RECOVERY FOR PERFORMANCE IN RACKET SPORTS

Alexander Ferrauti

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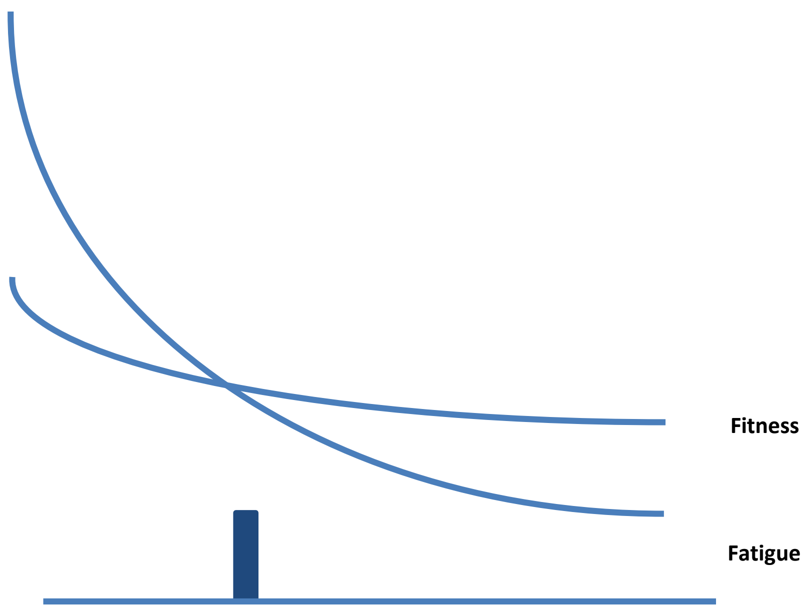
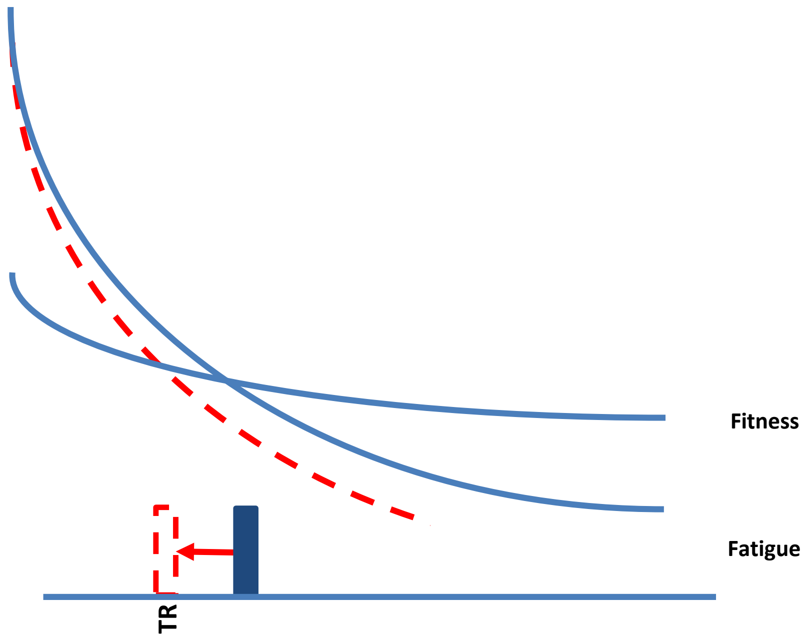


The *Fitness-Fatigue Model* from Banister (1982) and recovery



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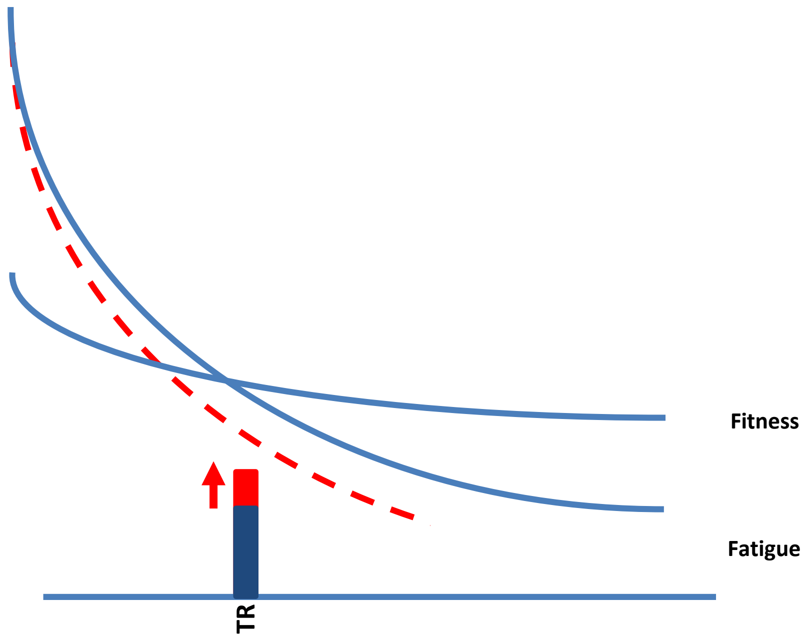

