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YOUR SPORT FOR LIFE

Science in Sport - Adaptation and Recovery

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Fatigue, Recovery & Adaptation

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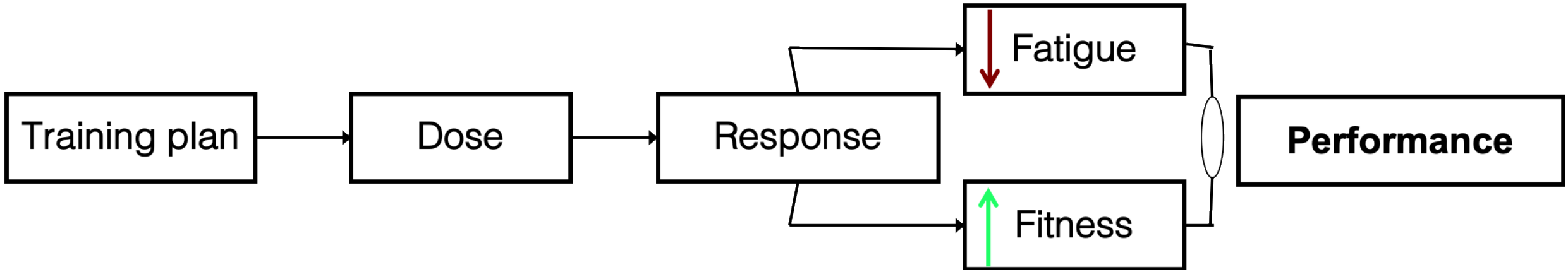

Coutts, 2016

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Fatigue, Recovery & Adaptation

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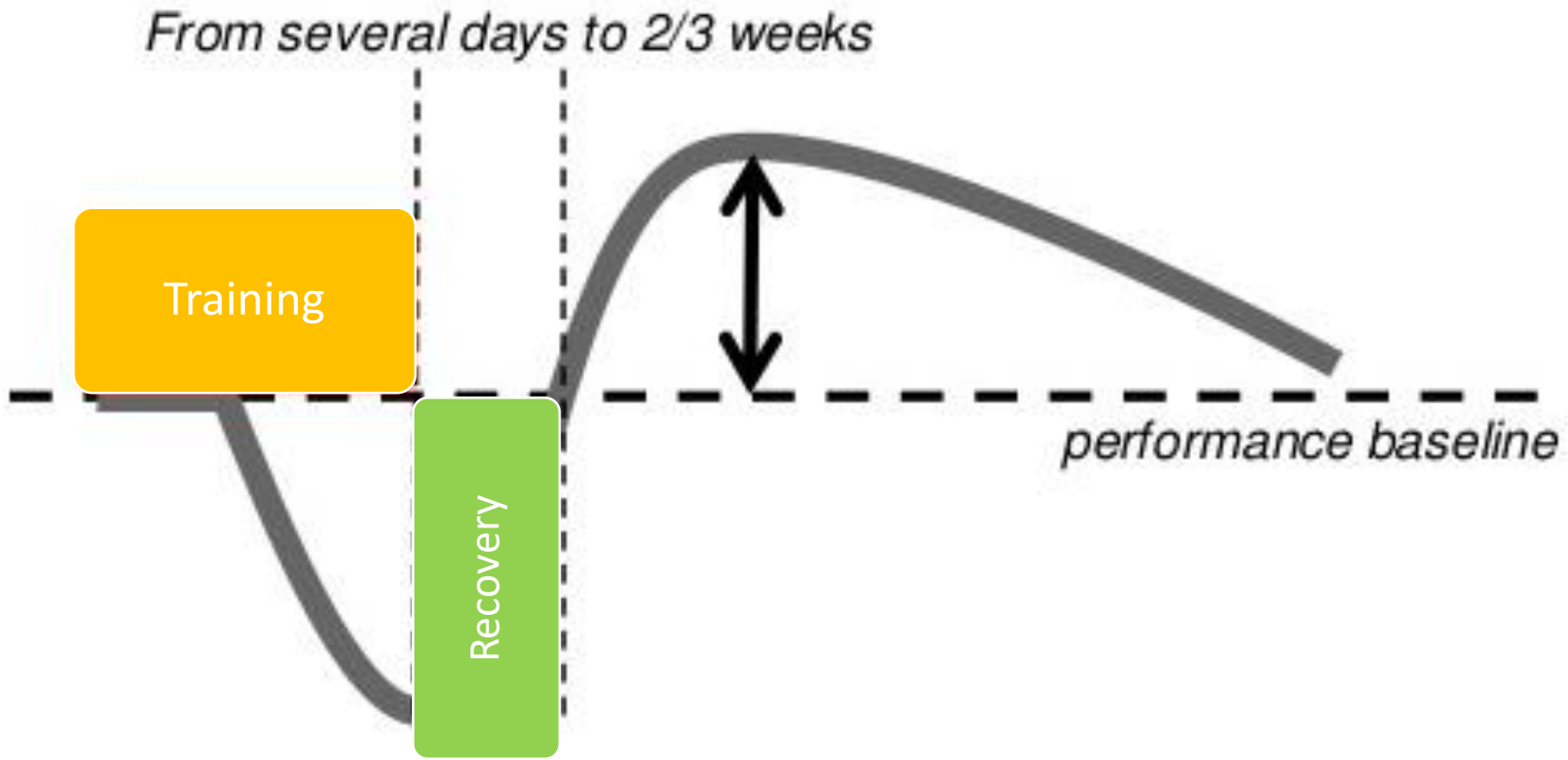

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Fatigue

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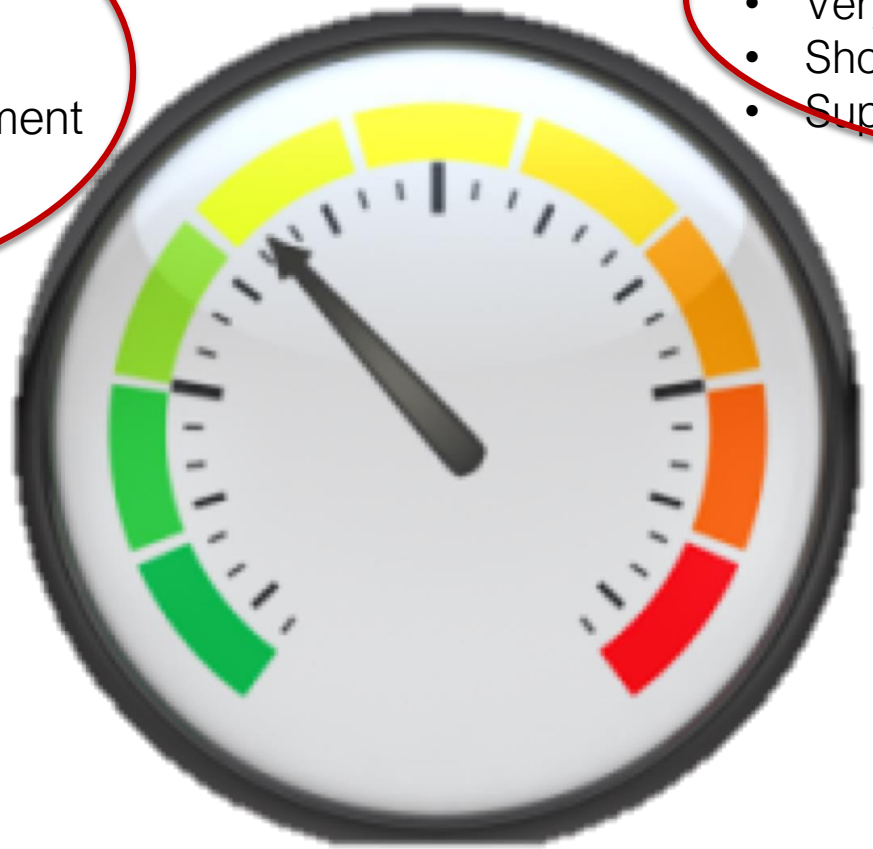
Acute fatigue
- High perceived fatigue
- No performance decrement
- Supercompensation



Functional Overreaching
- Very high perceived fatigue
- Short-term performance decrement (days, weeks)
- Supercompensation

Non-Functional Overreaching
- Very high perceived fatigue
- Performance decrement (< 1 month)
- Performance back to baseline
- No supercompensation

Overtraining
- Very high perceived fatigue
- Long-term performance decrement (months to years)

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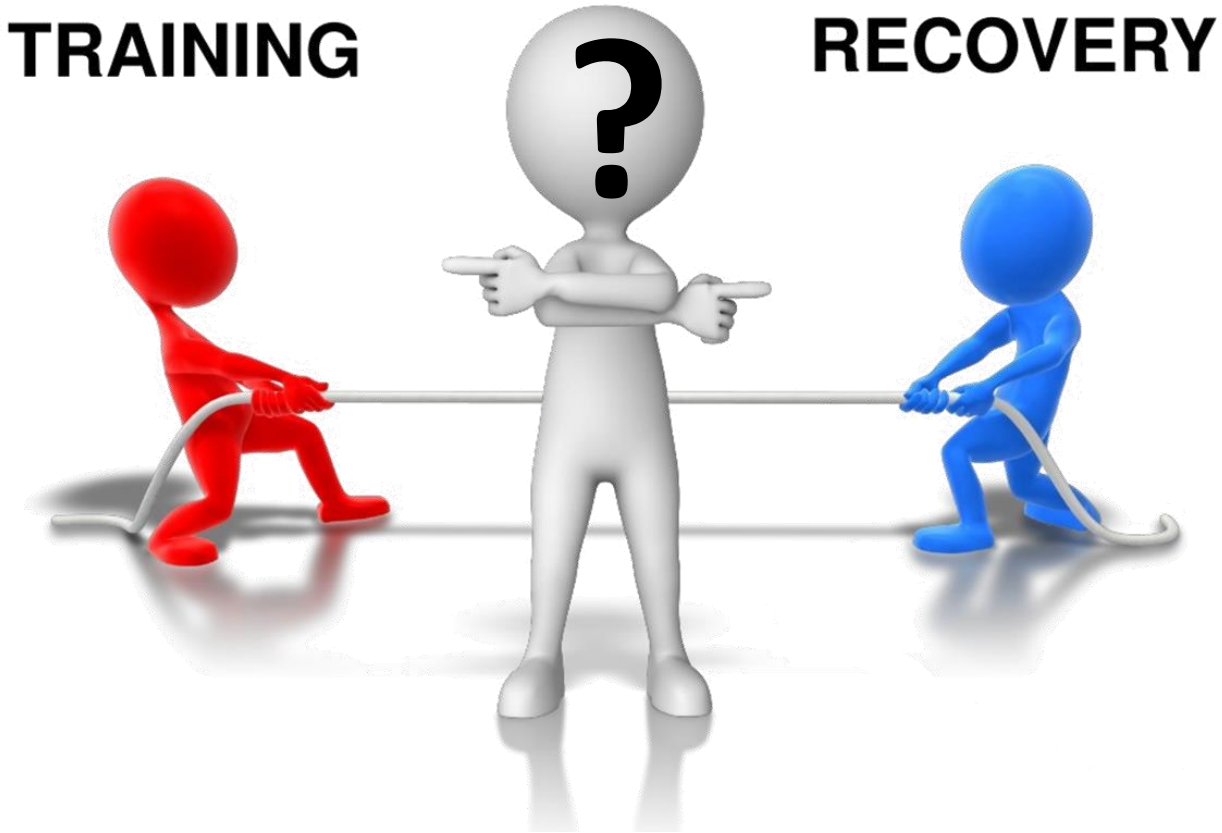
Training



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Cold-water Immersion

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Recovery

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International Journal of Sports Physiology and Performance, 2013, 7, 227-242

INTERNATIONAL JOURNAL OF SPORTS PHYSIOLOGY AND PERFORMANCE
www.IJSPP-Journal.com
BRIEF REVIEW

Cooling and Performance Recovery of Trained Athletes: A Meta-Analytical Review

Wigand Poppendieck, Oliver Faude, Melissa Wegmann, and Tim Meyer

- Decreased muscle & body temperature
- Reduced muscle damage, inflammation, heart rate & cardiac output
- Peripheral vasoconstriction reducing edema formation

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International Journal of Sports Physiology and Performance, 2013, 7, 227-242

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BRIEF REVIEW

Cooling and Performance Recovery of Trained Athletes: A Meta-Analytical Review

Wigand Poppendieck, Oliver Faude, Melissa Wegmann, and Tim Meyer

- Temperature: 10 – 12 °C
- Duration: 5 – 20 minutes whole-body or 1 – 5 minutes intermittent, 30 minutes post-exercise
- Depth: hips, shoulder or fatigued muscles only

