, 2013

Results: Metabolic Variables



WBC: +5.4%
ACT: + 3.4%

Change in $[La^-]_b$ during recovery



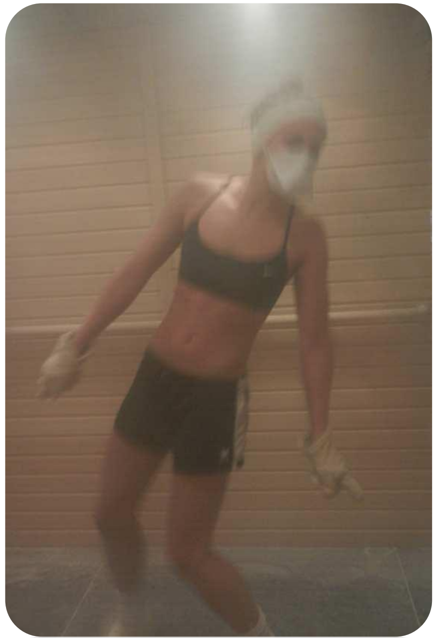
Values are mean ± SD.

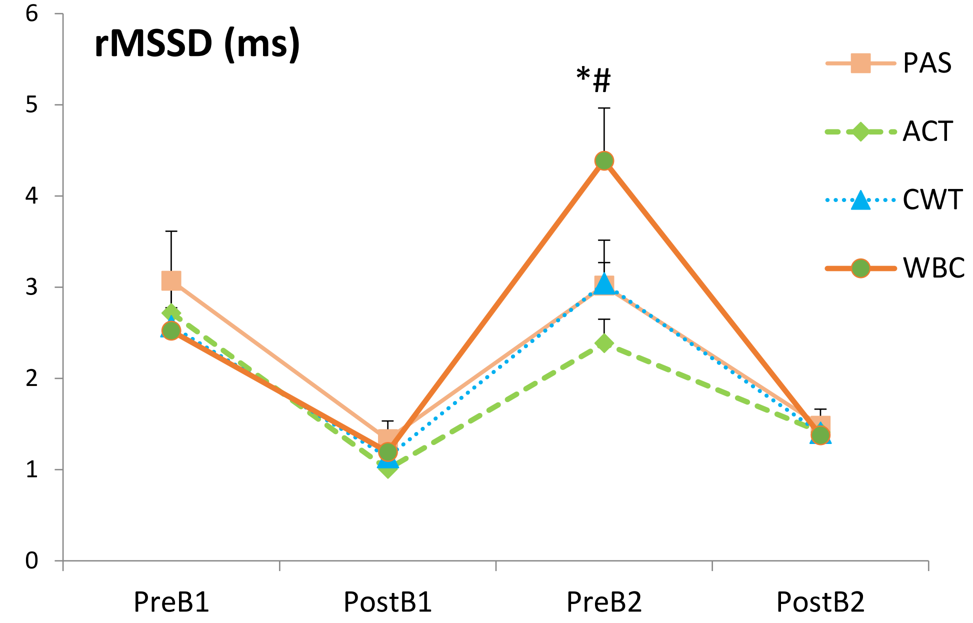
#, different from PAS ($p<0.05$)

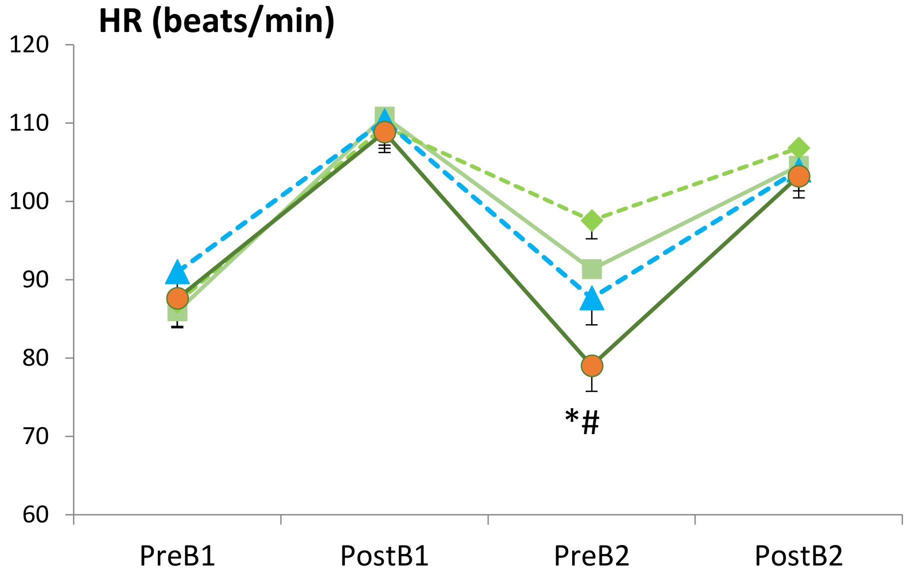
*, significant difference from PreB1 and PreB2 ($p<0.05$) , Wilcoxon test

Schaal et al. APNM, 2013

Results: Heart Rate Variability (HRV)







Mean ± SEM
*, different from PreB1 (p<0.05).
#, different from PAS (p<0.05)

Schaal et al. APNM, 2013

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SLEEP QUALITY AND FUNCTIONAL OVERREACHING: WBC VS. CONTROL

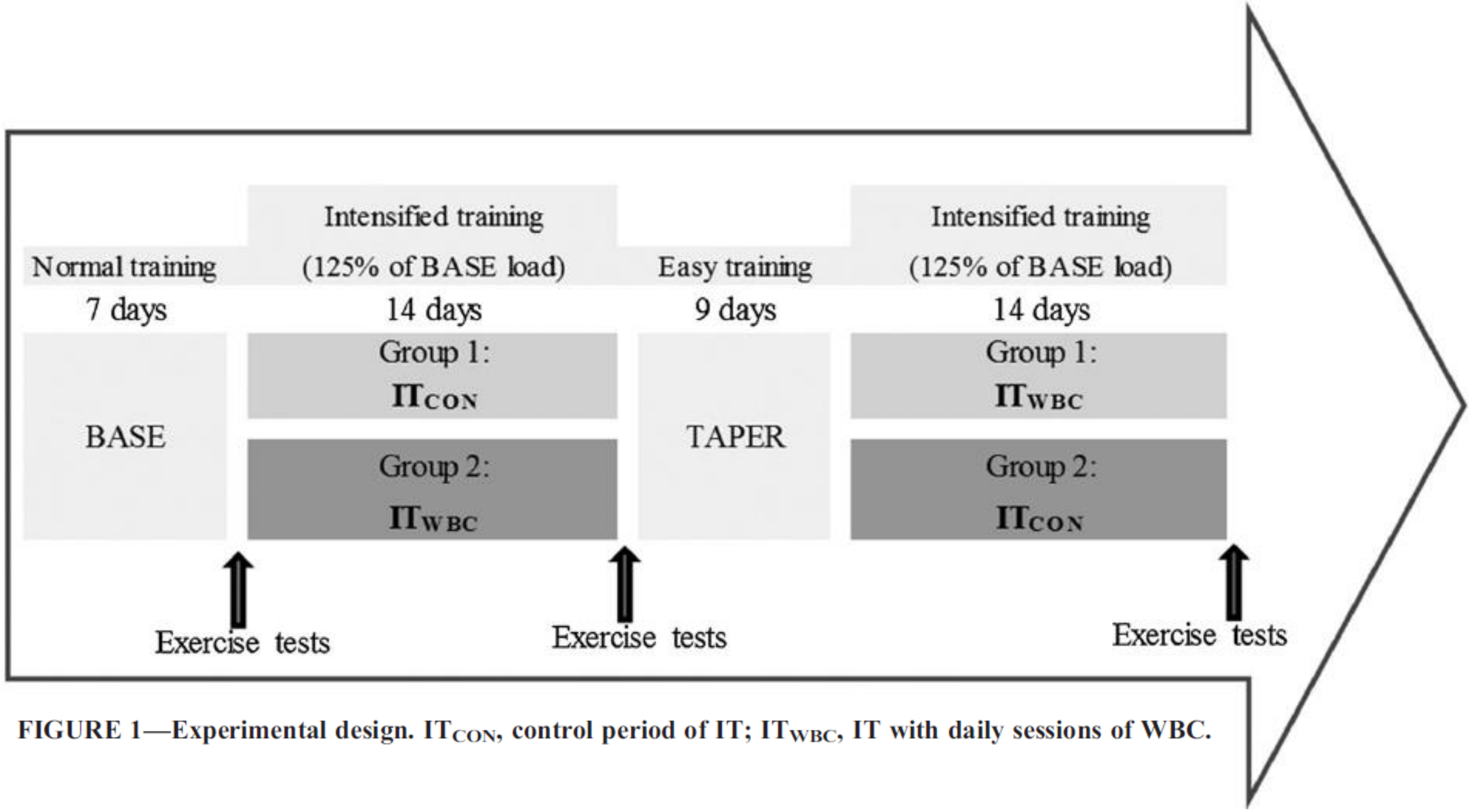
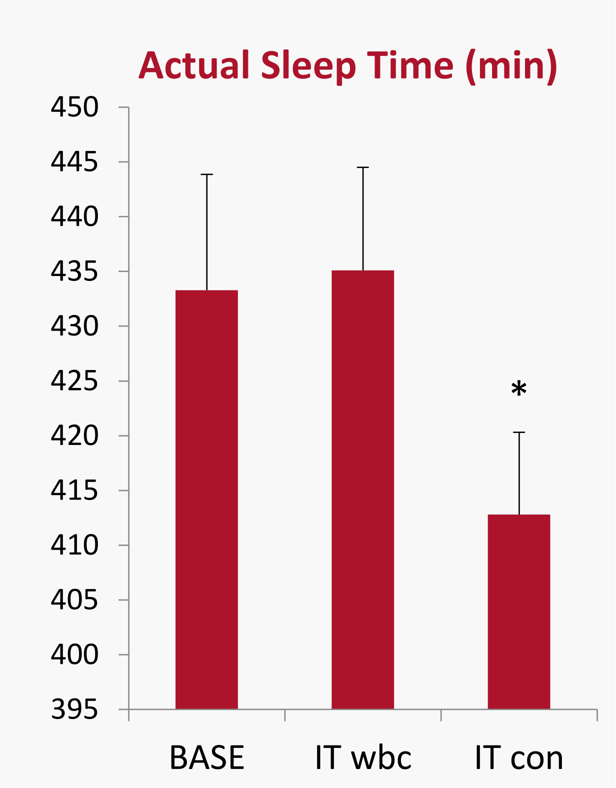


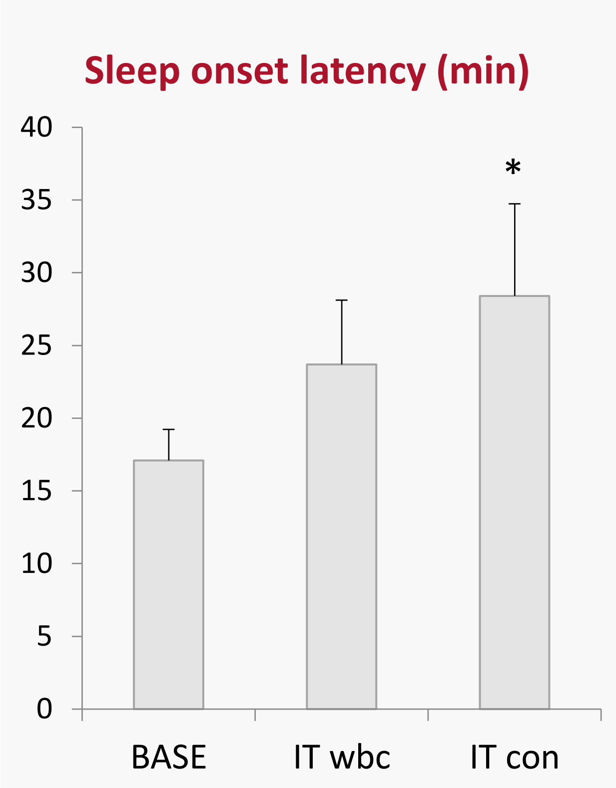
FIGURE 1—Experimental design. IT_{CON}, control period of IT; IT_{WBC}, IT with daily sessions of WBC.

Schaal et al. Med Sci Sport Exer 2015

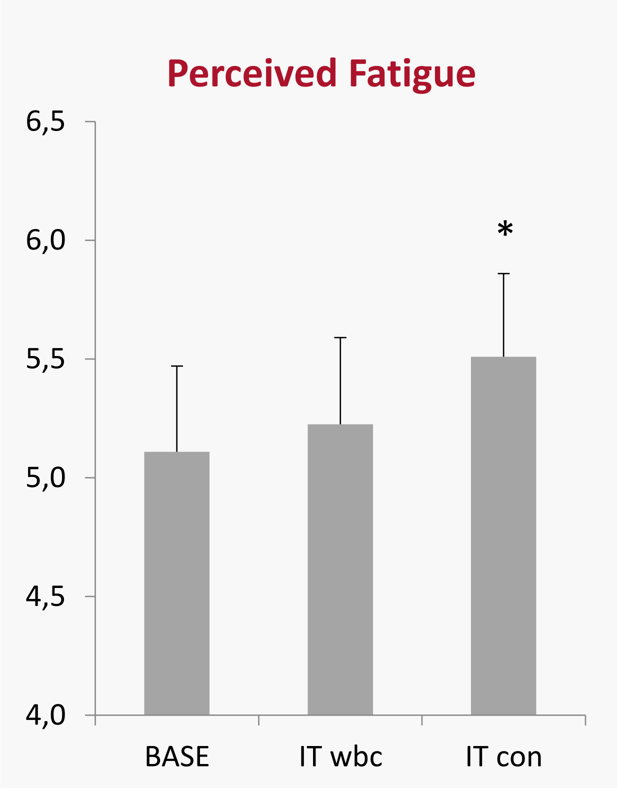
SLEEP QUALITY AND FUNCTIONAL OVERREACHING: WBC VS. CONTROL



Actual Sleep Time (min)



Sleep onset latency (min)