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Cold-water Immersion

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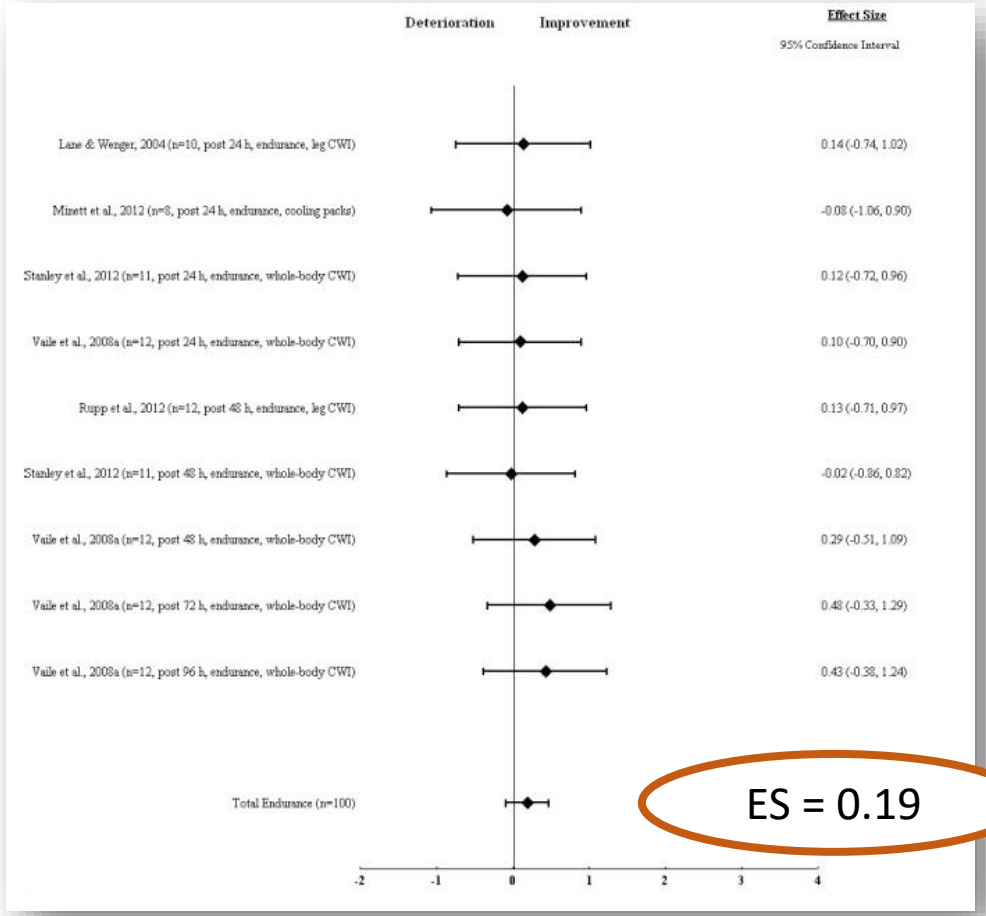
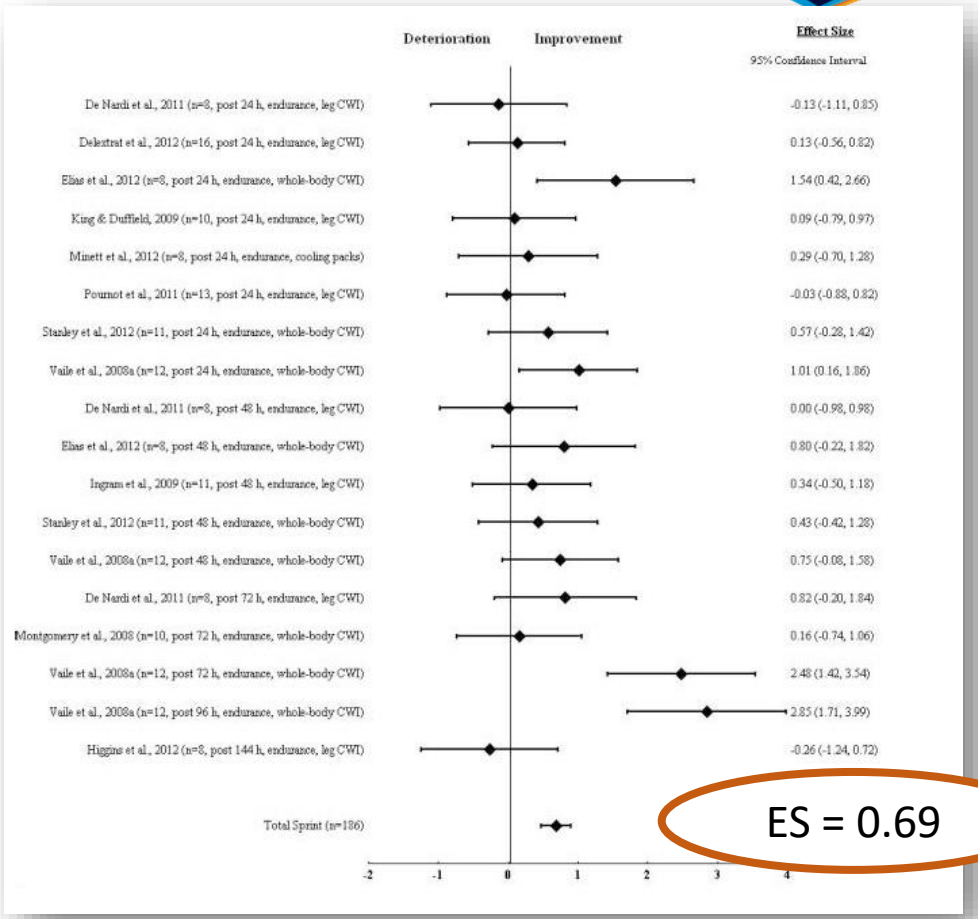
Endurance: + 2.6 %



ES = 0.19

Speed: + 2.6 %



ES = 0.69

Poppendieck et al. 2013

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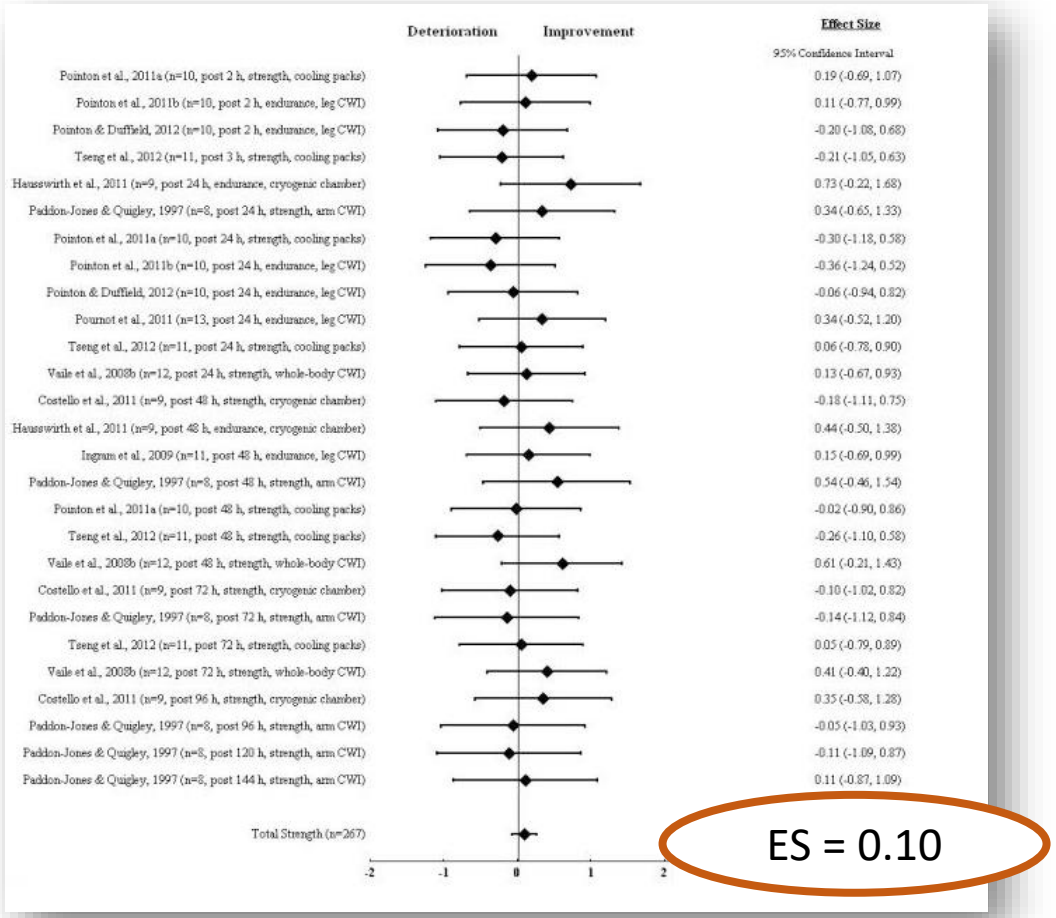
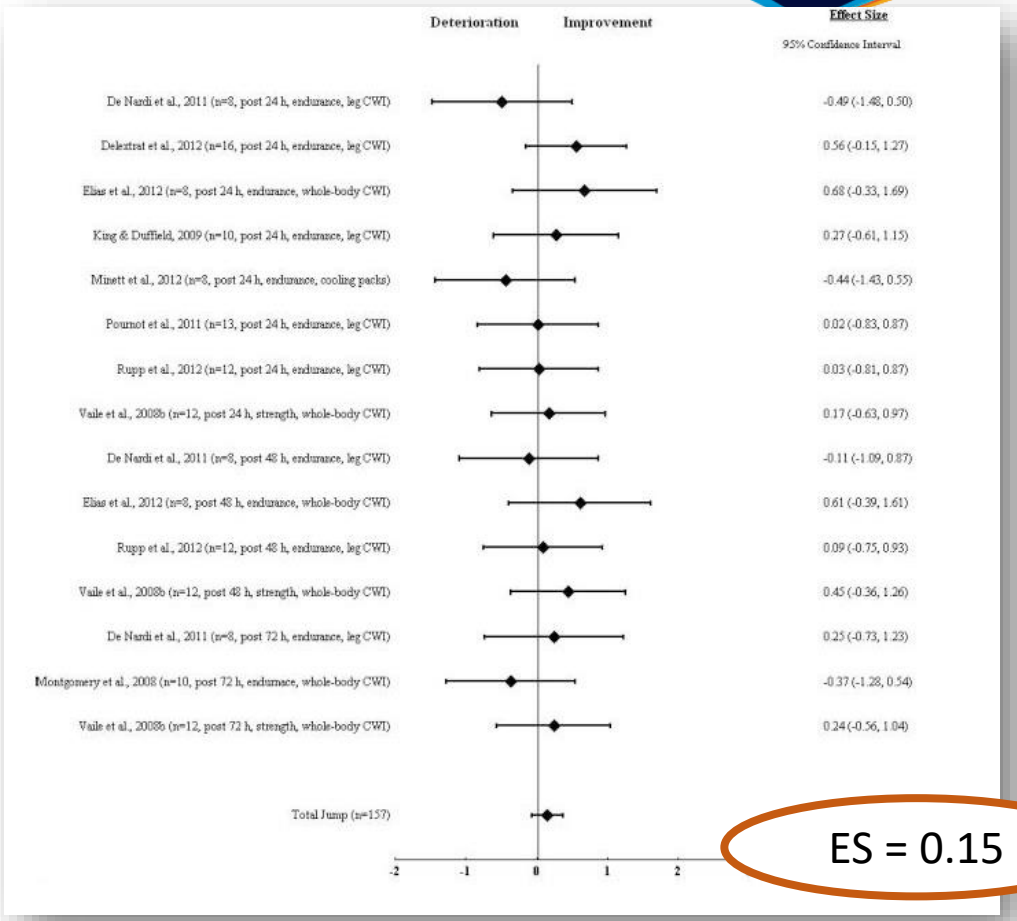
Strength: + 1.8 %



ES = 0.10

Jump: + 3.0 %



ES = 0.15

Poppendieck et al. 2013

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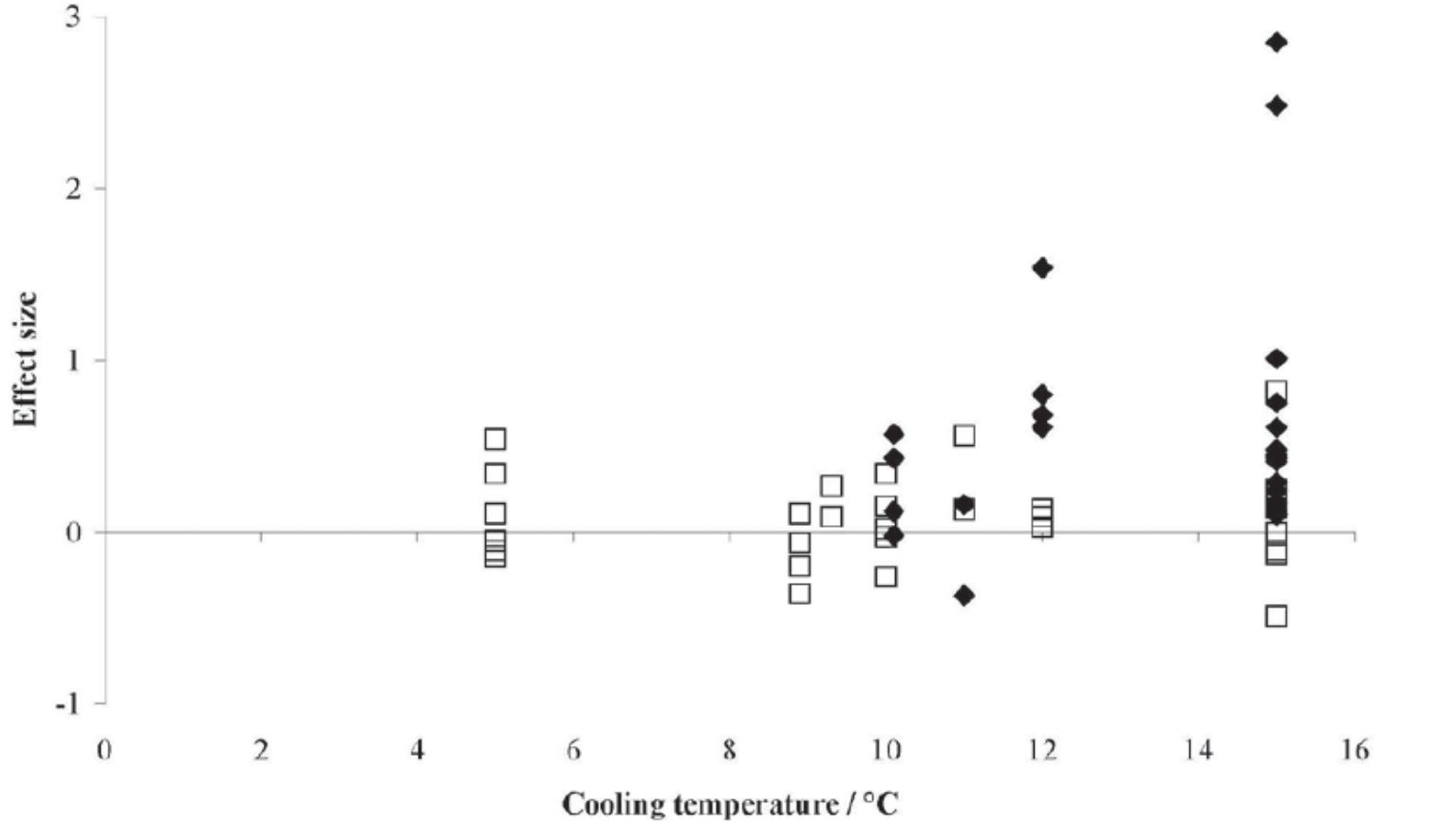
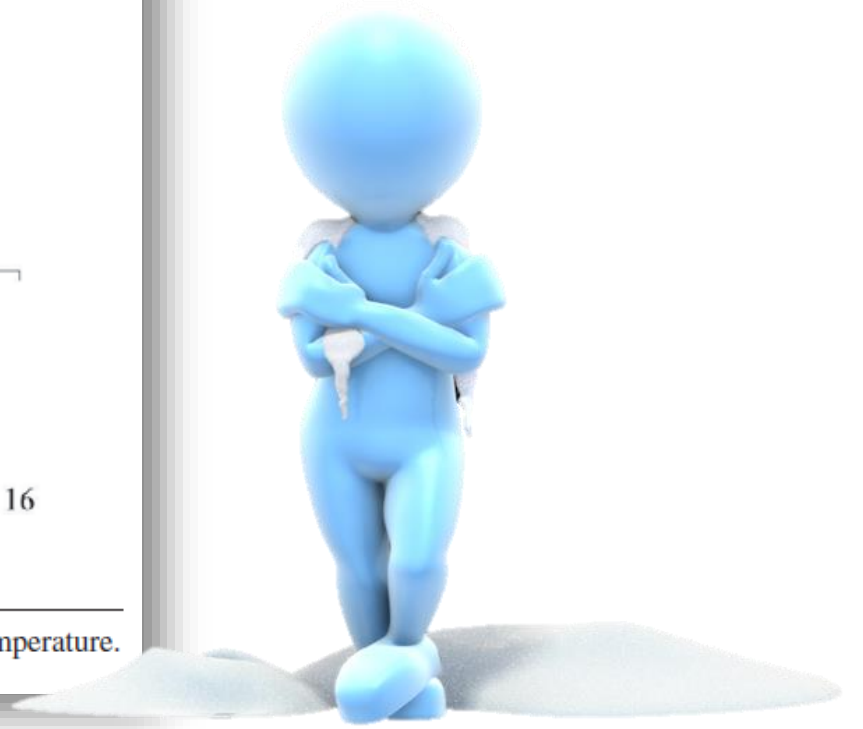


Figure 6 — Effects of cold-water immersion (CWI) after exercise on performance recovery with respect to water temperature. Black diamonds indicate whole-body CWI; white squares, part-body CWI.



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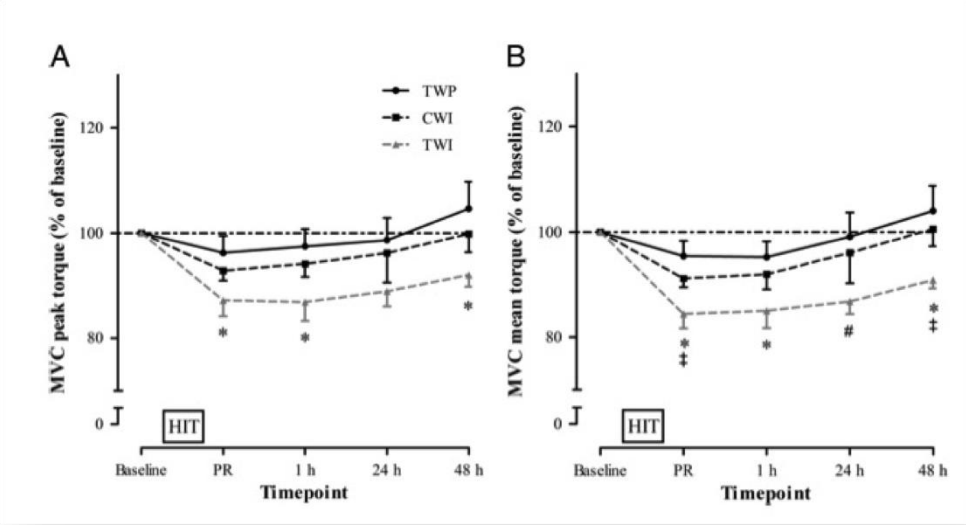
Cold-water Immersion



Broatch et al. 2014

CWI: 15 min, 10°C
TWI: 15 min, 35°C
Placebo: 15 min, 35 °C + “Recovery Oil”

	Time Point					
	Baseline	PE	PR	1 h	24 h	48 h
Physically ready						
CWI	7.7 ± 1.5	1.0 ± 1.5	4.8 ± 2.2	7.1 ± 1.8	8.4 ± 1.5	7.6 ± 1.9
TWP	7.1 ± 1.1	1.0 ± 0.7	3.7 ± 1.7	5.5 ± 2.1	6.8 ± 2.5[c]	7.4 ± 1.8
TWI	7.4 ± 1.4	0.8 ± 0.7	3.1 ± 1.6*	4.5 ± 1.5*	6.7 ± 1.8*	6.5 ± 2.3
Mentally ready						
CWI	7.2 ± 1.6	2.8 ± 2.5	5.5 ± 2.1	7.1 ± 1.9	7.9 ± 1.5	7.3 ± 1.9
TWP	6.7 ± 1.1	2.4 ± 1.9	4.5 ± 1.3	6.0 ± 1.9	7.0 ± 1.9	7.6 ± 1.2
TWI	7.3 ± 1.3	1.2 ± 0.9	2.7 ± 1.7* **	4.2 ± 2.2*	6.5 ± 2.1	5.6 ± 2.6[d]
Fatigue						
CWI	2.8 ± 1.9	9.1 ± 0.9	4.7 ± 2.0	3.2 ± 1.9	1.8 ± 1.5	3.0 ± 2.5
TWP	2.5 ± 1.6	9.0 ± 0.6	4.7 ± 1.5	4.2 ± 2.1	2.9 ± 1.9	2.7 ± 1.6
TWI	3.4 ± 1.8	8.4 ± 2.3	5.7 ± 2.1	3.9 ± 2.0	2.9 ± 2.0	3.7 ± 2.3

- No difference between placebo & CWI
- Improved performance after placebo compared to TWI

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Cold-water Immersion

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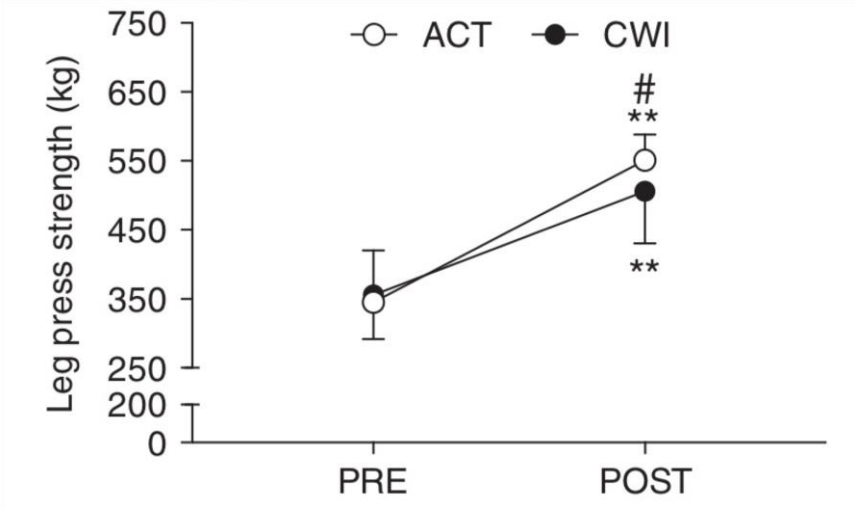
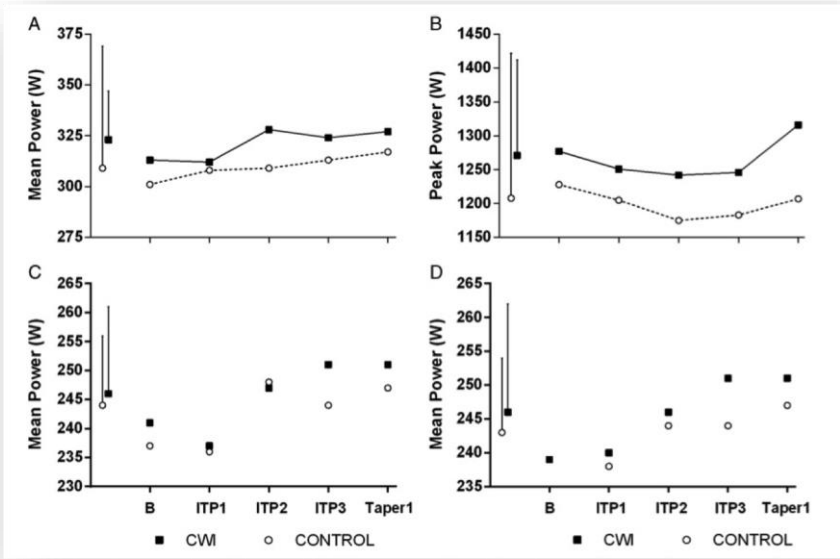


Roberts et al. 2015

- Reduced adaptation in strength & muscle mass
  (Roberts et al. 2015)

→ Molecular changes in inflammation & satellite cells *(Roberts et al. 2015; Yamane et al. 2006)*



Halson et al. 2014

- Improved VO_{2max} & time to exhaustion
  (Yamane et al. 2006; Ishan et al. 2015)
- Increased training tolerance (e. g. interval training) *(Halson et al. 2014)*

→ Molecular changes in mitochondrial biogenesis *(Ishan et al. 2015)*

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Massage

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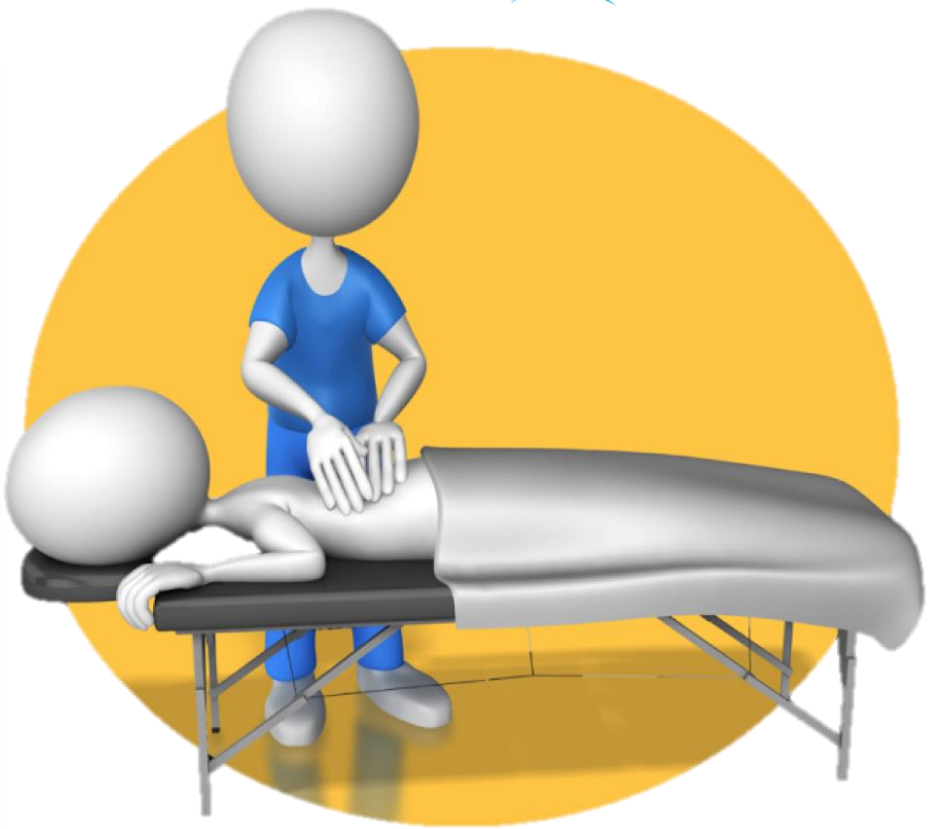

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Massage

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"Mechanical manipulation of body tissues with rhythmical pressure and stroking for the purpose of promoting health and well-being." *(Cafarelli et al., 2005)*

Application:

1. Recovery
2. Competition preparation
3. Injury prevention & rehabilitation

➡ Very popular in athletes but evidence on effects & physiological mechanisms are unclear.