Perceived Fatigue

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SLEEP QUALITY AND FUNCTIONAL OVERREACHING: WBC VS. CONTROL

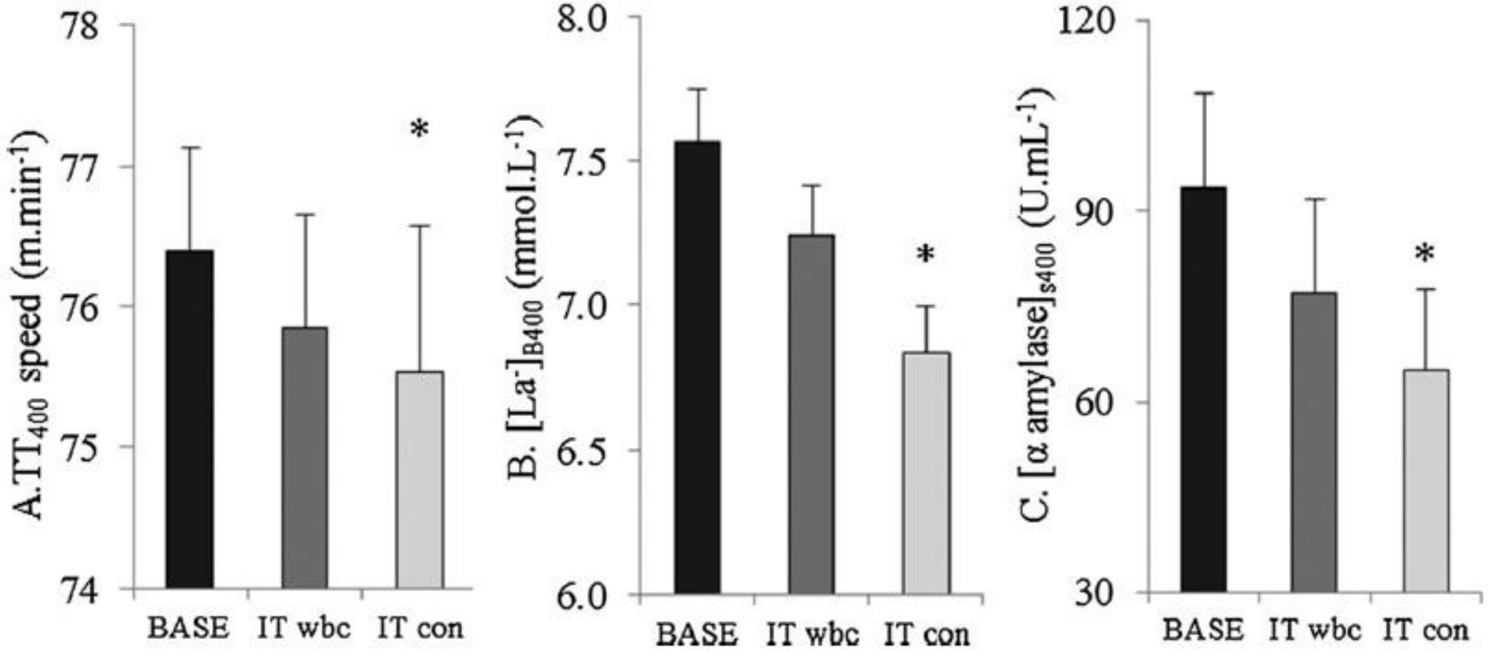


FIGURE 2—Maximal exercise performance and physiological response to 400-m swimming time trial. A, TT_{400} speed ($m{\cdot}min^{-1}$). B, $[La^{-}]_{B400}$ ($mmol{\cdot}L^{-1}$). C, $[\alpha\text{-amylase}_s]_{400}$ ($U{\cdot}mL^{-1}$). D, HR (bpm). *Significantly different from BASE, $P < 0.05$.

Schaal et al. Med Sci Sport Exer 2015

WBC: TAKE-HOME MESSAGES

IN ACUTE EXPOSITION

- One session of WBC can be programmed to maintain force generation after severe exercise
- After sport when we want to improve perceptual recovery: better well-being, less DOMS, less tiredness
- Beneficial for all sports involving muscle damage or eccentric exercise

IN CHRONIC EXPOSITION

- Prevent functional overreaching
- Facilitate sleep quality with increasing training loads
- No inhibitory effect on mitochondrial biogenesis and cycling performance

Qu Chaoyi et al. J Ath Training 2020

WBC: WHEN ?

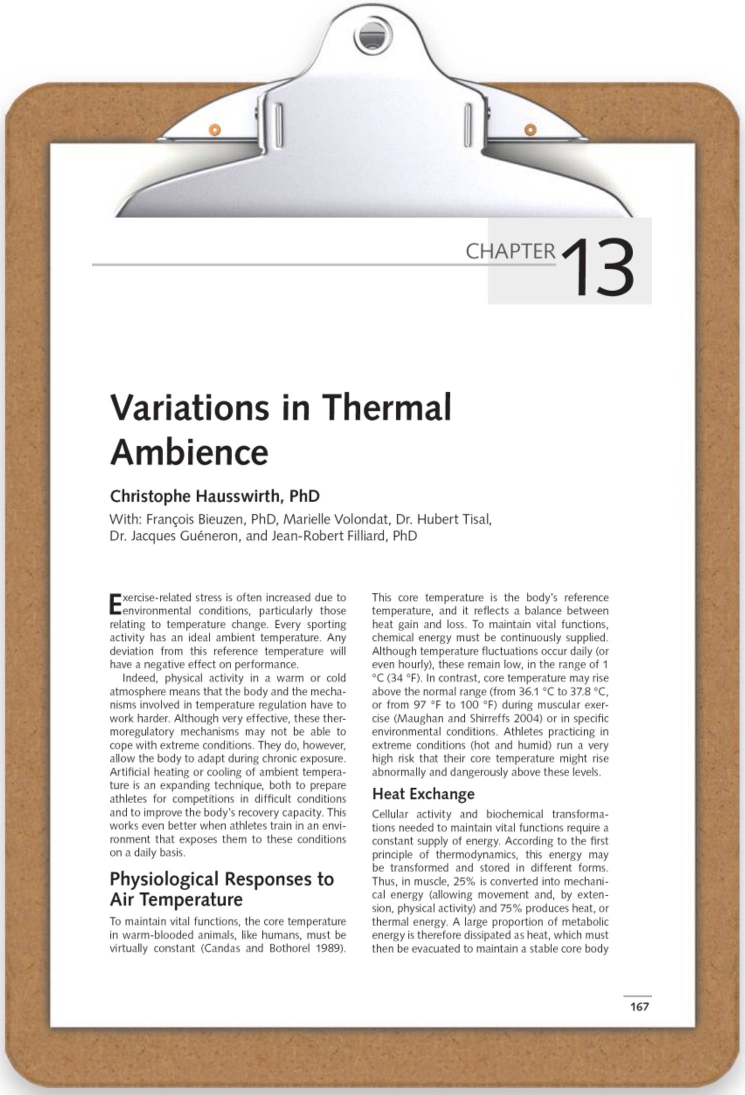
👍

- During a week with heavy loads.
- Between two events with light recovery (Ex: 2/3 matches in a week).
- Intense muscle soreness

👎

- Daily care:
  - ??? Training = stress → Adaptations.
  - In principle, it's not limiting.
  - What about protein synthesis? PGC1α?

TO FIND OUT MORE…



CHAPTER 13

Variations in Thermal Ambience

Christophe Hausswirth, PhD

With: François Bieuzen, PhD, Marielle Volondat, Dr. Hubert Tisal,
Dr. Jacques Guéneron, and Jean-Robert Filliard, PhD

Exercise-related stress is often increased due to environmental conditions, particularly those relating to temperature change. Every sporting activity has an ideal ambient temperature. Any deviation from this reference temperature will have a negative effect on performance.

Indeed, physical activity in a warm or cold atmosphere means that the body and the mechanisms involved in temperature regulation have to work harder. Although very effective, these thermoregulatory mechanisms may not be able to cope with extreme conditions. They do, however, allow the body to adapt during chronic exposure. Artificial heating or cooling of ambient temperature is an expanding technique, both to prepare athletes for competitions in difficult conditions and to improve the body's recovery capacity. This works even better when athletes train in an environment that exposes them to these conditions on a daily basis.

Physiological Responses to Air Temperature

To maintain vital functions, the core temperature in warm-blooded animals, like humans, must be virtually constant (Candas and Bothorel 1989). This core temperature is the body's reference temperature, and it reflects a balance between heat gain and loss. To maintain vital functions, chemical energy must be continuously supplied. Although temperature fluctuations occur daily (or even hourly), these remain low, in the range of 1 °C (34 °F). In contrast, core temperature may rise above the normal range (from 36.1 °C to 37.8 °C, or from 97 °F to 100 °F) during muscular exercise (Maughan and Shirreffs 2004) or in specific environmental conditions. Athletes practicing in extreme conditions (hot and humid) run a very high risk that their core temperature might rise abnormally and dangerously above these levels.

Heat Exchange

Cellular activity and biochemical transformations needed to maintain vital functions require a constant supply of energy. According to the first principle of thermodynamics, this energy may be transformed and stored in different forms. Thus, in muscle, 25% is converted into mechanical energy (allowing movement and, by extension, physical activity) and 75% produces heat, or thermal energy. A large proportion of metabolic energy is therefore dissipated as heat, which must then be evacuated to maintain a stable core body

- **Hausswirth C. & Mujika I (2013)**

Recovery for performance in sport

Eds. Human kinetics, pp386.

Do you know the 3 pillars of sports recovery?

WHAT ABOUT IMMERSION?

IMMERSION (PROTOCOLES)

- This recovery technique involves immersing **part** or **all of the body** in water.
- In the scientific literature, **four immersion modalities** (different according to water temperature) are mainly studied.

- **Cold Water Immersion (CWI)**
  8°C to 15°C / 5 to 15 min
- **Temperate Immersion**
  18°C to 36°C / 25 min
- **Hot Water Immersion (HWI)**
  36°C to 42°C / 10 to 15 min
- **Contrasted Water Immersion (CWI) :**
  alternative cold/hot/cold from 10 to 30 min

NEW DOSE-RESPONSES FOR CWI

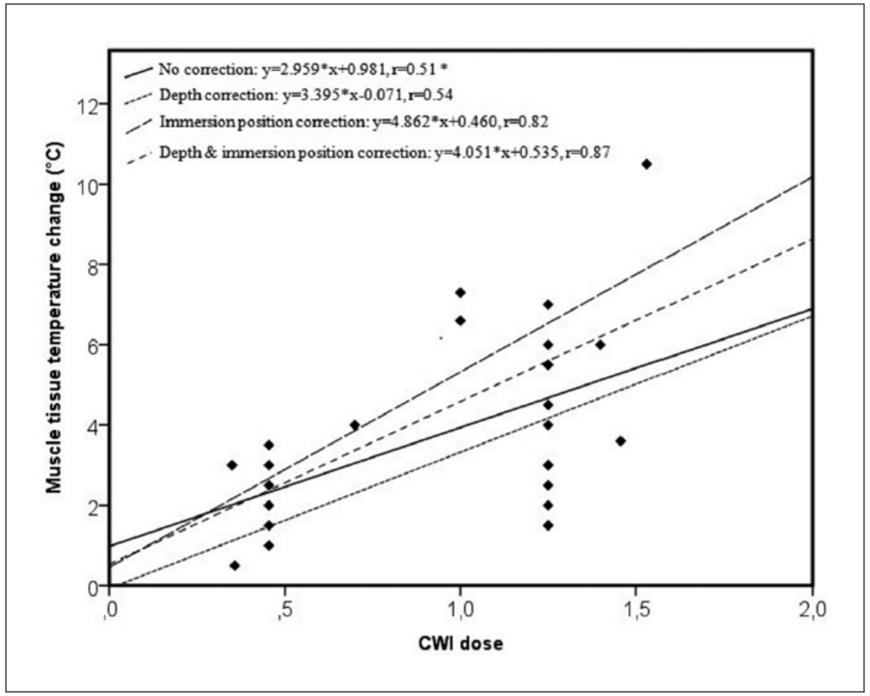


Figure 2.—Dose response relationships between CWI and muscle tissue temperature after no correction for muscle measurement depth and immersion position, with correction for only muscle measurement depth, with correction for only immersion position, and with correction for both.
$y=ax+b$, where y is the change in muscle tissue temperature and x is the CWI dose calculated as: duration × (1/water temperature).
*Statistically significant relationship.

CWI can significantly reduce muscle temperature if the minimum dose of CWI applied is **1.1**, corresponding, for example, to an **11-minute** immersion in water at **10°C**.

Vromans et al. J Sports Med Phys Fit 2019

INFLUENCE IN CWI POSITIONS ON DOMS

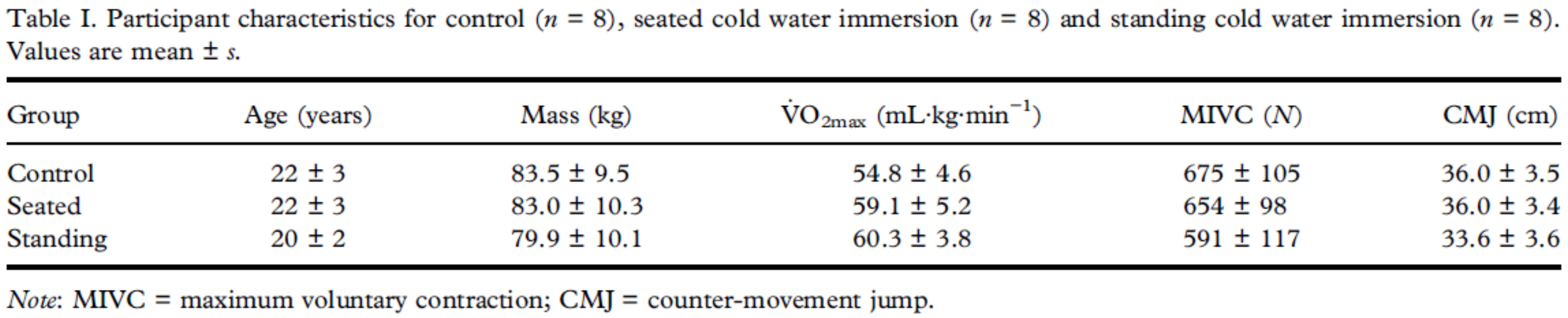


Table I. Participant characteristics for control (n = 8), seated cold water immersion (n = 8) and standing cold water immersion (n = 8). Values are mean ± s.

Group	Age (years)	Mass (kg)	$\dot{V}O_{2max}$ (mL·kg·min^{-1})	MIVC (N)	CMJ (cm)
Control	22 ± 3	83.5 ± 9.5	54.8 ± 4.6	675 ± 105	36.0 ± 3.5
Seated	22 ± 3	83.0 ± 10.3	59.1 ± 5.2	654 ± 98	36.0 ± 3.4
Standing	20 ± 2	79.9 ± 10.1	60.3 ± 3.8	591 ± 117	33.6 ± 3.6

Note: MIVC = maximum voluntary contraction; CMJ = counter-movement jump.

- **« LIST » TEST**: 5 sets of 15 min (sprints + running with changes of direction)
- 2 positions (sitting and standing): **14 min at 14°C.**

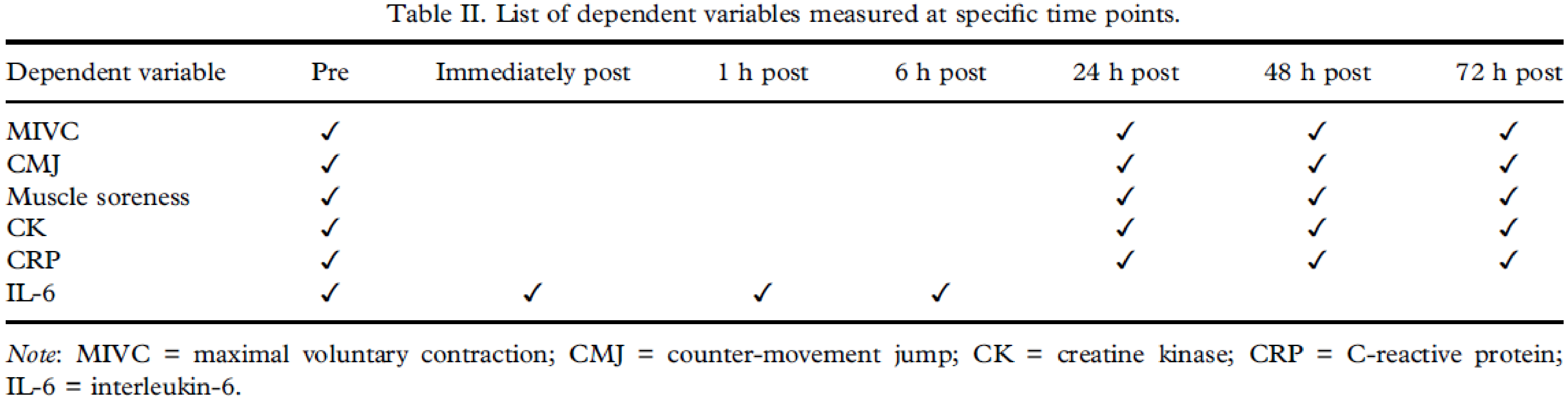


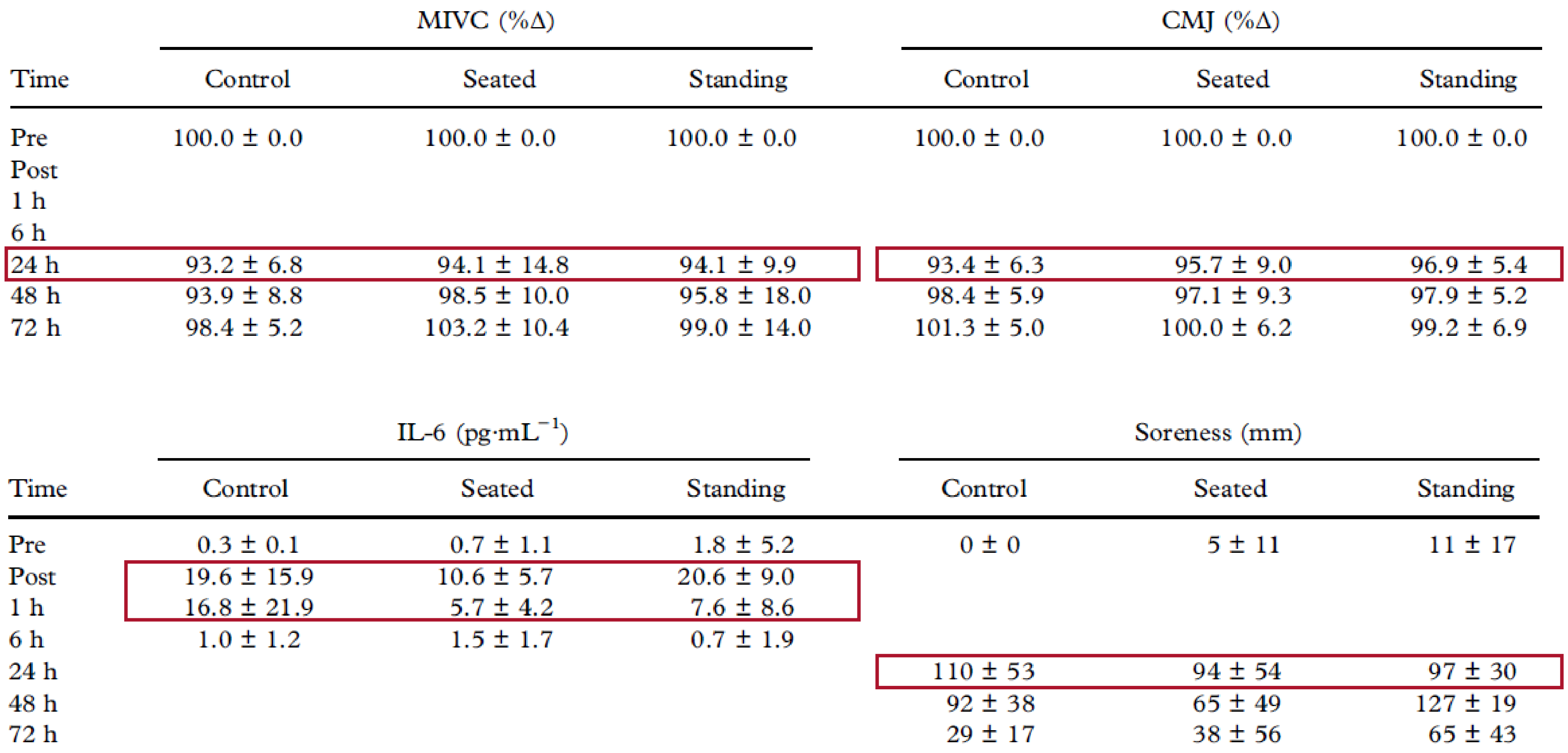
Table II. List of dependent variables measured at specific time points.

Dependent variable	Pre	Immediately post	1 h post	6 h post	24 h post	48 h post	72 h post
MIVC	✓				✓	✓	✓
CMJ	✓				✓	✓	✓
Muscle soreness	✓				✓	✓	✓
CK	✓				✓	✓	✓
CRP	✓				✓	✓	✓
IL-6	✓	✓	✓	✓			

Note: MIVC = maximal voluntary contraction; CMJ = counter-movement jump; CK = creatine kinase; CRP = C-reactive protein; IL-6 = interleukin-6.

Leeder et al. J Sport Sciences 2015

INFLUENCE IN CWI POSITIONS ON DOMS



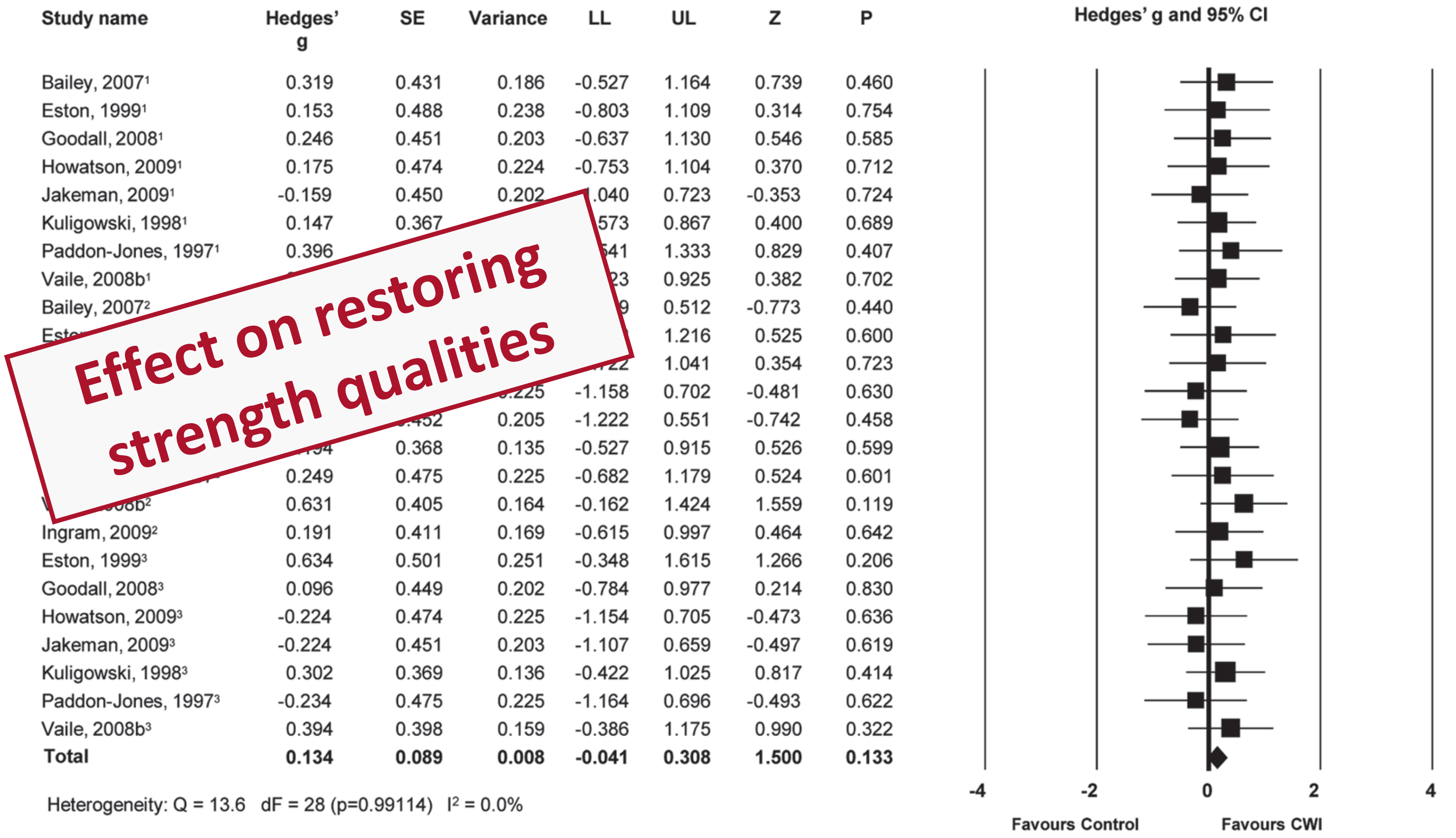
	MIVC (%Δ)			CMJ (%Δ)		
Time	Control	Seated	Standing	Control	Seated	Standing
Pre	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
Post						
1 h						
6 h						
24 h	93.2 ± 6.8	94.1 ± 14.8	94.1 ± 9.9	93.4 ± 6.3	95.7 ± 9.0	96.9 ± 5.4
48 h	93.9 ± 8.8	98.5 ± 10.0	95.8 ± 18.0	98.4 ± 5.9	97.1 ± 9.3	97.9 ± 5.2
72 h	98.4 ± 5.2	103.2 ± 10.4	99.0 ± 14.0	101.3 ± 5.0	100.0 ± 6.2	99.2 ± 6.9

	IL-6 ($pg \cdot mL^{-1}$)			Soreness (mm)		
Time	Control	Seated	Standing	Control	Seated	Standing
Pre	0.3 ± 0.1	0.7 ± 1.1	1.8 ± 5.2	0 ± 0	5 ± 11	11 ± 17
Post	19.6 ± 15.9	10.6 ± 5.7	20.6 ± 9.0			
1 h	16.8 ± 21.9	5.7 ± 4.2	7.6 ± 8.6			
6 h	1.0 ± 1.2	1.5 ± 1.7	0.7 ± 1.9			
24 h				110 ± 53	94 ± 54	97 ± 30
48 h				92 ± 38	65 ± 49	127 ± 19
72 h				29 ± 17	38 ± 56	65 ± 43

These data suggest that increasing hydrostatic pressure by standing in cold water provides no additional recovery benefit compared to cold water immersion in a seated position. no additional benefit in terms of recovery compared with cold water immersion in a seated position..

Leeder et al. J Sport Sciences 2015

META-ANALYSIS: CWI



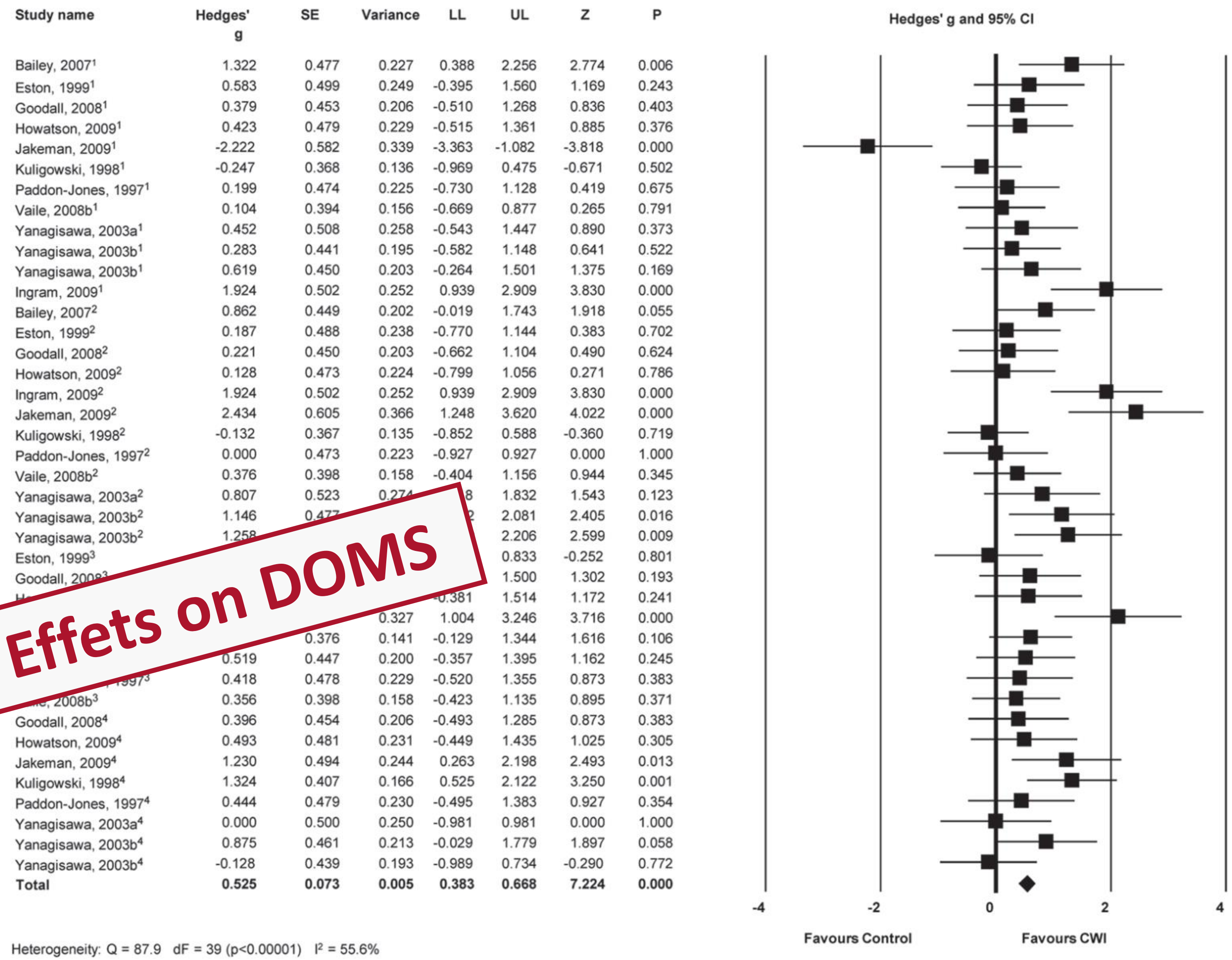
Study name	Hedges' g	SE	Variance	LL	UL	Z	P
Bailey, 2007[1]	0.319	0.431	0.186	-0.527	1.164	0.739	0.460
Eston, 1999[1]	0.153	0.488	0.238	-0.803	1.109	0.314	0.754
Goodall, 2008[1]	0.246	0.451	0.203	-0.637	1.130	0.546	0.585
Howatson, 2009[1]	0.175	0.474	0.224	-0.753	1.104	0.370	0.712
Jakeman, 2009[1]	-0.159	0.450	0.202	[illegible]	0.723	-0.353	0.724
Kuligowski, 1998[1]	0.147	0.367	[illegible]	[illegible]	0.867	0.400	0.689
Paddon-Jones, 1997[1]	0.396	[illegible]	[illegible]	[illegible]	1.333	0.829	0.407
Vaile, 2008b[1]	[illegible]	[illegible]	[illegible]	[illegible]	0.925	0.382	0.702
Bailey, 2007[2]	[illegible]	[illegible]	[illegible]	[illegible]	0.512	-0.773	0.440
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.216	0.525	0.600
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.041	0.354	0.723
[illegible]	[illegible]	[illegible]	[illegible]	-1.158	0.702	-0.481	0.630
[illegible]	[illegible]	[illegible]	0.205	-1.222	0.551	-0.742	0.458
[illegible]	[illegible]	0.368	0.135	-0.527	0.915	0.526	0.599
[illegible]	0.249	0.475	0.225	-0.682	1.179	0.524	0.601
[illegible]	0.631	0.405	0.164	-0.162	1.424	1.559	0.119
Ingram, 2009[2]	0.191	0.411	0.169	-0.615	0.997	0.464	0.642
Eston, 1999[3]	0.634	0.501	0.251	-0.348	1.615	1.266	0.206
Goodall, 2008[3]	0.096	0.449	0.202	-0.784	0.977	0.214	0.830
Howatson, 2009[3]	-0.224	0.474	0.225	-1.154	0.705	-0.473	0.636
Jakeman, 2009[3]	-0.224	0.451	0.203	-1.107	0.659	-0.497	0.619
Kuligowski, 1998[3]	0.302	0.369	0.136	-0.422	1.025	0.817	0.414
Paddon-Jones, 1997[3]	-0.234	0.475	0.225	-1.164	0.696	-0.493	0.622
Vaile, 2008b[3]	0.394	0.398	0.159	-0.386	1.175	0.990	0.322
Total	**0.134**	**0.089**	**0.008**	**-0.041**	**0.308**	**1.500**	**0.133**