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Massage

Possible mechanisms of massage

Biomechanical effects	Physiological effects	Neurological effects	Psychological effects
Mechanical pressure on tissues	Changes in tissue or organ	Reflex stimulation	Increased relationship between body and mind
↓ Tissue adhesion ↑ Muscle compliance ↑ Range of joint motion ↓ Passive stiffness ↓ Active stiffness	↑ Muscle blood flow ↑ Skin blood circulation ↑ Parasympathetic activity ↑ Relaxation hormones ↓ Stress hormones	↓ Neuromuscular excitability ↓ Pain ↓ Muscle tension or spasm	↑ Relaxation ↓ Anxiety

Weerpong et al. 2014

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Massage

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Overall effect: 3.3%

Type of Massage

Classic Western Massage:	3.5%
Vibration:	1.8%
Underwater Massage:	2.8%

Sports Med
DOI 10.1007/s40279-015-0420-x

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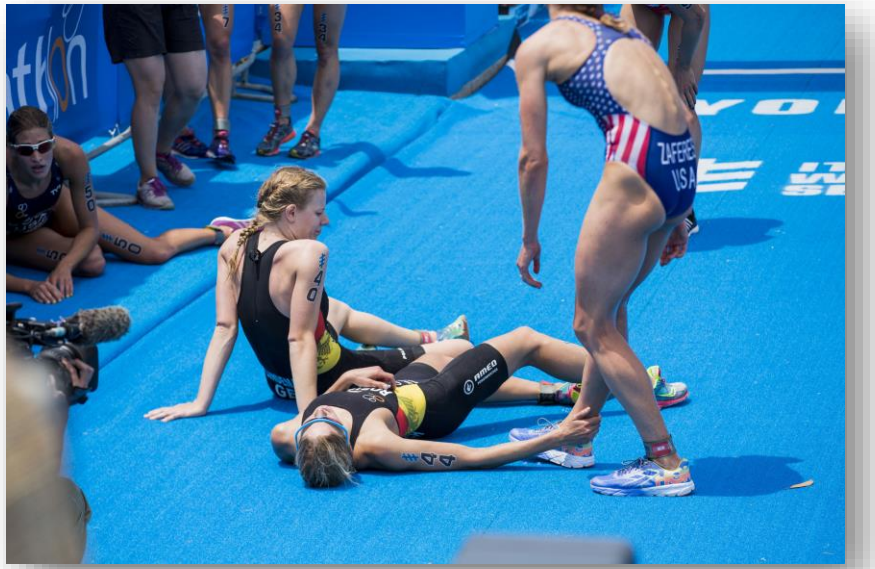
REVIEW ARTICLE

Massage and Performance Recovery: A Meta-Analytical Review

Wigand Poppendieck[1,2] · Melissa Wegmann[1] · Alexander Ferrauti[3] · Michael Kellmann[4,5] · Mark Pfeiffer[6] · Tim Meyer[1]

Duration:

5 – 6 min:	7.8%
8 – 12 min:	6.1%
15 – 20 min:	0.9%
>30 min:	1.1%



Duration of effect:

Up to 10 min:	7.9%
24 h:	1.7%
48 h:	2.8%
72 h:	3.9%
96 h:	4.6%
>96 h:	1.1%

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Massage

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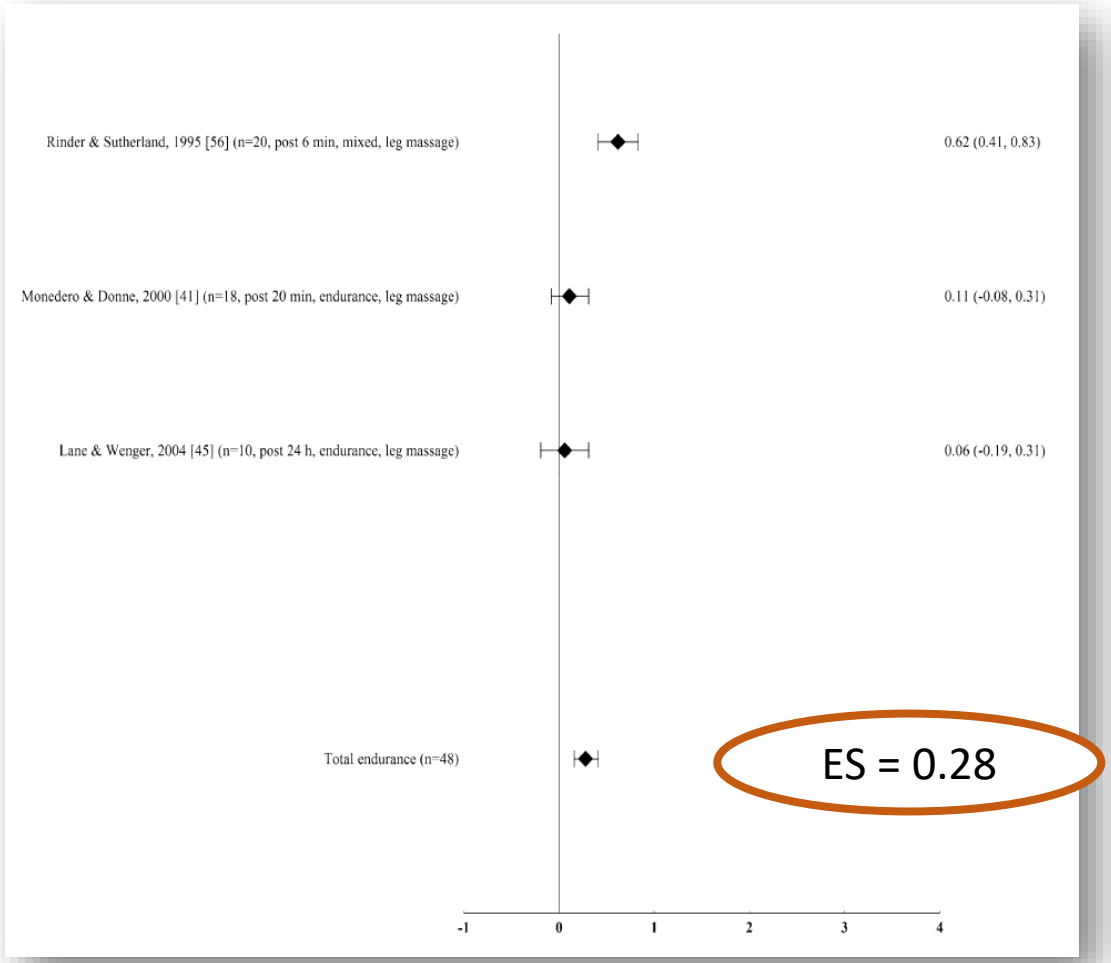
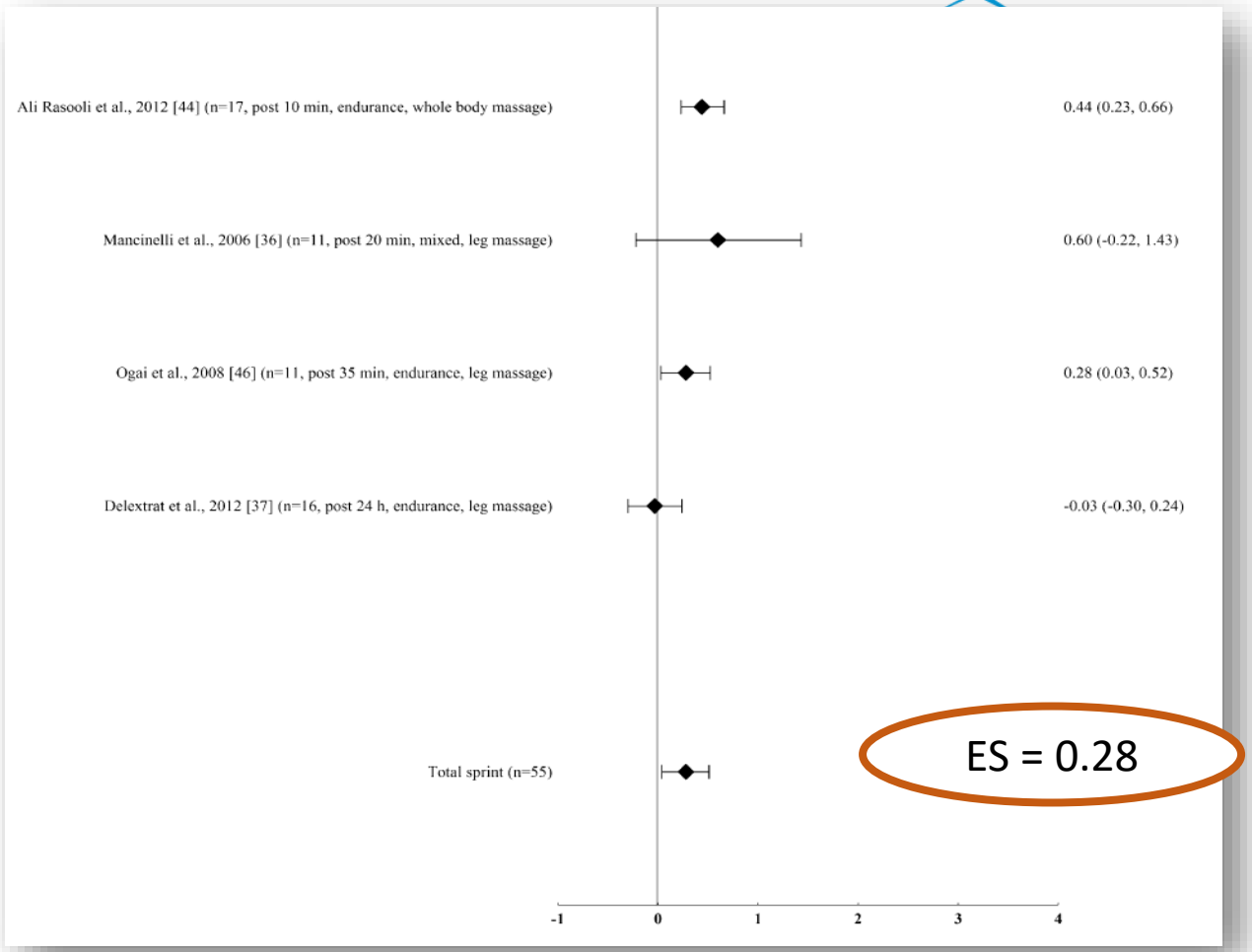
Endurance: + 6.0 %