Heterogeneity: Q = 13.6 dF = 28 (p=0.99114) I^2 = 0.0%

Effect on restoring strength qualities

Leeder et al. Brit J Sport Med 2012

META-ANALYSIS: CWI



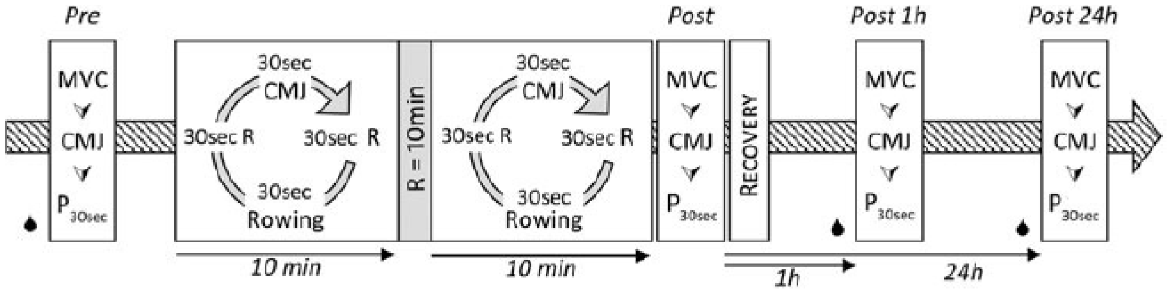
Study name	Hedges' g	SE	Variance	LL	UL	Z	P
Bailey, 2007¹	1.322	0.477	0.227	0.388	2.256	2.774	0.006
Eston, 1999¹	0.583	0.499	0.249	-0.395	1.560	1.169	0.243
Goodall, 2008¹	0.379	0.453	0.206	-0.510	1.268	0.836	0.403
Howatson, 2009¹	0.423	0.479	0.229	-0.515	1.361	0.885	0.376
Jakeman, 2009¹	-2.222	0.582	0.339	-3.363	-1.082	-3.818	0.000
Kuligowski, 1998¹	-0.247	0.368	0.136	-0.969	0.475	-0.671	0.502
Paddon-Jones, 1997¹	0.199	0.474	0.225	-0.730	1.128	0.419	0.675
Vaile, 2008b¹	0.104	0.394	0.156	-0.669	0.877	0.265	0.791
Yanagisawa, 2003a¹	0.452	0.508	0.258	-0.543	1.447	0.890	0.373
Yanagisawa, 2003b¹	0.283	0.441	0.195	-0.582	1.148	0.641	0.522
Yanagisawa, 2003b¹	0.619	0.450	0.203	-0.264	1.501	1.375	0.169
Ingram, 2009¹	1.924	0.502	0.252	0.939	2.909	3.830	0.000
Bailey, 2007²	0.862	0.449	0.202	-0.019	1.743	1.918	0.055
Eston, 1999²	0.187	0.488	0.238	-0.770	1.144	0.383	0.702
Goodall, 2008²	0.221	0.450	0.203	-0.662	1.104	0.490	0.624
Howatson, 2009²	0.128	0.473	0.224	-0.799	1.056	0.271	0.786
Ingram, 2009²	1.924	0.502	0.252	0.939	2.909	3.830	0.000
Jakeman, 2009²	2.434	0.605	0.366	1.248	3.620	4.022	0.000
Kuligowski, 1998²	-0.132	0.367	0.135	-0.852	0.588	-0.360	0.719
Paddon-Jones, 1997²	0.000	0.473	0.223	-0.927	0.927	0.000	1.000
Vaile, 2008b²	0.376	0.398	0.158	-0.404	1.156	0.944	0.345
Yanagisawa, 2003a²	0.807	0.523	0.274	[illegible]	1.832	1.543	0.123
Yanagisawa, 2003b²	1.146	0.477	[illegible]	[illegible]	2.081	2.405	0.016
Yanagisawa, 2003b²	1.258	[illegible]	[illegible]	[illegible]	2.206	2.599	0.009
Eston, 1999³	[illegible]	[illegible]	[illegible]	[illegible]	0.833	-0.252	0.801
Goodall, 2008³	[illegible]	[illegible]	[illegible]	[illegible]	1.500	1.302	0.193
[illegible]	[illegible]	[illegible]	[illegible]	-0.381	1.514	1.172	0.241
[illegible]	[illegible]	[illegible]	0.327	1.004	3.246	3.716	0.000
[illegible]	[illegible]	0.376	0.141	-0.129	1.344	1.616	0.106
[illegible]	0.519	0.447	0.200	-0.357	1.395	1.162	0.245
[illegible]	0.418	0.478	0.229	-0.520	1.355	0.873	0.383
[illegible]	0.356	0.398	0.158	-0.423	1.135	0.895	0.371
Goodall, 2008⁴	0.396	0.454	0.206	-0.493	1.285	0.873	0.383
Howatson, 2009⁴	0.493	0.481	0.231	-0.449	1.435	1.025	0.305
Jakeman, 2009⁴	1.230	0.494	0.244	0.263	2.198	2.493	0.013
Kuligowski, 1998⁴	1.324	0.407	0.166	0.525	2.122	3.250	0.001
Paddon-Jones, 1997⁴	0.444	0.479	0.230	-0.495	1.383	0.927	0.354
Yanagisawa, 2003a⁴	0.000	0.500	0.250	-0.981	0.981	0.000	1.000
Yanagisawa, 2003b⁴	0.875	0.461	0.213	-0.029	1.779	1.897	0.058
Yanagisawa, 2003b⁴	-0.128	0.439	0.193	-0.989	0.734	-0.290	0.772
Total	**0.525**	**0.073**	**0.005**	**0.383**	**0.668**	**7.224**	**0.000**

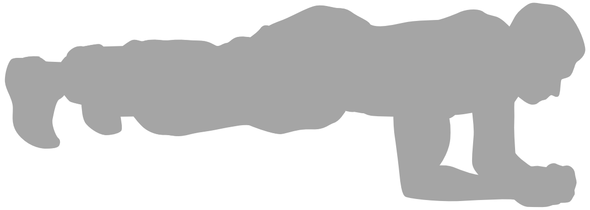
Heterogeneity: Q = 87.9 dF = 39 (p<0.00001) I² = 55.6%

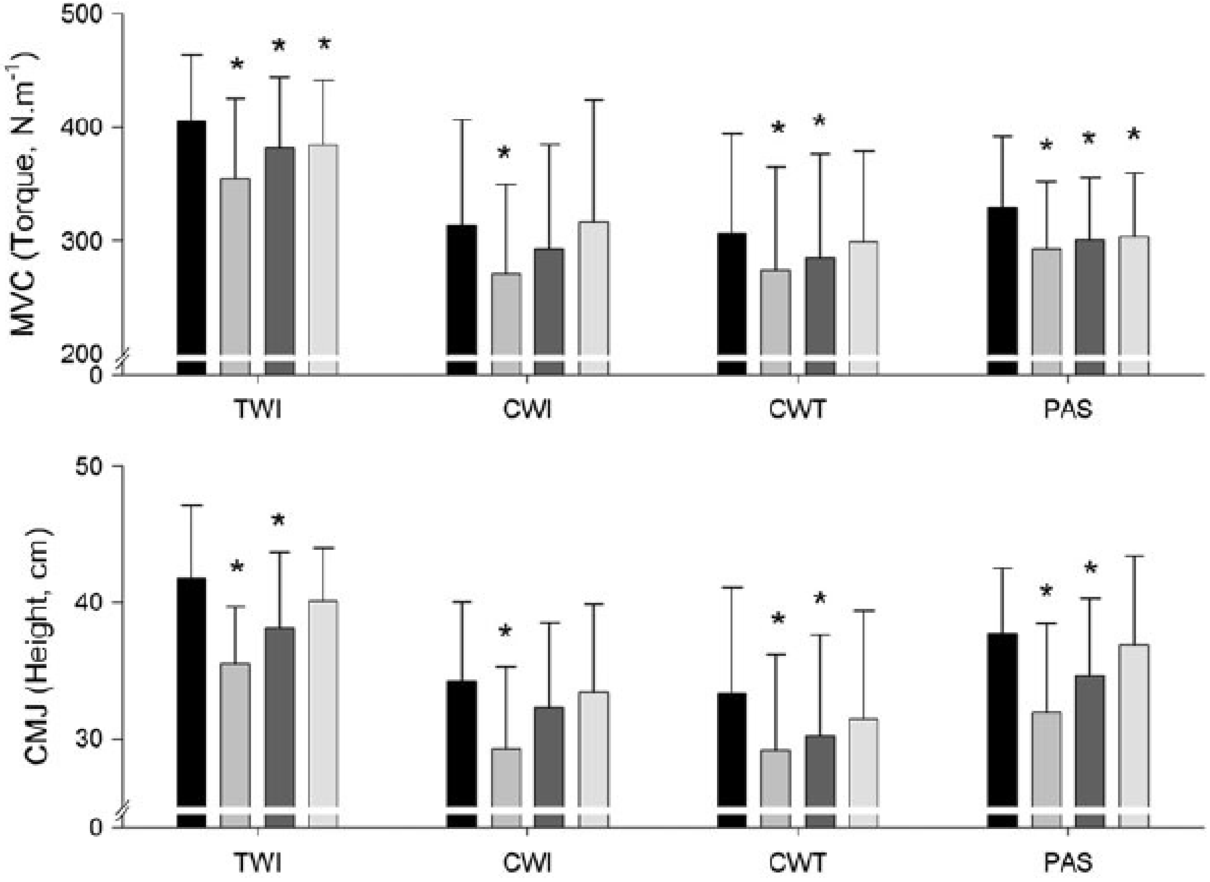
Effets on DOMS

Leeder et al. Brit J Sport Med 2012

IMMERSION CWI VS. TWI VS. CWT







Hausswirth, Pournot et al. Eur J Appl Physiol 2012

PLACEBO EFFECT? IMMERSION & RECOVERY

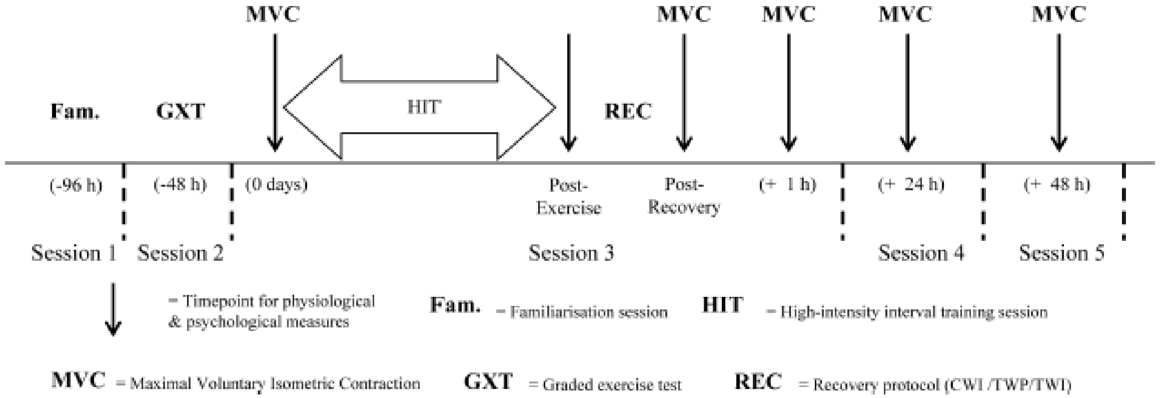
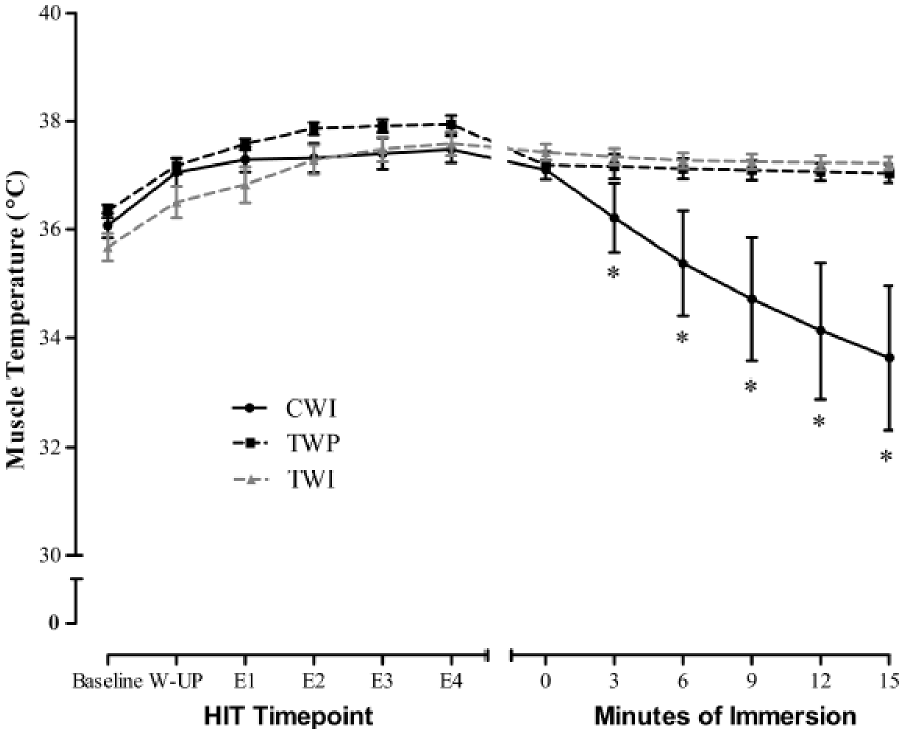