Speed: + 3.1 %



Poppendieck et al. 2016

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Massage

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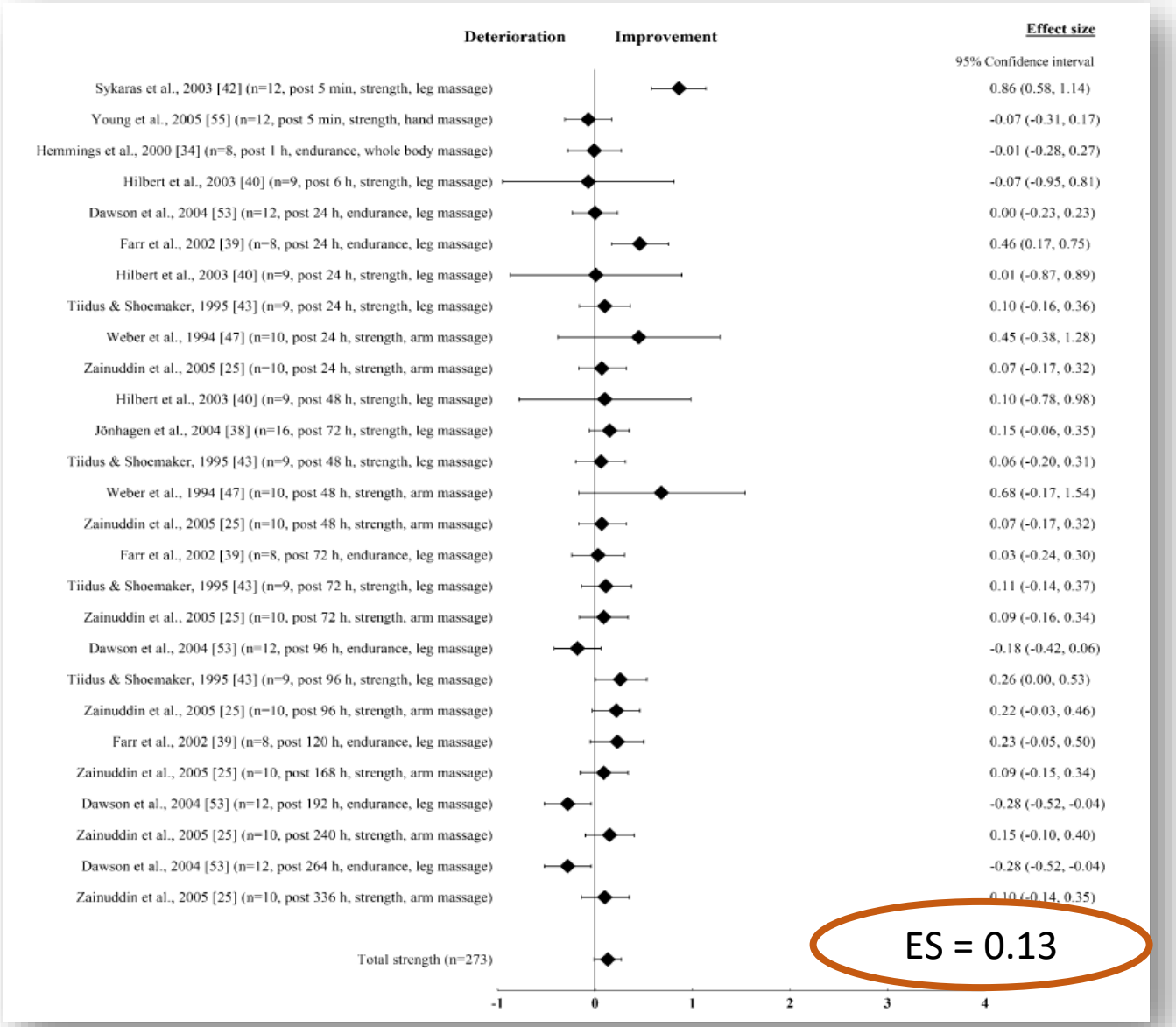
Strength: + 6.0 %



ES = 0.13

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Massage and Performance Recovery: Does it Really Work?

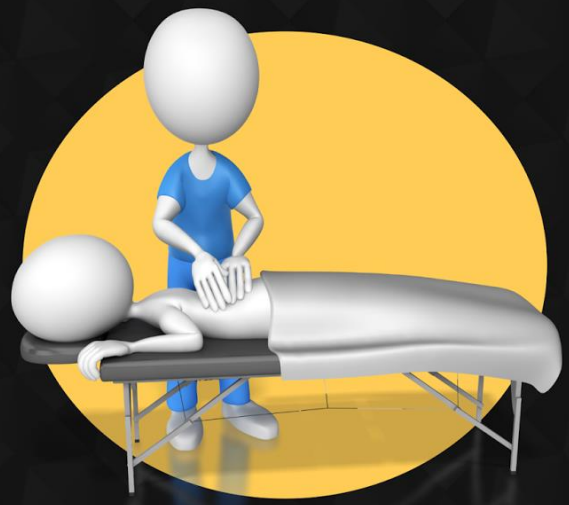
By Wigand Poppendieck et al. in Sports Medicine, January 2016

Designed by ©YLMSportScience

The statistical analyses of this meta-analysis were based on 22 studies with 270 subjects
5 used techniques of automated massage (e.g. vibration), while the other 17 used classic manual massage

HOW LONG?

A tendency was found for shorter massage (5–12 min) to have larger effects than massage lasting more than 12 min



WHEN?

The effects were larger for short-term recovery of up to 10 min (than for recovery periods of more than 20 min). Although after high-intensity mixed exercise, massage yielded medium positive effects, the effects after strength exercise and endurance exercise were smaller

WHO?

A tendency was found for untrained subjects to benefit more from massage than trained athletes

CONCLUSION

The effects of massage on performance recovery are rather small and partly unclear, but can be relevant under appropriate circumstances (short-term recovery after intensive mixed training). However, it remains questionable if the limited effects justify the widespread use of massage as a recovery intervention in competitive athletes

Designed by Yann Le Meur (@YLMSportScience)

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Sleep

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Sport > Football > News & Comment

Meet Cristiano Ronaldo's secret weapon - the man behind why the world's biggest stars sleep so soundly

For nearly two decades Nick Littlehales has been advising athletes on why it's not as simple as getting eight hours per night - it's in fact quite the opposite

Tim Rich | @timrich001 | Wednesday 6 September 2017 11:44 |
744 shares |

How Gareth Bale and Real Madrid sleep their way to the top

21 April 2015
Last updated at 08:11 GMT
Share

By Alec Fenn
Football writer

At 1pm every afternoon, the hustle and bustle of Real Madrid's Valdebebas training ground grinds to a halt and the facility resembles a ghost town.

A silence descends over the complex for the following two hours as players and staff close their eyes and drift into a siesta before waking and resuming their day - but they're not sleeping on the job.

The scene is a window into football's relentless pursuit of marginal gains

The search for performance enhancement leads some athletes to turn some pretty dark co
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Athletes' Magic Pill: A Good Night's Sleep

Quality sleep impacts overall performance in professional athletes.

By L. Hostetler | Feb 18, 2019, 1:19pm PST

What's t

SHARE

There's been a welcome uptick in the attention pai

Sleep And Athletic Performance: How Just An Extra Hour Of Rest Can Make You A Better Athlete

The Huffington Post | By Sarah Klein
Posted: 03/26/2013 8:07 am EDT | Updated: 03/26/2013 10:02 am EDT

Sleep

Sleep is

„.. *Not simply the absence of waking, sleep is a special activity of the brain, controlled by elaborate and precise mechanisms. Not simply a state of rest, sleep has its own specific, positive functions*“ *(Hobson, 1995)*

Essential for cognitive & physical function:

1. Restorative effects on immune & endocrine systems
2. Assistance in recovery of central nervous system & metabolic cost
3. Cognitive development

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Sleep Phases

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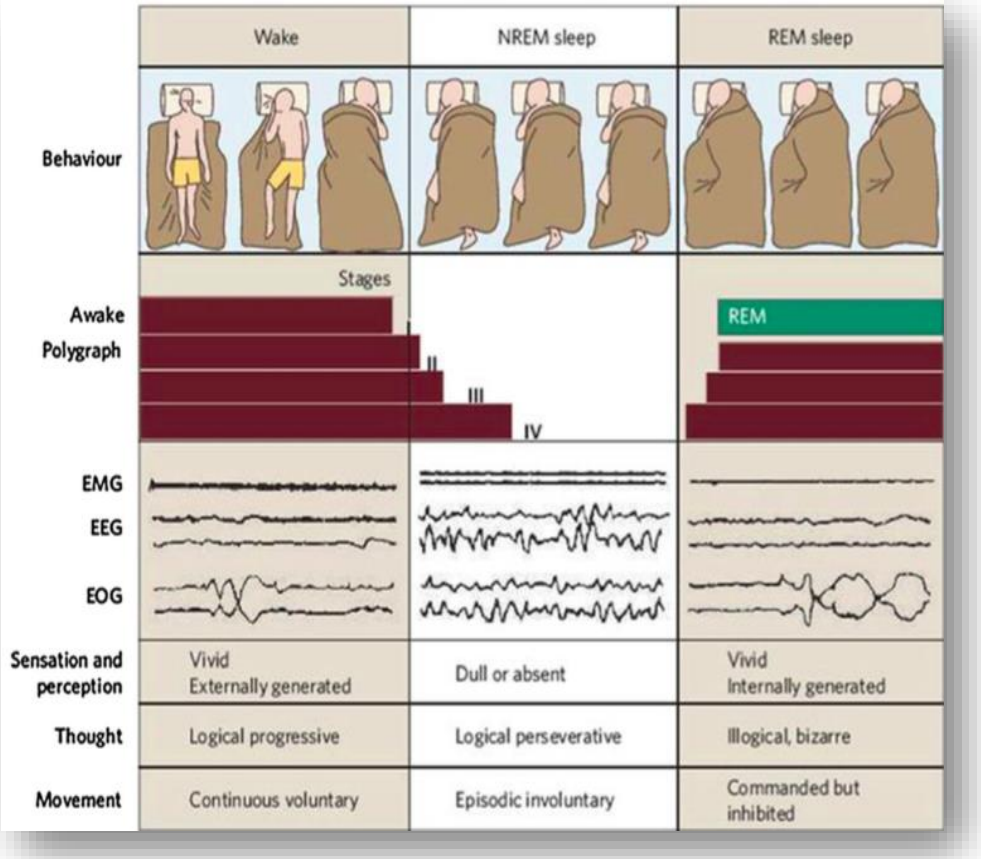

Hobson 2005

90 min cycles separated in REM and NREM sleep

NREM:

- ↑ Protein synthesis
- ↑ Mobilisation of free fatty acids
- ↑ Increased release in growth hormones

→ Accelerated healing of peripheral muscle damage.

REM: Critical in establishing brain connections.

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Sleep in Athletes

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- Ø sleep duration & sleep quality
- Sleep onset latency

Table II. Sleep actigraphy data comparing athletes (including data on individual athletic groups) with non-athletic controls. Values are means ± standard deviation.

Group	*n*	Time in bed (hrs:mins)	Sleep latency (mins)	Time asleep (hrs:mins)	Time awake (hrs:mins)	Sleep efficiency (%)	Fragmentation index	Actual sleep (%)	Moving minutes (mins)	Moving time (%)
Controls	20	$8:07 \pm 0:20_a$	$5.0 \pm 2.5_b$	$7:11 \pm 0:25$	$0:50 \pm 0:16_c$	$88.7 \pm 3.6_d$	$29.8 \pm 9.0_e$	$89.7 \pm 3.3_f$	$45.4 \pm 11.6_g$	$9.4 \pm 2.4_h$
Athletes	46	$8:36 \pm 0:53_a$	$18.2 \pm 16.5_b$	$6:55 \pm 0:43$	$1:17 \pm 0:31_c$	$80.6 \pm 6.4_d$	$36.0 \pm 12.4_e$	$84.3 \pm 5.7_f$	$87.6 \pm 32.6_g$	$17.8 \pm 6.2_h$
Canoeing	*11*	*8:32 ± 0:35*	*19.1 ± 20.2*	*6:58 ± 0:23*	*1:06 ± 0:17*	*81.8 ± 4.3*	*31.0 ± 9.0*	*86.3 ± 3.4*	*75.6 ± 19.8*	*15.6 ± 4.2*
Diving	*14*	*8:46 ± 0:55*	*21.0 ± 19.0*	*7:05 ± 0:47*	*1:17 ± 0:19*	*80.9 ± 5.3*	*39.3 ± 11.8*	*84.5 ± 3.7*	*96.5 ± 30.3*	*19.3 ± 5.3*
Rowing	*10*	*7:46 ± 0:40*	*10.2 ± 6.6*	*6:25 ± 0:50*	*1:08 ± 0:32*	*82.5 ± 8.3*	*35.6 ± 16.1*	*84.8 ± 7.2*	*77.9 ± 41.3*	*17.3 ± 9.1*
Speed skating	*11*	*9:13 ± 0:47*	*21.1 ± 15.1*	*7:06 ± 0:38*	*1:38 ± 0:46*	*77.2 ± 7.1*	*37.3 ± 12.2*	*81.6 ± 7.5*	*97.0 ± 34.8*	*18.4 ± 5.7*

Note: Mean values with the same subscript are significantly different ($p < 0.05$).