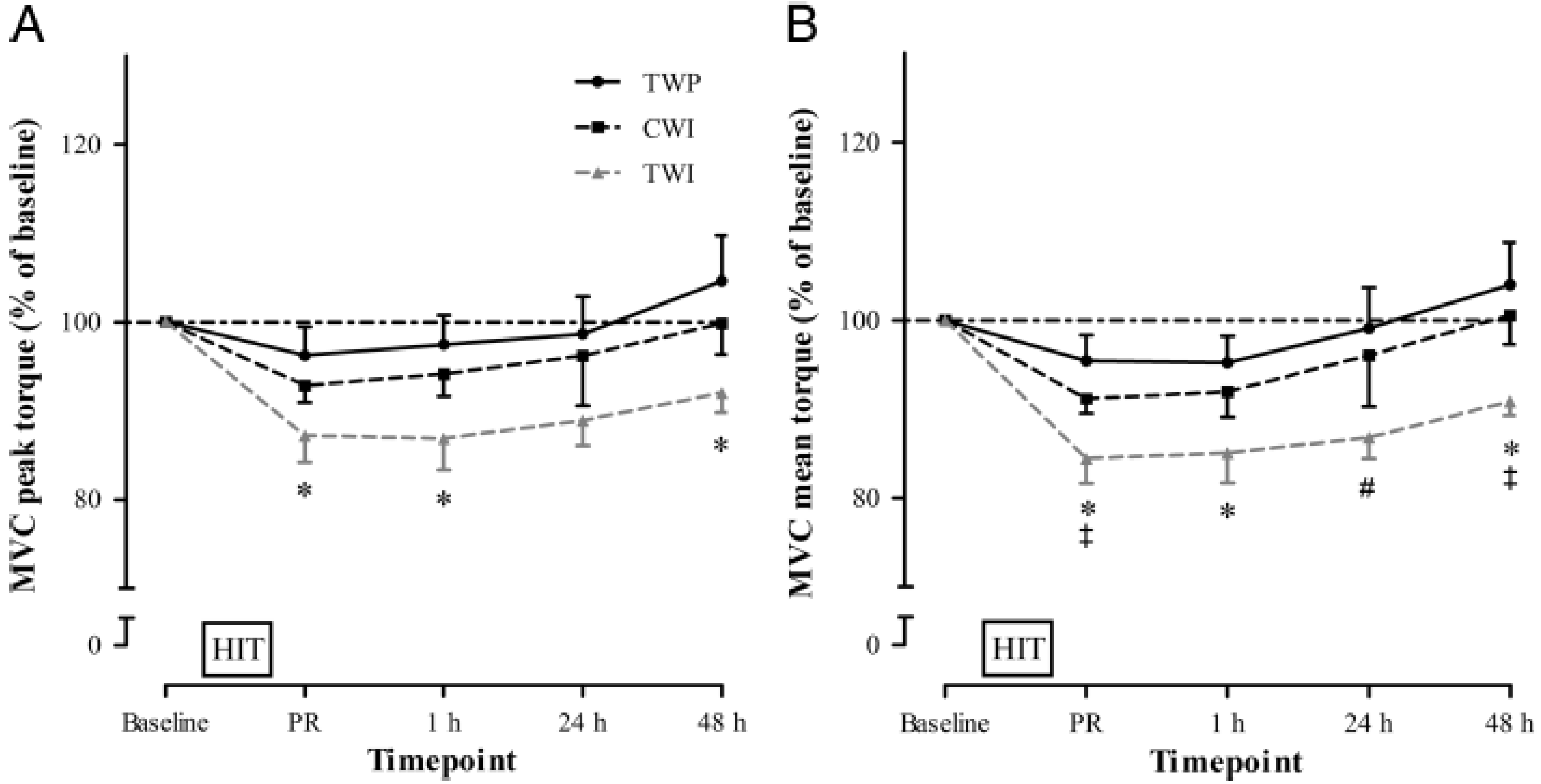
FIGURE 1—Schematic representation of the experimental design.



- 3 conditions CWI, TWI et TWP.
- **CWI** : 15 min at 10,3°C.
- **TWI** : 15 min at 34,7°C.
- **TWP** : 15 min at 34,7°C (cleaned skin then « **Recovery Oil** »).

Broatch et al. Med Sci Sport Exer 2014

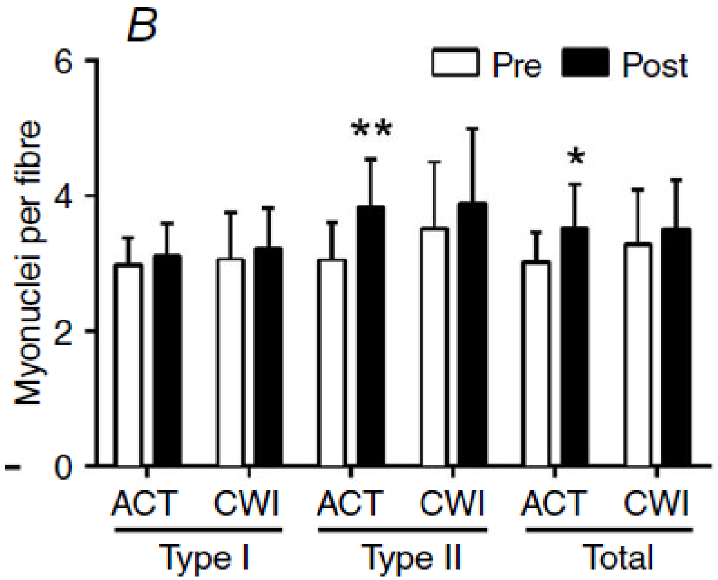
PLACEBO EFFECT? IMMERSION & RECOVERY

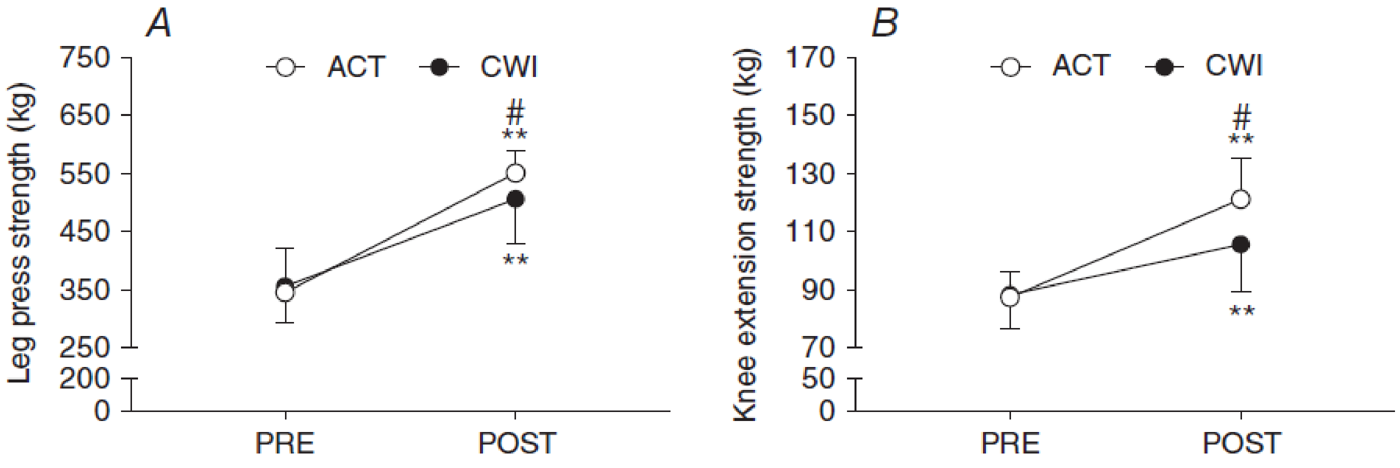


*Significantly different from that in TWP ($P < 0.05$)

Broatch et al. Med Sci Sport Exer 2014

PROMOTE TRAINING ADAPTATIONS?





- Cold water immersion attenuated long-term gains in muscle mass and strength. It also slowed the activation of key proteins and satellite cells in muscles for up to two days after exercise.
- Those using strength training to enhance performance or recovering from injury should therefore reconsider the use of cold water immersion as an adjunct to their training.
- The notion of recovery timing seems to be important (> 1h post-exercise).

Roberst et al. J Physiol 2015

IMMERSION: WHEN?

👍

- Contrasted: immediately after exercise.
- Cold: > 1 and within 6 hours of "traumatic" exercise.
- No diff between seated and standing to reduce DOMS.

👎

- Choose deep immersion.
- Contrasted: more than 1 hour after exercise.
- Warm.

FOR MORE INFORMATION…

Sports Med
https://doi.org/10.1007/s40279-018-0910-8

CrossMark

REVIEW ARTICLE

The Influence of Post-Exercise Cold-Water Immersion on Adaptive Responses to Exercise: A Review of the Literature

James R. Broatch[1,2] · Aaron Petersen[1] · David J. Bishop[1,3]

Abstract Post-exercise cold-water immersion (CWI) is used extensively in exercise training as a means to minimise fatigue and expedite recovery between sessions. However, debate exists around its merit in long-term training regimens. While an improvement in recovery following a single session of exercise may improve subsequent training quality and stimulus, reports have emerged suggesting CWI may attenuate long-term adaptations to exercise training. Recent developments in the understanding of the molecular mechanisms governing the adaptive response to exercise in human skeletal muscle have provided potential mechanistic insight into the effects of CWI on training adaptations. Preliminary evidence suggests that CWI may blunt resistance signalling pathways following a single exercise session, as well as attenuate key long-term resistance training adaptations such as strength and muscle mass. Conversely, CWI may augment endurance signalling pathways and the expression of genes key to mitochondrial biogenesis following a single endurance exercise session, but have little to no effect on the content of proteins key to mitochondrial biogenesis following long-term endurance training. This review explores current evidence regarding the underlying molecular mechanisms by which CWI may alter cellular signalling and the long-term adaptive response to exercise in human skeletal muscle.

Key Points

Despite short-term increases in markers of mitochondrial biogenesis following a single session of post-exercise cold-water immersion (CWI), regular post-exercise CWI appears to have little to no effect on long-term endurance training adaptations in human skeletal muscle.

Evidence to date suggests either no effect or negative effects of post-exercise CWI on the molecular mechanisms regulating resistance training adaptations, as well as key resistance training adaptations (e.g., strength and muscle mass).

Research supporting or refuting the use of post-exercise CWI during endurance or resistance training programmes is scarce, and further research is needed to determine its influence on human skeletal muscle adaptations during real-world training scenarios.

1 Introduction

Recovery from exercise refers to the restoration of the body's physiological and psychological processes to a pre-fatigue state and performance level [1]. A large body of research has focused on modalities designed to hasten recovery, with one of the most prevalent techniques being cold-water immersion (CWI). However, given the widespread use of CWI as a recovery modality, as well as the contrasting findings reported to date, clarification of the

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3 School of Medical and Health Sciences, Edith Cowan University, Joondalup, WA, Australia

Springer

Broatch J, Petersen A, Bishop D (2018)

The Influence of Post-Exercise Cold-Water Immersion on Adaptive Responses to Exercise: A Review of the Literature.

Sports Med :1369-1387

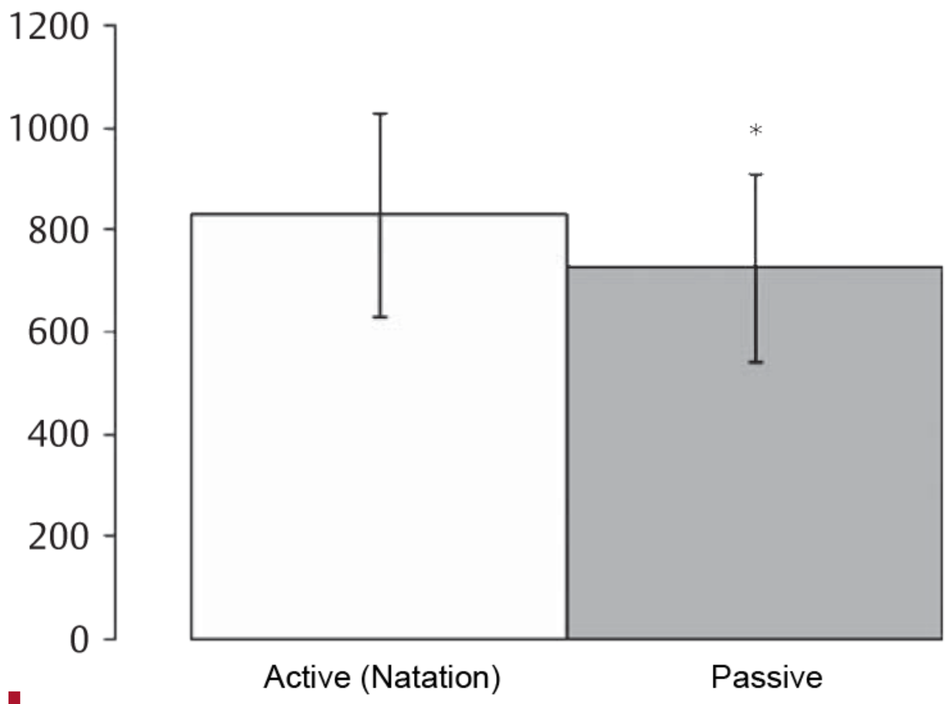
REDUCE OVERALL FATIGUE: ACTIVE RECOVERY

MAIN IDEAS

- **Accelerate** blood flow.
- **Eliminate** metabolites.
- **Restore** neuromuscular properties.
- **Reduce** muscle soreness.

ACTIVE RECOVERY

- Limits the drop in performance between two intense exercises spaced less than an hour apart.
- Maintains initial performance if R > 1h.