Leeder et al. 2012

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Sleep & Training

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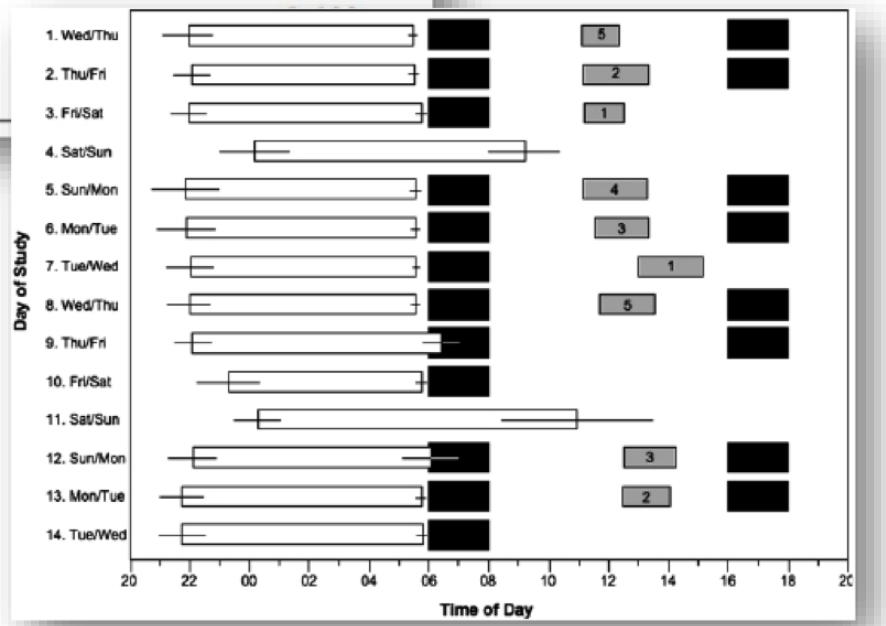
Table II. Sleep/wake variables on training days and rest days (mean ± *s*)

Measure	Training days	Rest days	*p*-Value
Bedtime (hh:mm)	22:05 ± 00:52	00:32 ± 01:29	< 0.001
Get-up time (hh:mm)	05:48 ± 00:24	09:47 ± 01:47	< 0.001
Time in bed (h)	7.7 ± 0.9	9.3 ± 1.7	< 0.001
Sleep onset latency (min)	40.8 ± 43.2	31.8 ± 21.6	0.543
Sleep duration (h)	5.4 ± 1.3	7.1 ± 1.2	< 0.001
Sleep efficiency (%)	70.7 ± 15.1	77.2 ± 7.5	0.220
Wake after sleep onset (%)	17.6 ± 8.8	16.2 ± 7.7	
Daytime nap duration (h)	0.2 ± 0.5	0.0 ± 0.0	
Total sleep time (h)	5.6 ± 1.4	7.1 ± 1.2	

Sargent et al. 2014



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Sleep & Competition

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- Increased sleep disturbances be fore competition.
- Total sleep duration reduced up to 60 min.
- Total sleep volume & efficacy be low recommendations.
- Nervousness, increased physical & mental stress.

	All Participants		Gender			
	Absolute	Frequency (%)	Male (%)	Female (%)	Chi square	*p*-Value
Overall	181	64.0	65.9	62.4	0.55	0.619
"What kinds of problems did you experience with your sleep prior to an important competition or game?" $n = 179$						
Problems falling asleep	147	82.1	80.7	83.3	0.21	0.698
Waking up early in the morning	48	26.8	24.1	29.2	0.58	0.501
Waking up at night	68	38.0	32.5	42.7	1.96	0.169
Unpleasant dreams	10	5.6	0	10	9.16	0.002*
Not feeling refreshed in morning	65	36.3	34.9	37.5	0.13	0.757
"What reasons were responsible for your sleeping problems prior to an important competition or game?" $n = 176$						
Thoughts about competition	147	83.5	82.9	84.0	0.16	0.837
Nervousness about competition	77	43.8	42.7	44.7	0.07	0.877
Not used to surroundings	39	22.2	23.3	22.3	0.02	1.000
Noises in room or outside	31	17.6	15.0	19.0	0.75	0.428
"In what manner did the sleeping problems influence your performance during the competition or game?" $n = 178$						
No influence	83	46.6	48.2	45.3	0.15	0.764
Increased daytime sleepiness	75	42.1	36.1	47.4	2.29	0.171
Bad mood the following day	24	13.4	13.3	13.7	0.01	1.000
Worse performance in competition	25	14.0	17.0	12.0	1.03	0.388
"Which strategies did you use to sleep well in the nights preceding a competition?" $n = 176$						
No Strategy	91	51.7	54.3	49.5	0.41	0.548
Methods to relax	37	21.0	22.2	20.0	0.13	0.853
Sleeping pills	23	13.1	12.3	13.7	0.07	0.826
Reading	46	26.1	18.5	32.6	4.51	0.034*
Watching TV	34	19.3	22.2	16.8	0.81	0.445

Juliff et al. 2013

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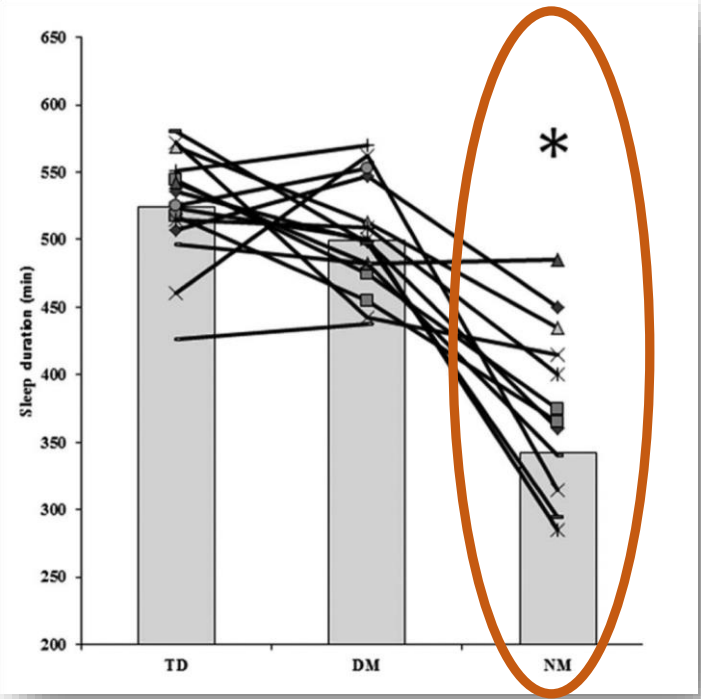
Sleep & Competition

EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE



Fullagar et al. 2016

"Normal" sleep behaviour on training days & day matches.

After night matches:

- Sleep duration
- Perceived recovery
- Accumulated negative effect over season?

	TD (n = 95)	DM (n = 38)	NM (n = 116)
Bedtime	0:14 ± 0:38	2:16 ± 2:37[a]	2:17 ± 0:57[a]
Awakening time	8:04 ± 0:19	9:04 ± 1:08[a]	8:01 ± 0:41[c]
Time in bed (h:min)	7:40 ± 0:42	8:05 ± 1:42[a]	6:55 ± 1:36[a,c]
Total sleep duration (h:min)	6:36 ± 0:45	6:39 ± 1:32	5:28 ± 1:28[a,c]

Carrico et al. 2017

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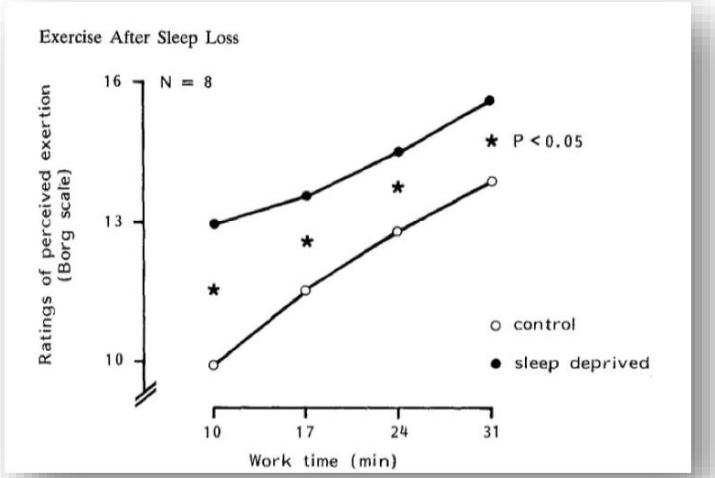
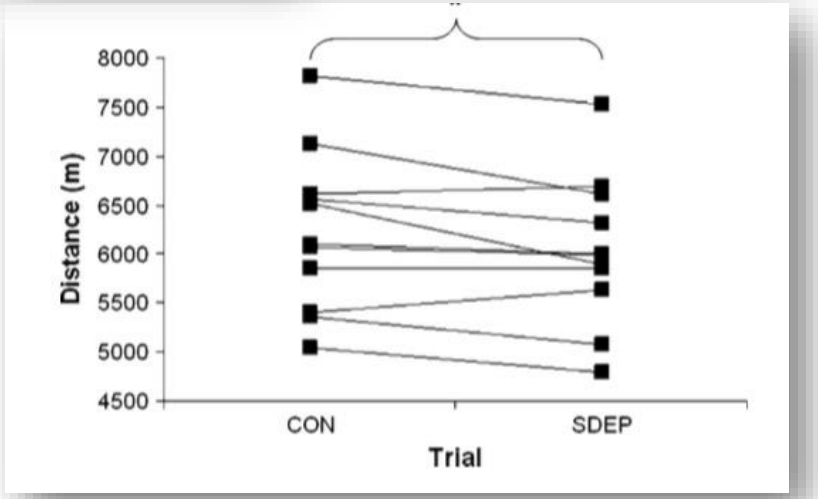
Total Sleep Deprivation

- Endurance performance (> 30 min)
- Speed
- Strength



Martin 1981

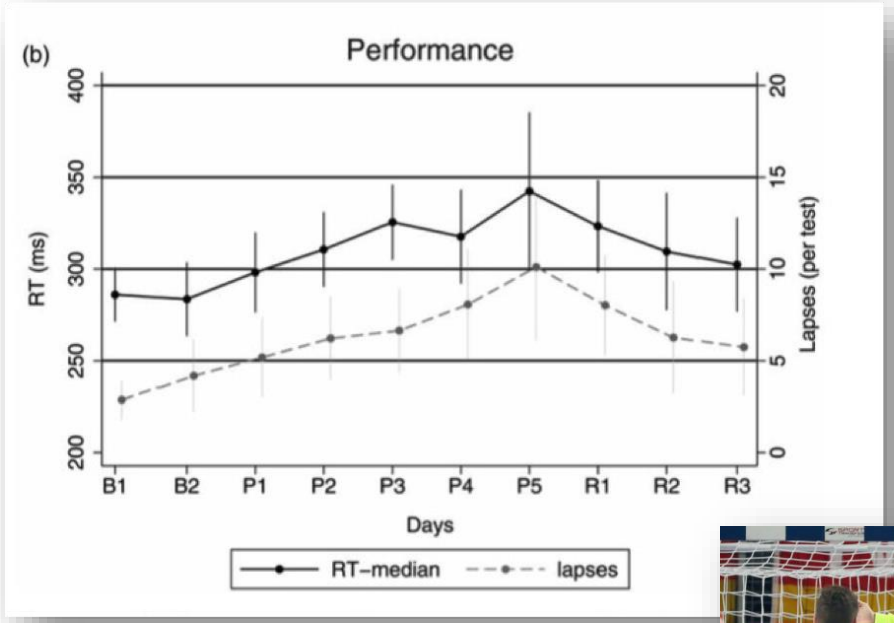
- Increased perceived load
- Reduced neuro activity
- Reduced muscle activity
- Impaired availability of energy



Oliver et al. 2009

Partial Sleep Deprivation

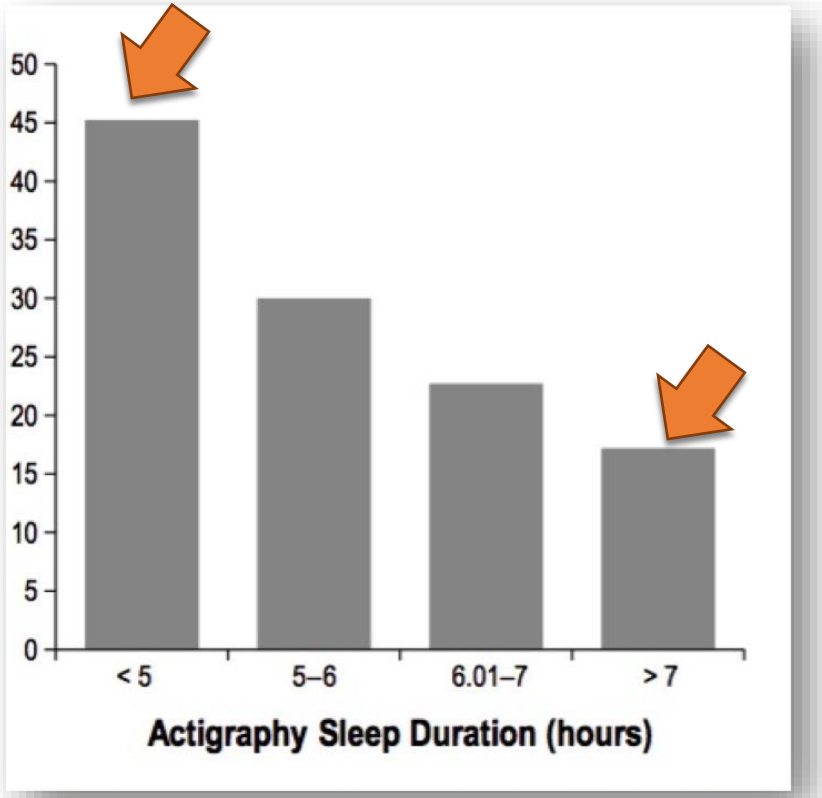
- Anaerobic capacity
- Peak performance
- Cognitive performance
  (reaction time, attention, decision making, m emory)



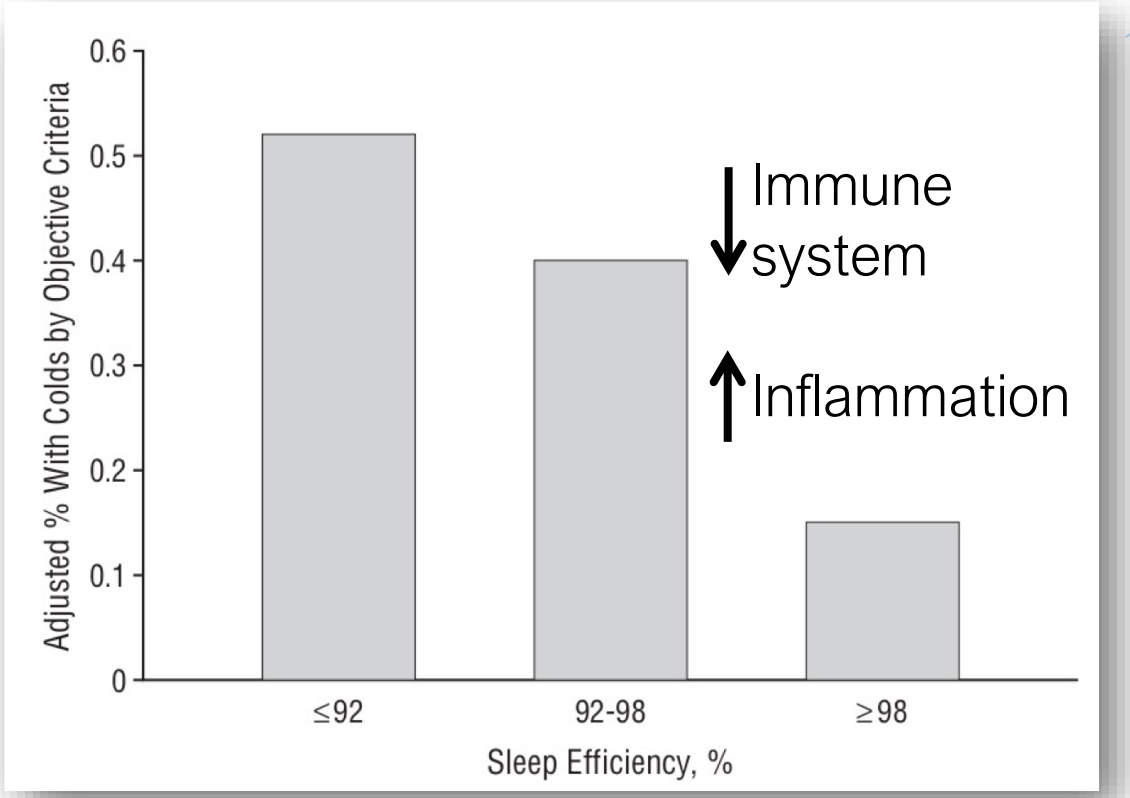
Axelsson et al. 2009

- Perceived load
- Impaired anaerobic glycolysis

Sleep & Infections



Prather et al. 2016



Cole et al. 2009

< 5 h sleep/night increases risk for infection by **4.5 times.**

< 92% SE increases risk by **5.5 times.**

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Sleep & Injury

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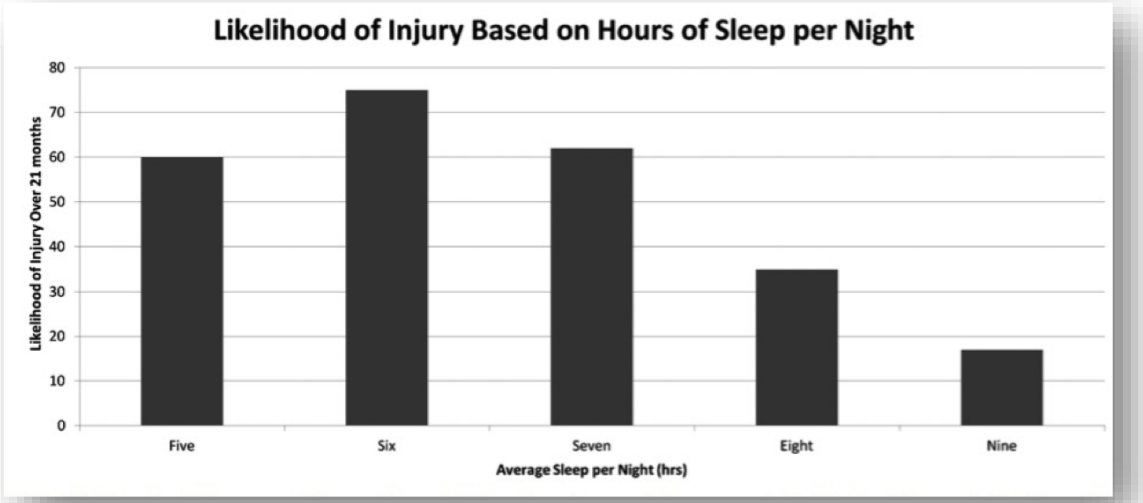

Milewski et al. 2014

Univariate logistic regression*	*P* value	OR (95% CI)	Multiple logistic regression*	*P* value	OR (95% CI)
Sleep weekdays†	0.04	0.41 (0.17–0.96)	Sleep weekdays†	0.05	0.39 (0.16–0.99)
Nutrition recommendation‡	0.03	0.38 (0.16–0.90)	Nutrition recommendation‡	0.03	0.36 (0.14–0.91)

von Rosen et al. 2017

- Athletes who sleep < 8 h/night have <u>1.7 times</u> increased risk of injury.
- 61% reduced re-injury risk when athletes meet sleep recommendations.

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Take Home Messages I

EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

Do it simple but do it well!

CWI: Context
Placebo-effect
Individual response

Massage: Standardisation is difficult
Science vs practice

Sleep: Should be a cornerstone
Sleep-Hygiene protocols
Awareness is important

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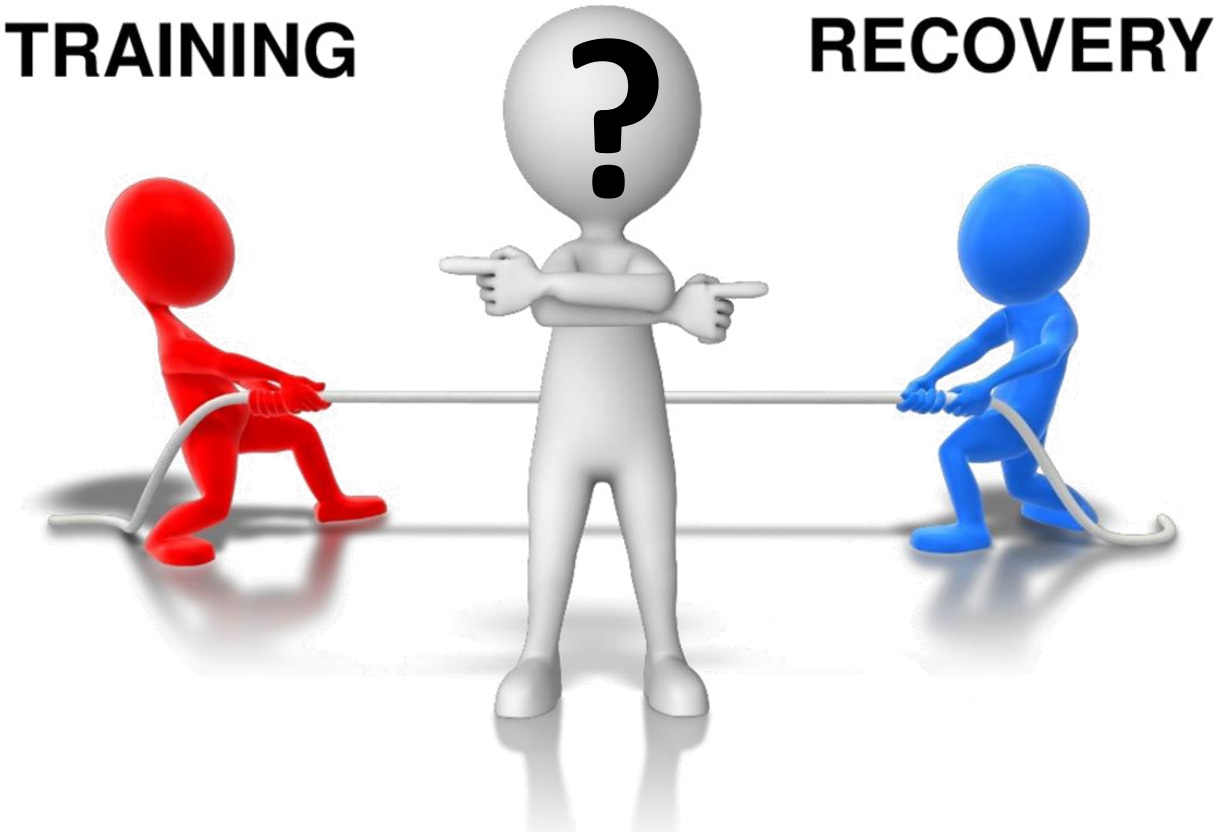
TRAINING
?
RECOVERY

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Fatigue & Recovery

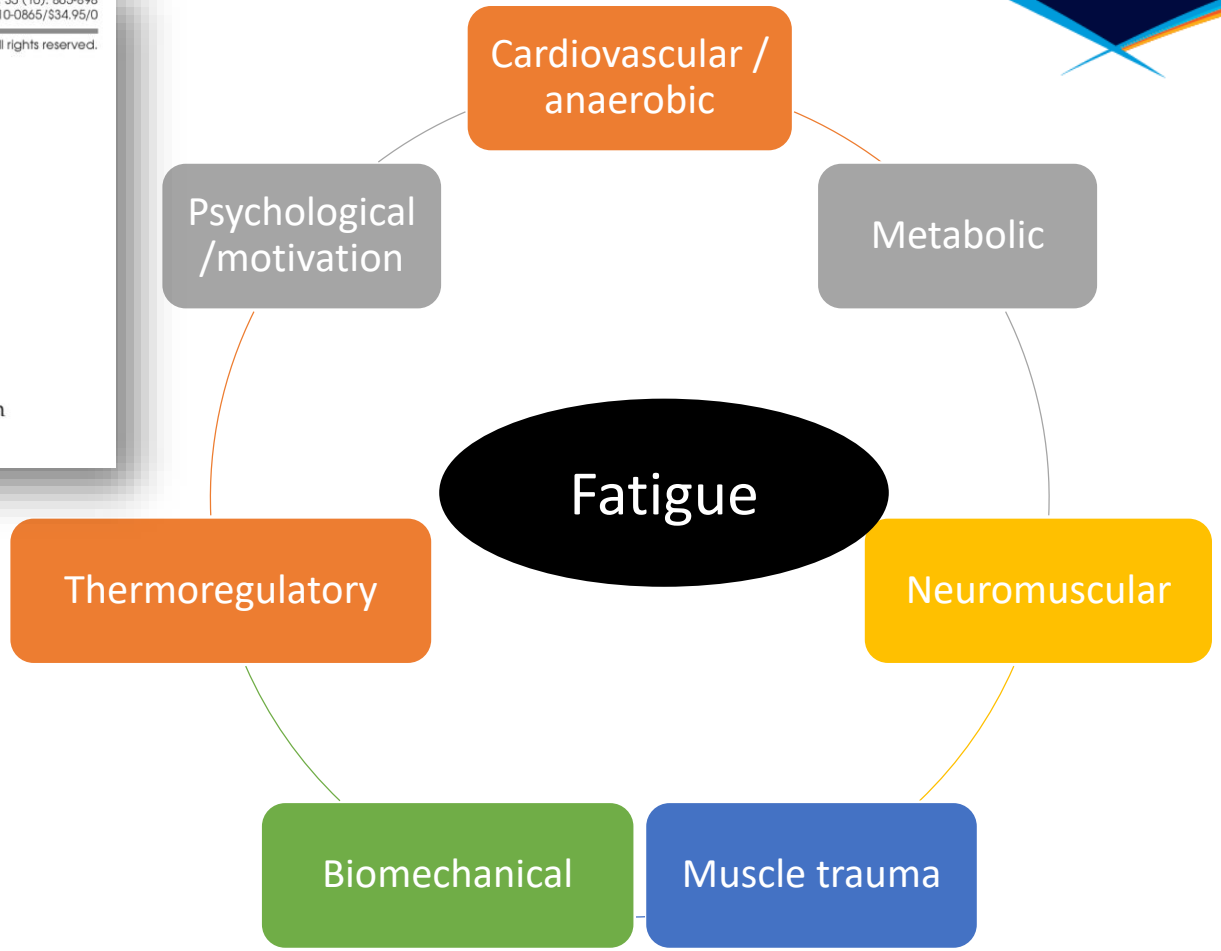
EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