Effects of a Recovery Swim on Subsequent Running Performance

Lum et al. Int J Sports Med 2010

ACTIVE RECOVERY AND CWI

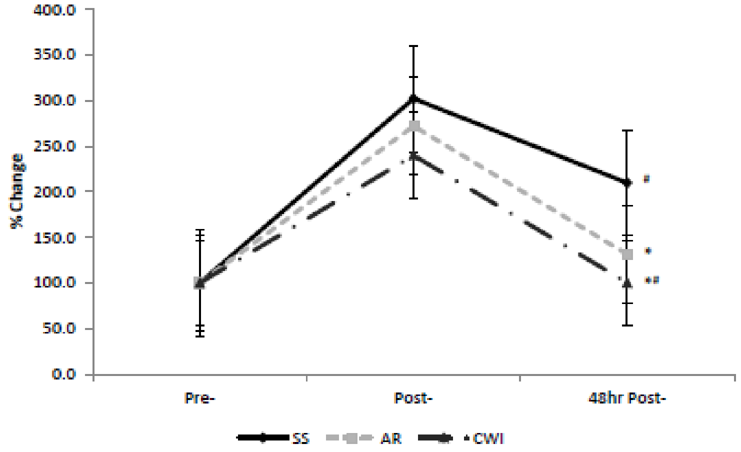


Figure 1. Percentage change in CK (ng/Ml) levels between pre-exercise, immediately post-exercise and 48 hours post-exercise, grouped by condition (SS, static stretching; AR, active recovery; CWI, cold water immersion). Error bars represent SE at respective time points. $^{*}p < 0.05$, significantly different from SS. $^{\#}p < 0.05$, significantly different from AR (n=15).

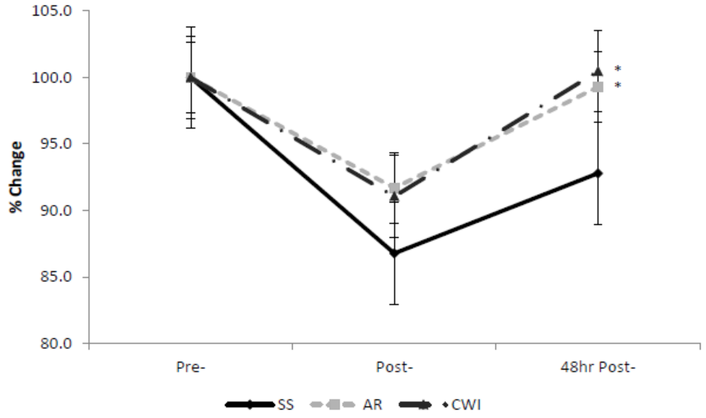


Figure 2. Percentage change in CMJA (cm) performance between pre-exercise, immediately post-exercise and 48 hours post-exercise, grouped by condition (SS, static stretching; AR, active recovery; CWI, cold water immersion). Error bars represent SE at respective time points. $^{*}p < 0.05$, significantly different from SS (n=15).

- 15 Players
- 3 matches of 80 min
- Recov. Stretch (SS)
- Recov. (CWI)
- Active Recov. (AR)

- The present study indicates that AR and CWI are beneficial recovery interventions for young Elite soccer players following high-intensity matches.

Pooley et al. J Sport Sci 2019

ACTIVE RECOVERY & METABOLITES CLEARANCE

SPORT	EXERCISE DURATION	TIME BETWEEN TESTS	ACTIVE RECOVERY METHOD	OUTCOME
Swimming (Greenwood 2008)	**2 min**	10 min	10 min at the lactic threshold	☺
Artistic gymnastics (Jemni 2003)	**6x ~30s**	10 min	5 min passive recovery followed by 5 min active recovery	☺
Judo (Franchini 2003)	**5 min**	15 min	15 min running at 70% of the anaerobic threshold	Ø
Judo (Franchini 2009)	**5 min**	15 min	15 min cycling at 70% of the anaerobic threshold	☺
Climbing (Heyman 2009)	**~8 min**	20 min	20 min pedalling with the legs at 30-40 W (increase in brachial arterial circulation noted)	☺
Cycling (Monedero 2000)	**(~6 min)**	20 min	50% VO_{2max}	☺
Cycling (Thiriet 1993)	**4 x~2 min**	20 min	Arm or leg pedalling	☺
Running (Coffey 2004)	**~5 min**	4 h	15 minutes at 50% of MAS	Ø
Futsal (Tessitore 2008)	**1 h**	6 h	8 min jogging, 8 min alternating walking / side skipping, 4 min stretching	Ø
Cycling (Lane 2004)	**18 min**	24 h	15 min at 30% VO_{2max}	Ø
Netball (King 2009)	**60 min**	24 h	15 min running at 40% VO_{2max}	Ø
Soccer (Andersson 2008)	**90min**	72 h	20 min pedalling at 45% of O_{2peak}, 30 min circuit training < 50% 1RM, 10 min at 45% of VO $_{2peak}$	Ø

beScored Institute

ACTIVE RECOVERY: WHEN?

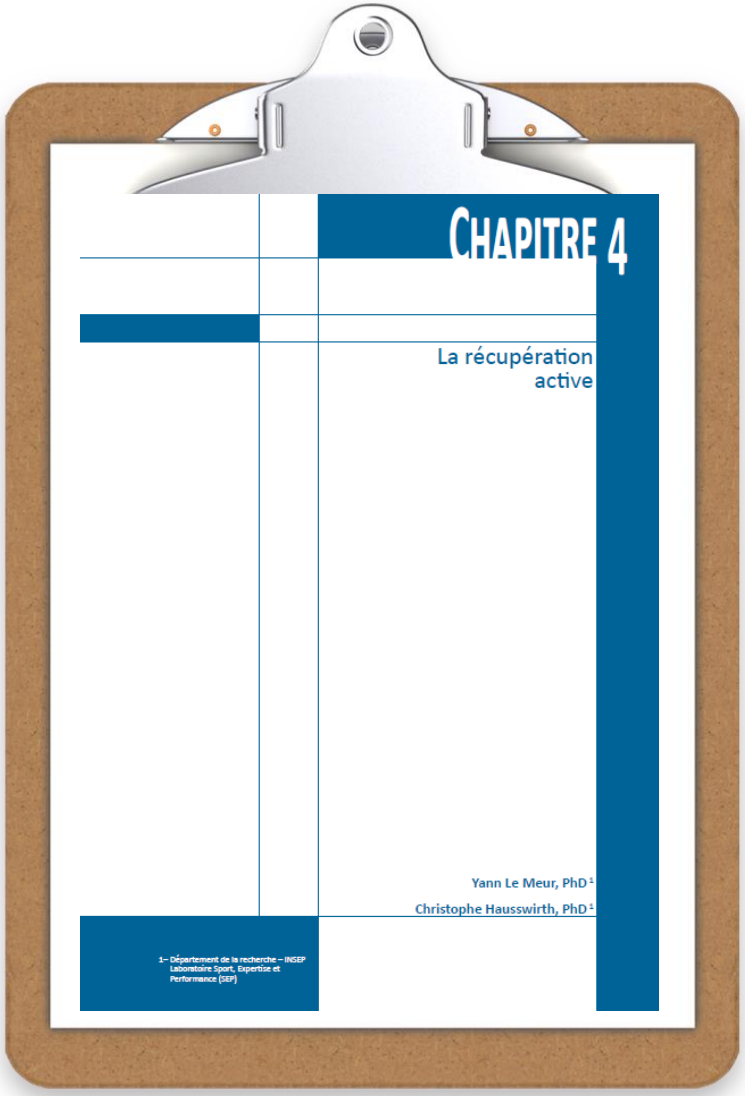
👍

- Immediately after exercise.
- Low intensity.

👎

- More than 1 hour after exercise.
- Avoid a mode of locomotion that accentuates muscle damage.
- Limit glycogen depletion.

FOR MORE INFORMATION….



CHAPITRE 4

La récupération active

Yann Le Meur, PhD[1]

Christophe Hausswirth, PhD[1]

[1] Département de la recherche – INSEP Laboratoire Sport, Expertise et Performance (SEP)

Le Meur et Hausswirth (2013)

La récupération active

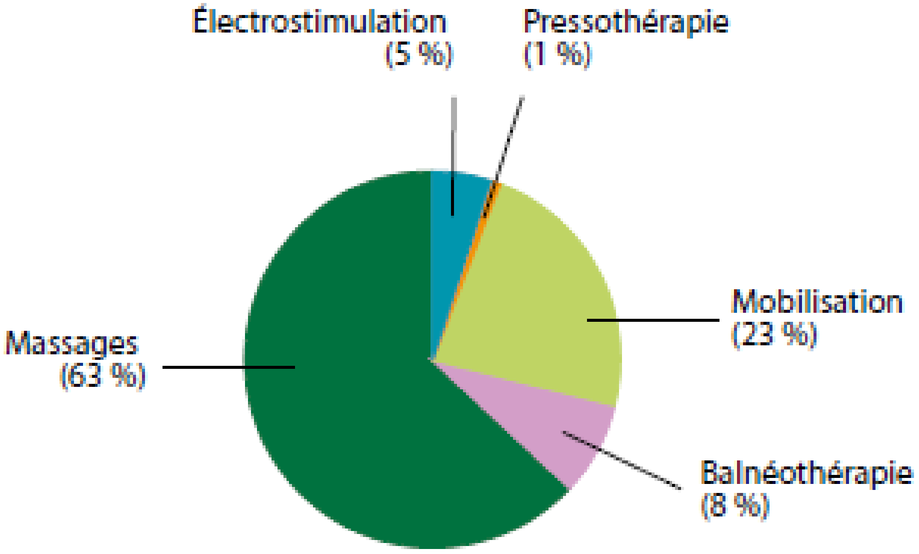
Extrait du livre : “Améliorer sa recuperation en sport”

C. Hausswirth

Eds Vigot: 54-69

MASSAGES

MASSAGES: PERCENTAGES & TECHNIQUES



Procédés de récupération utilisés par
les athlètes de la délégation française lors des Jeux
olympiques de TOKYO 2021 (données CNOSF).

DEPENDS ON TYPE

Grazing

Pressing

Kneading

Frictions

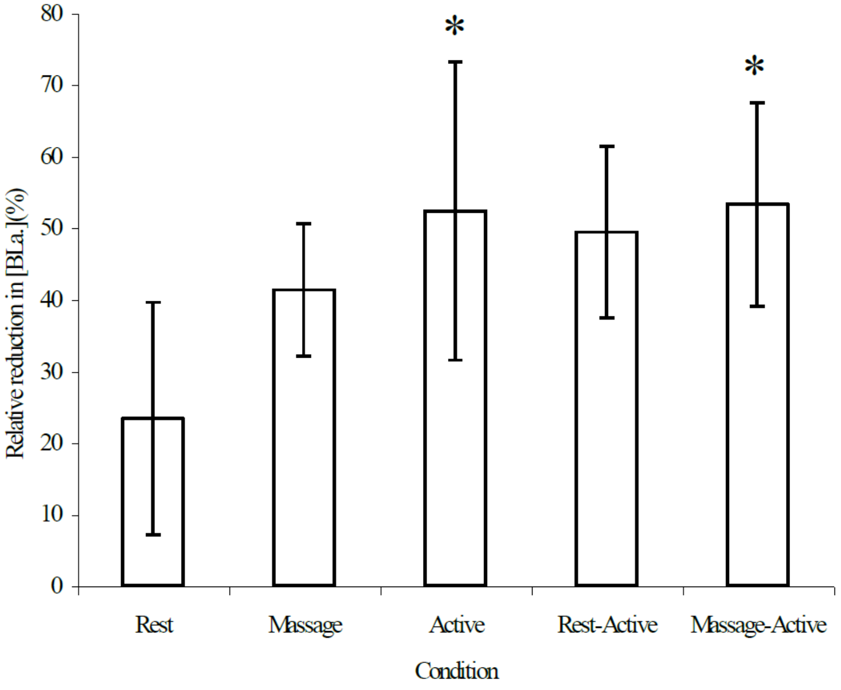
Tapping

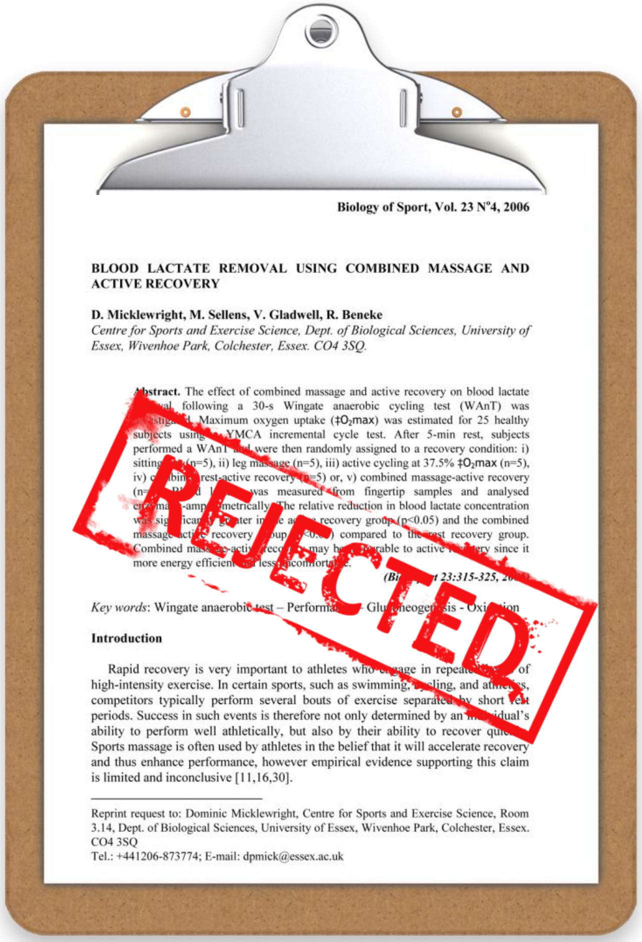
Vibrations

Palpating and rolling

MASSAGE: PHYSIOLOGICAL RESPONSE

- No effect on $[La^-]_{bl}$





Biology of Sport, Vol. 23 N°4, 2006

BLOOD LACTATE REMOVAL USING COMBINED MASSAGE AND ACTIVE RECOVERY

D. Micklewright, M. Sellens, V. Gladwell, R. Beneke
Centre for Sports and Exercise Science, Dept. of Biological Sciences, University of Essex, Wivenhoe Park, Colchester, Essex. CO4 3SQ.

Abstract. The effect of combined massage and active recovery on blood lactate removal following a 30-s Wingate anaerobic cycling test (WAnT) was investigated. Maximum oxygen uptake (‡O₂max) was estimated for 25 healthy subjects using [illegible] YMCA incremental cycle test. After 5-min rest, subjects performed a WAnT and were then randomly assigned to a recovery condition: i) sitting [illegible] (n=5), ii) leg massage (n=5), iii) active cycling at 37.5% ‡O₂max (n=5), iv) combined rest-active recovery (n=5) or, v) combined massage-active recovery (n=[illegible]) [illegible] was measured from fingertip samples and analysed enzymatic-amperometrically. The relative reduction in blood lactate concentration was significantly greater in the active recovery group (p<0.05) and the combined massage-active recovery group [illegible] compared to the rest recovery group. Combined massage-active recovery may be [illegible]rable to active recovery since it [illegible] more energy efficient [illegible] less uncomfortable.