REVIEW ARTICLE
Sports Med 2005; 35 (10): 865-898
0112-1642/05/0010-0865/$34.95/0

Models to Explain Fatigue during Prolonged Endurance Cycling

Chris R. Abbiss and *Paul B. Laursen*

School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Joondalup, Western Australia, Australia



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Fatigue & Recovery

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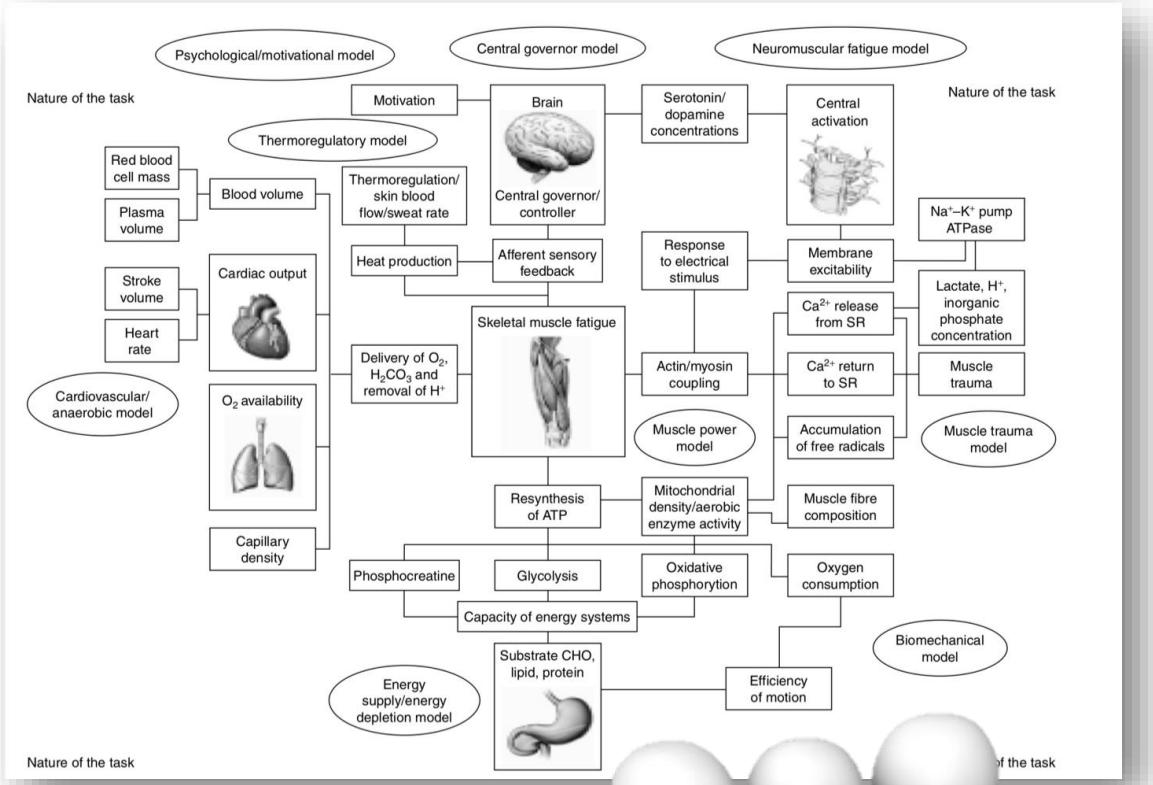
YOUR SPORT FOR LIFE



Abbiss & Laursen 2005

- Fatigue depends on the exercise type/mode, duration & intensity.
- Fatigue-induced changes vary within & between individuals.
- Different time periods for recovery.

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Time course

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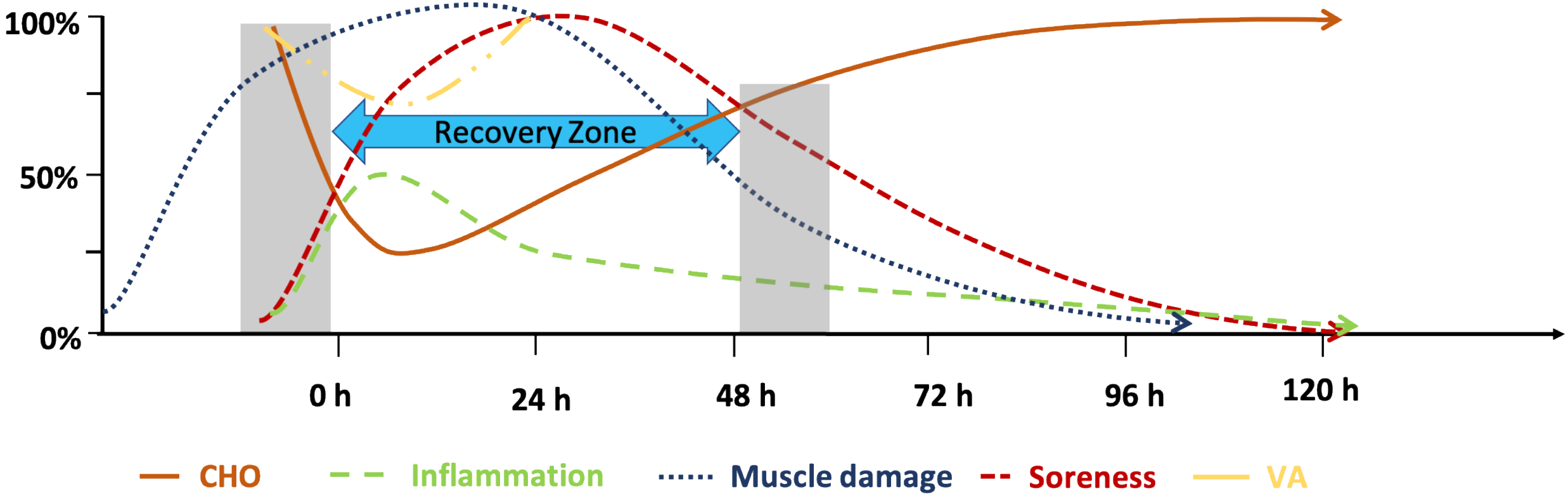
YOUR SPORT FOR LIFE



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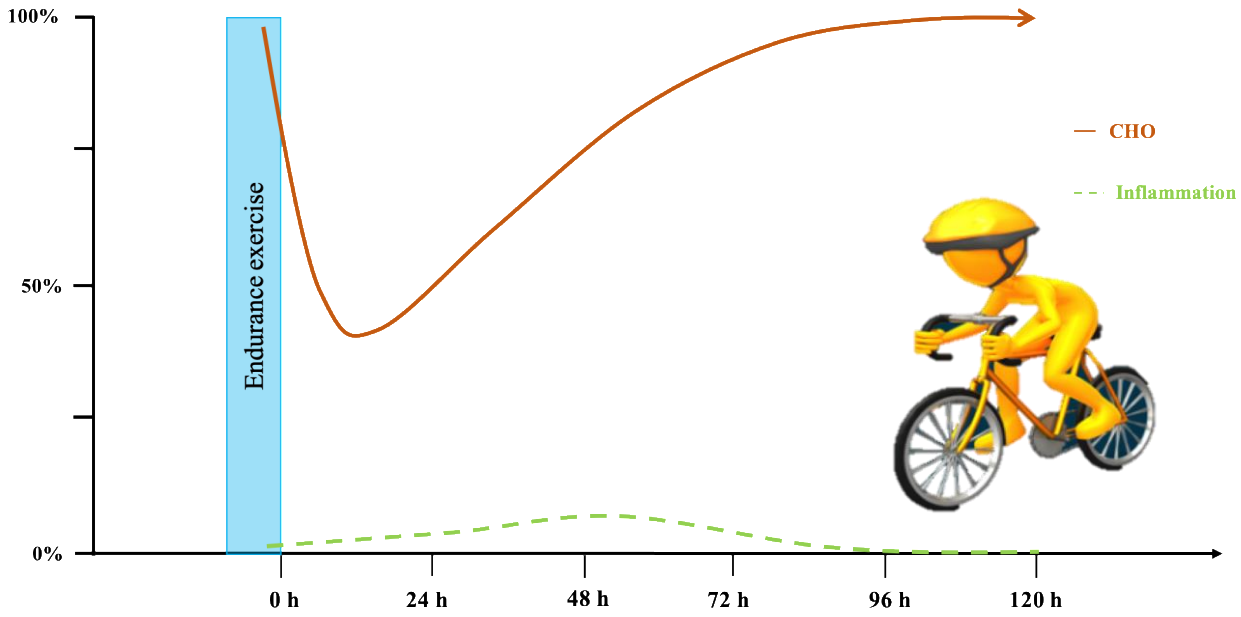
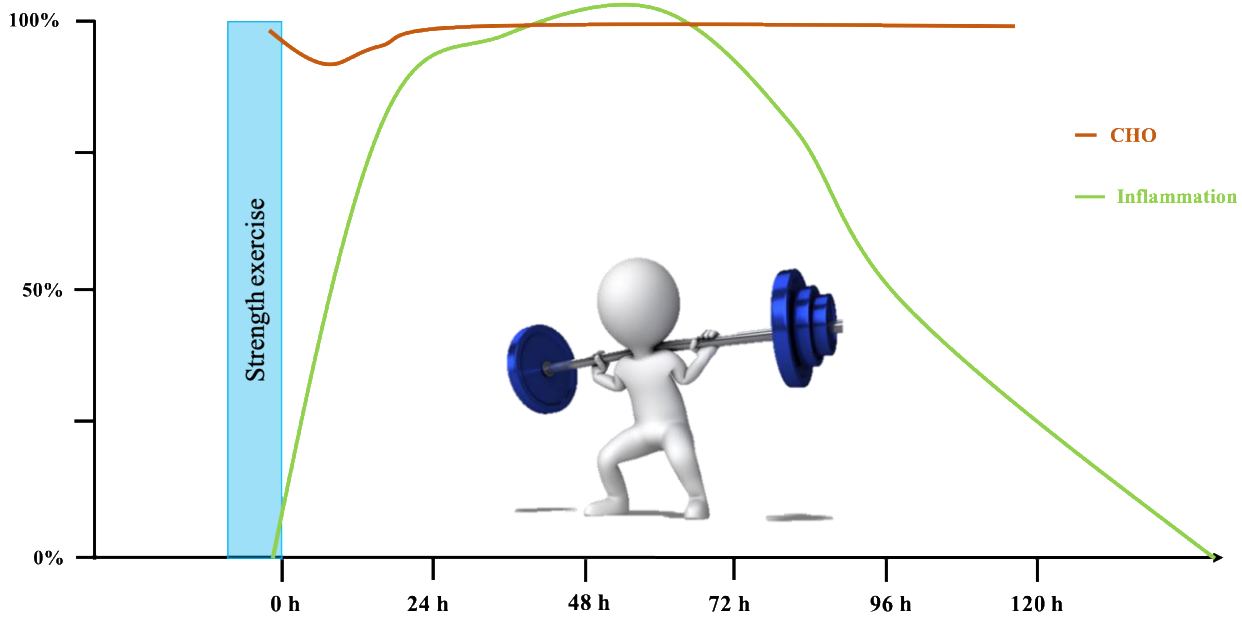
Time course





Alterations in training stimulus highlight the need to adapt recovery interventions.

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Take Home Message II

EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

- Many physiological systems are involved with differing time courses of recovery.
- Effectiveness of recovery interventions are related to the nature & extend of fatigue.
- Planning & implementation of recovery interventions is complex.

General preperation	Specific preperation	Taper	Competition
Appropriate recovery to maximize adaptation.	Specific recovery support after key sessions, especially high-quality/skill sessions.	Recovery to minimize fatigue, decrease time to taper appropriately.	Recovery support to minimize fatigue and maximize competition performance.
Potentially withholding recovery.	Recovery to reduce fatigue & soreness for specific sessions.	Increased recovery to maintain high-intensity training.	Support to manage fatigue around travel & jetlag.

Mujika et al. 2018

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Take Home Message II

EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

Compression
Active recovery
Recovery boots
Sauna
Foam rolling
EMS
Stretching

CWI
Massage

Fluid
Nutrition
Sleep

Recovery zone

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EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

Thank you very much for your attention!

Dziękuję za uwagę!

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Infographics designed by Dr. Yann Le Meur