(Bi[illegible] 23:315-325, 20[illegible])

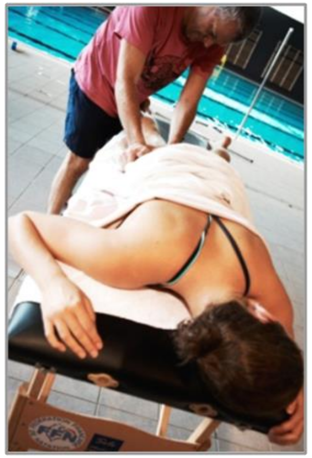
Key words: Wingate anaerobic test – Performa[illegible] - Glu[illegible]neogenesis - Oxi[illegible]tion

REJECTED

Introduction

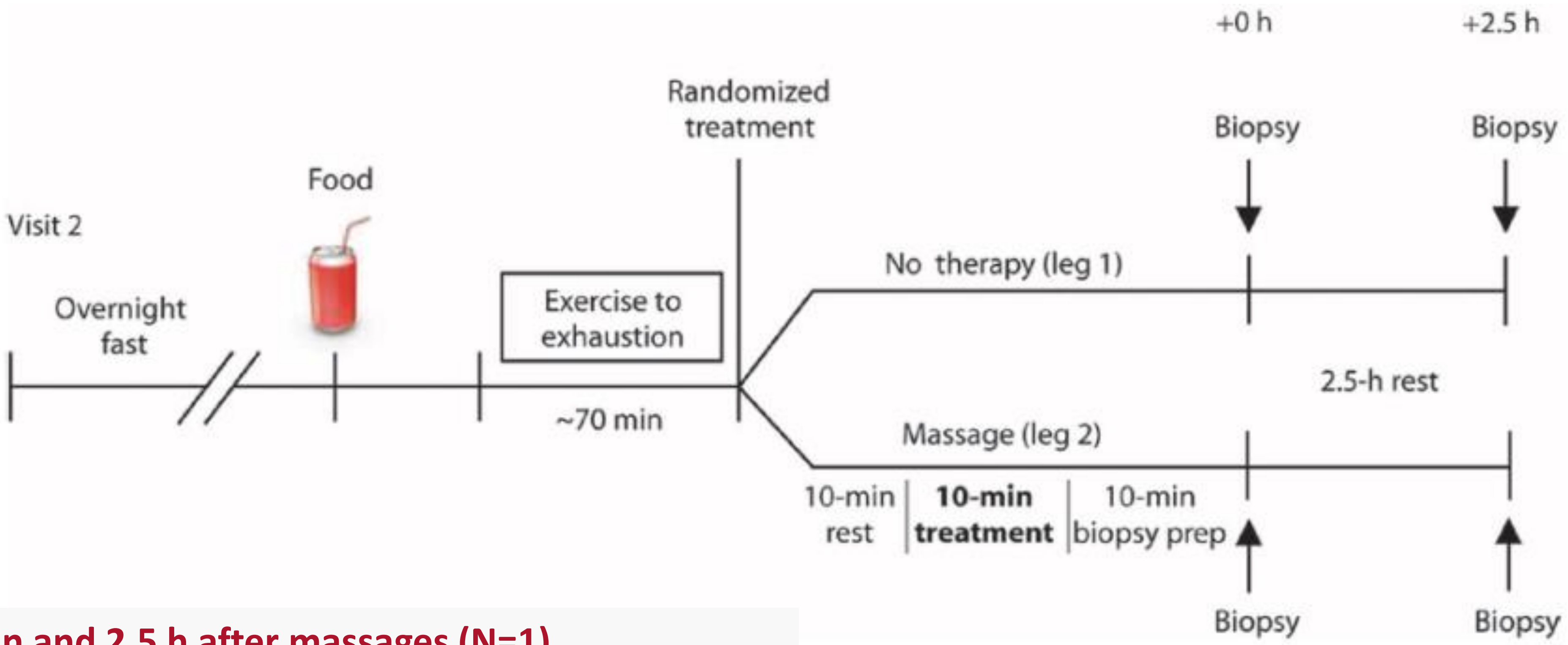
Rapid recovery is very important to athletes who engage in repeate[illegible] of high-intensity exercise. In certain sports, such as swimming, cycling, and athletics, competitors typically perform several bouts of exercise separated by short rest periods. Success in such events is therefore not only determined by an individual's ability to perform well athletically, but also by their ability to recover qui[illegible] Sports massage is often used by athletes in the belief that it will accelerate recovery and thus enhance performance, however empirical evidence supporting this claim is limited and inconclusive [11,16,30].

Reprint request to: Dominic Micklewright, Centre for Sports and Exercise Science, Room 3.14, Dept. of Biological Sciences, University of Essex, Wivenhoe Park, Colchester, Essex. CO4 3SQ
Tel.: +441206-873774; E-mail: dpmick@essex.ac.uk



Micklewright et al. Medicine & Science in Sports & Exercise 2003

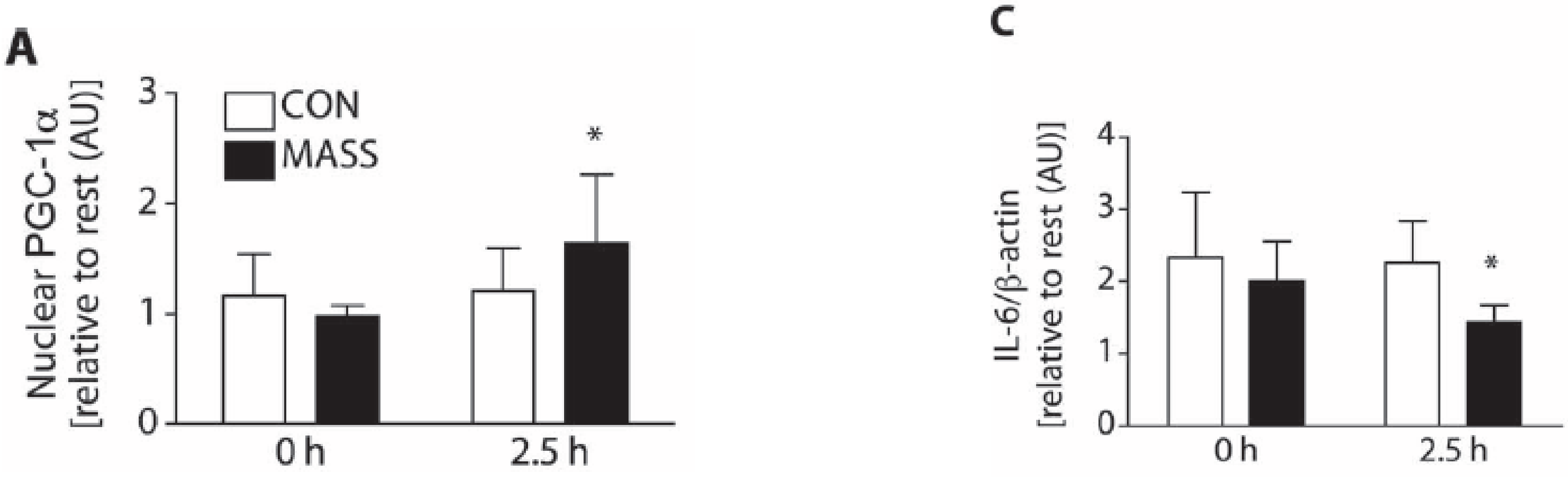
MASSAGE: PHYSIOLOGICAL RESPONSE



- **10 min and 2.5 h after massages (N=1).**

Crane et al. Sci Trans Med 2012

MASSAGE: PHYSIOLOGICAL RESPONSE

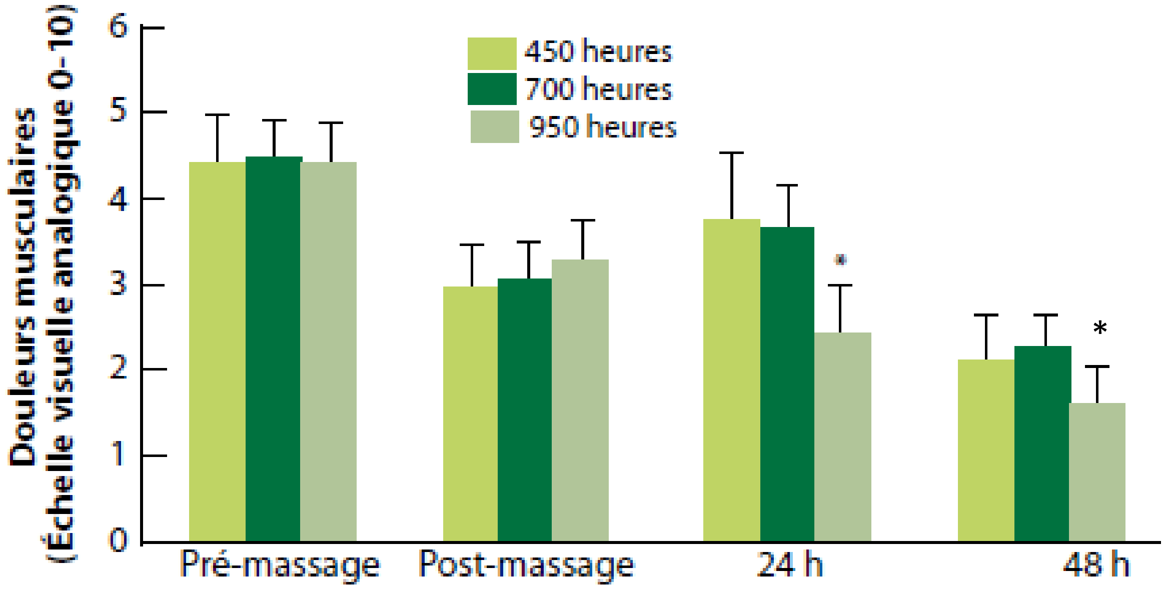


- **10 min and 2.5 h after massages (N=11).**
- PGC-1$^{\alpha}$ activation : mitochondrial biogenesis and decrease in inflammation
- Decrease in TNF-a and IL-6 : pro-inflammatory cytokines.

beScored Institute

Crane et al. Sci Trans Med 2012

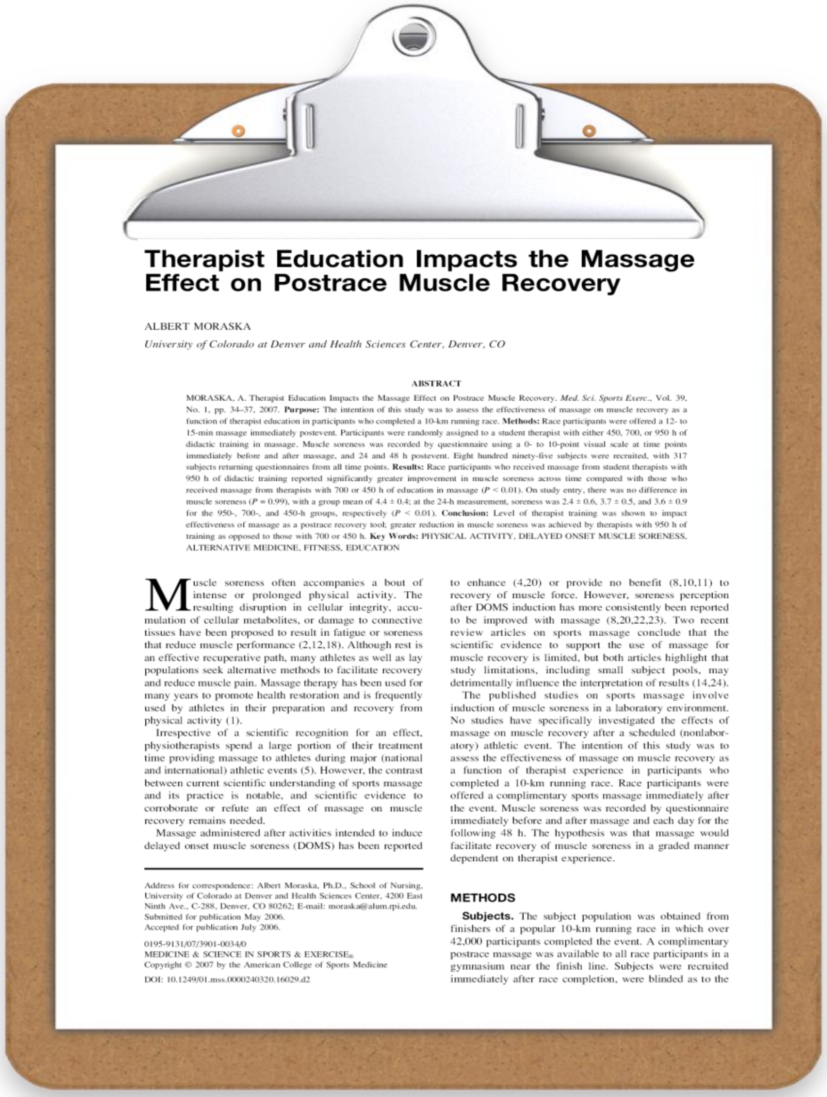
MASSAGES: INFLUENCE IN THERAPIST EDUCATION?



Evolution of muscle pain following a 10 km race.

In the 48h following the race, participants massaged by physiotherapy students with 950h of practice reported less pain than those massaged by physiotherapists with 700h or 450h of practice.

* : différence significative (p < 0,001).



Therapist Education Impacts the Massage Effect on Postrace Muscle Recovery

ALBERT MORASKA
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ABSTRACT

MORASKA, A. Therapist Education Impacts the Massage Effect on Postrace Muscle Recovery. *Med. Sci. Sports Exerc.*, Vol. 39, No. 1, pp. 34–37, 2007. **Purpose:** The intention of this study was to assess the effectiveness of massage on muscle recovery as a function of therapist education in participants who completed a 10-km running race. **Methods:** Race participants were offered a 12- to 15-min massage immediately postevent. Participants were randomly assigned to a student therapist with either 450, 700, or 950 h of didactic training in massage. Muscle soreness was recorded by questionnaire using a 0- to 10-point visual scale at time points immediately before and after massage, and 24 and 48 h postevent. Eight hundred ninety-five subjects were recruited, with 317 subjects returning questionnaires from all time points. **Results:** Race participants who received massage from student therapists with 950 h of didactic training reported significantly greater improvement in muscle soreness across time compared with those who received massage from therapists with 700 or 450 h of education in massage ($P < 0.01$). On study entry, there was no difference in muscle soreness ($P = 0.99$), with a group mean of 4.4 ± 0.4; at the 24-h measurement, soreness was 2.4 ± 0.6, 3.7 ± 0.5, and 3.6 ± 0.9 for the 950-, 700-, and 450-h groups, respectively ($P < 0.01$). **Conclusion:** Level of therapist training was shown to impact effectiveness of massage as a postrace recovery tool; greater reduction in muscle soreness was achieved by therapists with 950 h of training as opposed to those with 700 or 450 h. **Key Words:** PHYSICAL ACTIVITY, DELAYED ONSET MUSCLE SORENESS, ALTERNATIVE MEDICINE, FITNESS, EDUCATION

Muscle soreness often accompanies a bout of intense or prolonged physical activity. The resulting disruption in cellular integrity, accumulation of cellular metabolites, or damage to connective tissues have been proposed to result in fatigue or soreness that reduce muscle performance (2,12,18). Although rest is an effective recuperative path, many athletes as well as lay populations seek alternative methods to facilitate recovery and reduce muscle pain. Massage therapy has been used for many years to promote health restoration and is frequently used by athletes in their preparation and recovery from physical activity (1).

Irrespective of a scientific recognition for an effect, physiotherapists spend a large portion of their treatment time providing massage to athletes during major (national and international) athletic events (5). However, the contrast between current scientific understanding of sports massage and its practice is notable, and scientific evidence to corroborate or refute an effect of massage on muscle recovery remains needed.

Massage administered after activities intended to induce delayed onset muscle soreness (DOMS) has been reported to enhance (4,20) or provide no benefit (8,10,11) to recovery of muscle force. However, soreness perception after DOMS induction has more consistently been reported to be improved with massage (8,20,22,23). Two recent review articles on sports massage conclude that the scientific evidence to support the use of massage for muscle recovery is limited, but both articles highlight that study limitations, including small subject pools, may detrimentally influence the interpretation of results (14,24).

The published studies on sports massage involve induction of muscle soreness in a laboratory environment. No studies have specifically investigated the effects of massage on muscle recovery after a scheduled (nonlaboratory) athletic event. The intention of this study was to assess the effectiveness of massage on muscle recovery as a function of therapist experience in participants who completed a 10-km running race. Race participants were offered a complimentary sports massage immediately after the event. Muscle soreness was recorded by questionnaire immediately before and after massage and each day for the following 48 h. The hypothesis was that massage would facilitate recovery of muscle soreness in a graded manner dependent on therapist experience.

METHODS

Subjects. The subject population was obtained from finishers of a popular 10-km running race in which over 42,000 participants completed the event. A complimentary postrace massage was available to all race participants in a gymnasium near the finish line. Subjects were recruited immediately after race completion, were blinded as to the

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MORASKA A. Medicine & Science in Sports & Exercise 2007

MASSAGES: WHEN ?

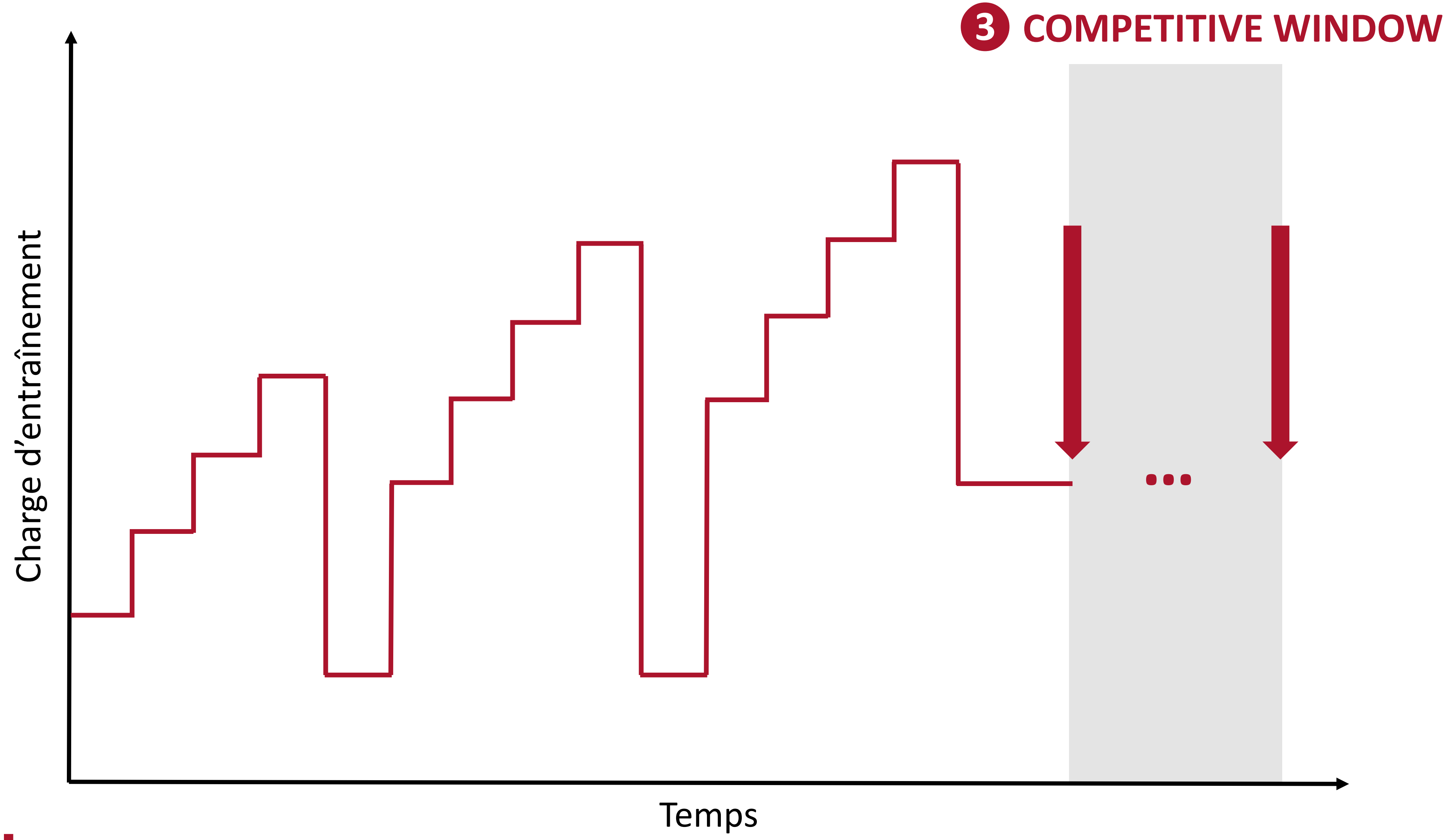
👍

- In the minutes or hours following exercise.
- Duration 30 min to 1h 30, possible effect in 10 min.
- Highly experienced therapist (>950h)

👎

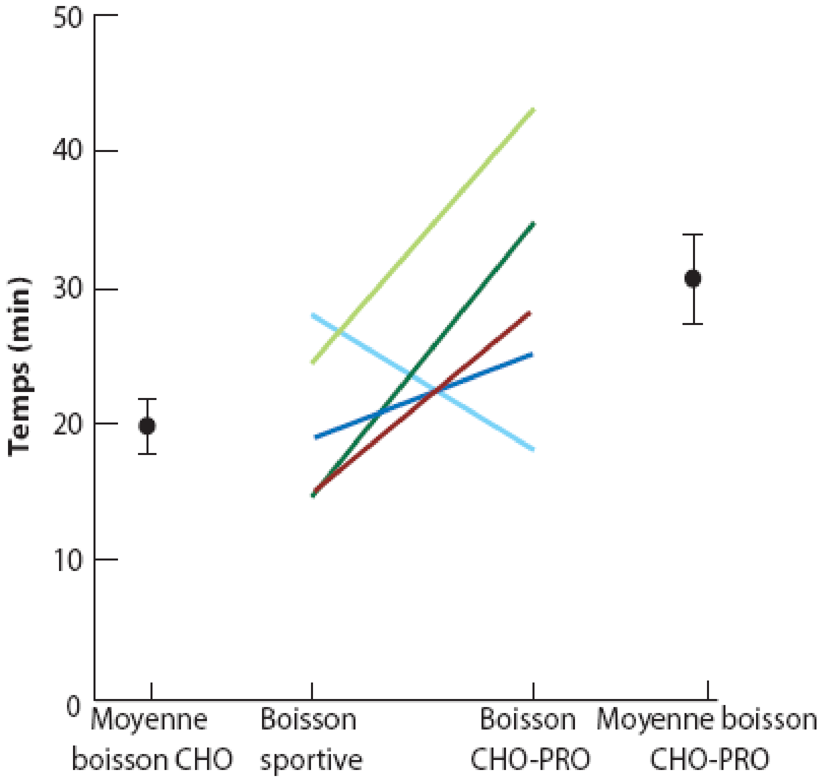
- Essentially psychological effect.
- Risk of masking potential injuries.
- Therapist with little experience.

THE VARIOUS ROLES OF RECOVERY



NUTRITION & RECOVERY IN-BETWEEN RACES

Effects of energy drinks on sports performance



- *Means obtained by cyclists during the time-limit to exhaustion.*
- 2h ergocycle at 65-75% VO2max.
- 2h recovery (with recovery drink): then time-limit.
- Results: **128% improvement** in Glyc resynthesis and 30% improvement in performance in CHO-PRO condition.

Berardi et al. Med Sci Sport Exerc 2006

PROMOTE SPORTS RECOVERY!

9 CONSEILS POUR MIEUX RÉCUPÉRER

Manger pour récupérer.

Choisir des aliments riches en glucides combinés avec des protéines dans les **30-60 minutes** qui suivent la fin de l’entrainement pour aider le corps à récupérer rapidement

au moins **15 min** d’ **exercice à faible intensité** chaque jour

Les vêtements **compressifs** améliorent la perception de la récupération

Se plonger **10 min** dans un **bain froid** entre **8° et 10°C** si des courbatures sont pressenties

6 nuits par semaine d’un **sommeil de qualité**

Les **massages** et **bains chauds** améliorent le **bien-être** et augmentent la perception de la récupération

1 période de vacances par an

20 min de récupération “passive“ par **l’électrostimulation** est plus efficace qu’une récup. active lorsque les températures ambiantes sont **chaudes** ou que peu d’envie pour une recup active

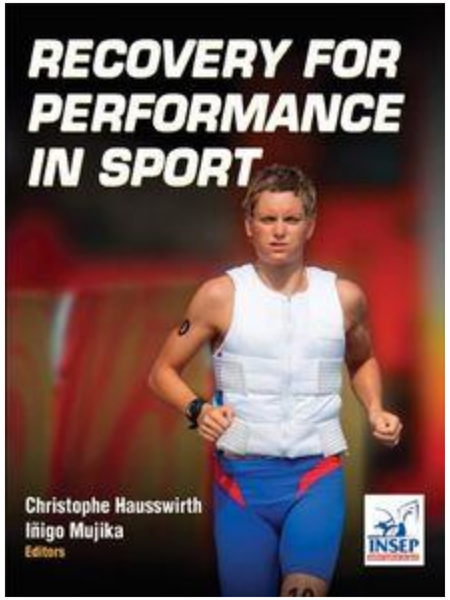
Toujours **rester hydraté.**

Boire suffisamment de façon à ce que l’urine soit claire

TOWARDS PERIODIZATION OF SPORTS RECOVERY

	DEVELOPMENT	TAPER	COMPETITION
Sleep	✓	✓	✓
Nutrition	✓	✓	✓
Hydration	✓	✓	✓
Immersion & WBC	Only in severe fatigue state	✓	✓
Active recovery	✓	✓	✓
EMS	Depending on the device used?		
Compression	No?	✓	✓
Massage	?	✓	✓
Ice jacket?	One-off use	No	✓

THANKS FOR YOUR ATTENTION…



RECOVERY FOR PERFORMANCE IN SPORT

Christophe Hausswirth
Iñigo Mujika
Editors

INSEP

RÉCUPÉRATION ET PERFORMANCE EN SPORT Coordonné par Christophe HAUSSWIRTH

Suivi de
«S'AMÉLIORER À HAUT NIVEAU PAR LA RÉCUPÉRATION»
Congrès organisé à l'INSEP les 10 et 11 décembre 2009

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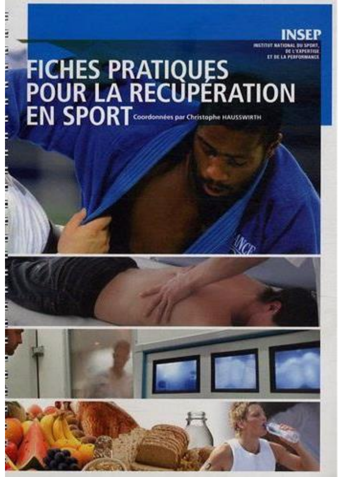

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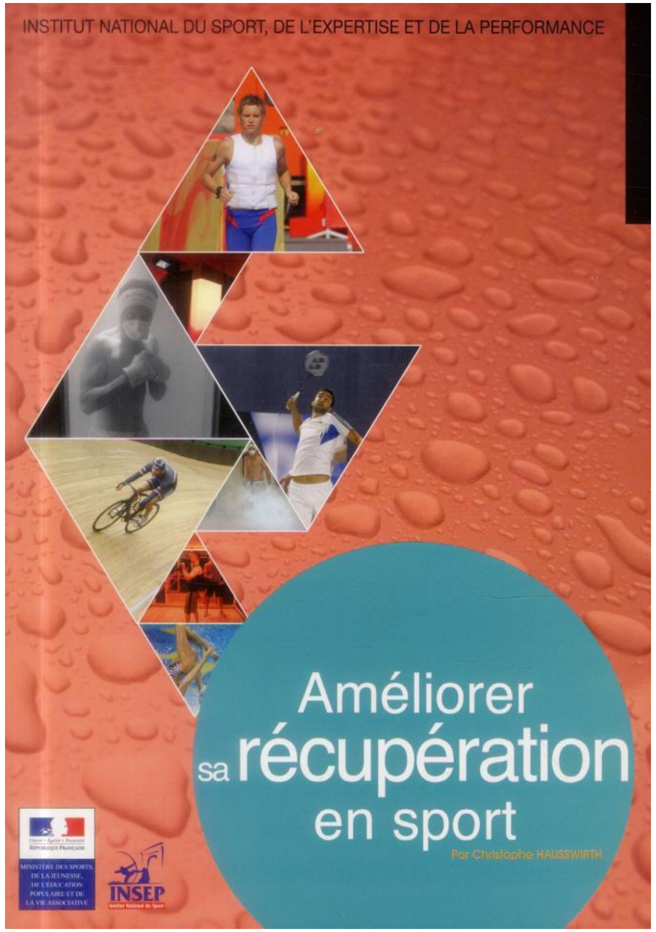
FICHES PRATIQUES POUR LA RÉCUPÉRATION EN SPORT Coordonnées par Christophe HAUSSWIRTH



INSTITUT NATIONAL DU SPORT, DE L'EXPERTISE ET DE LA PERFORMANCE

Améliorer sa récupération en sport
Par Christophe HAUSSWIRTH

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