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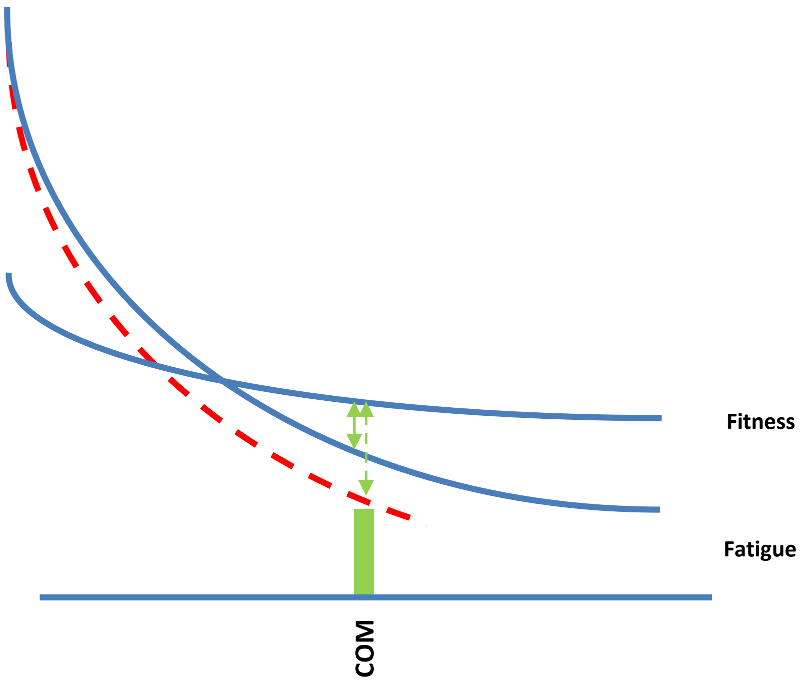

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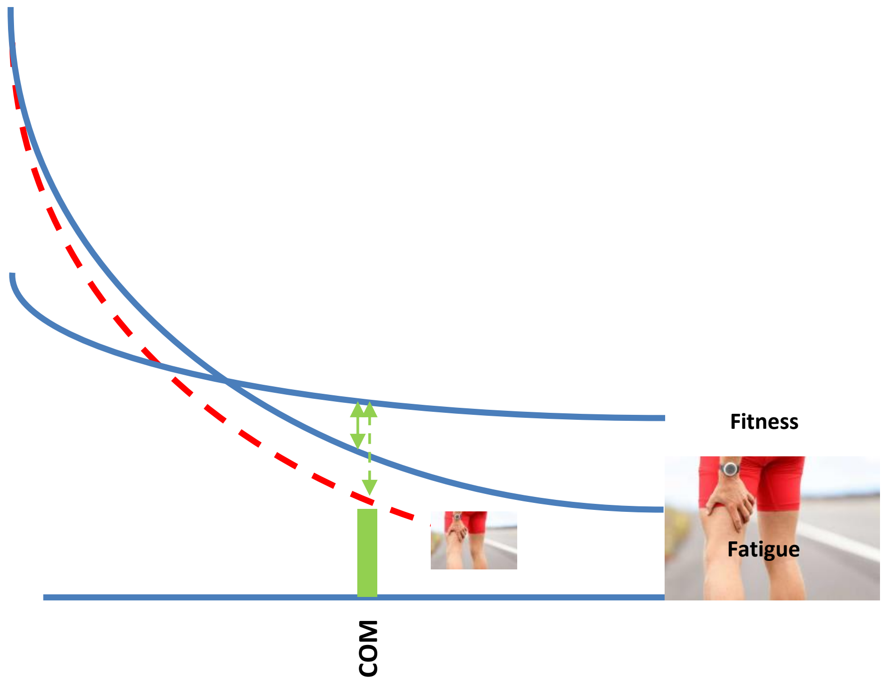
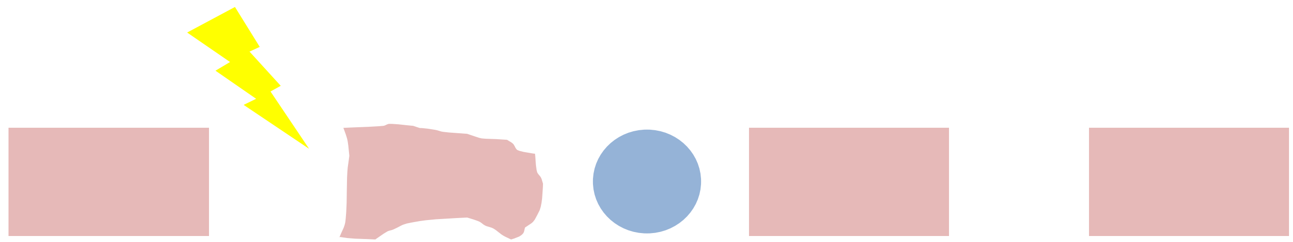


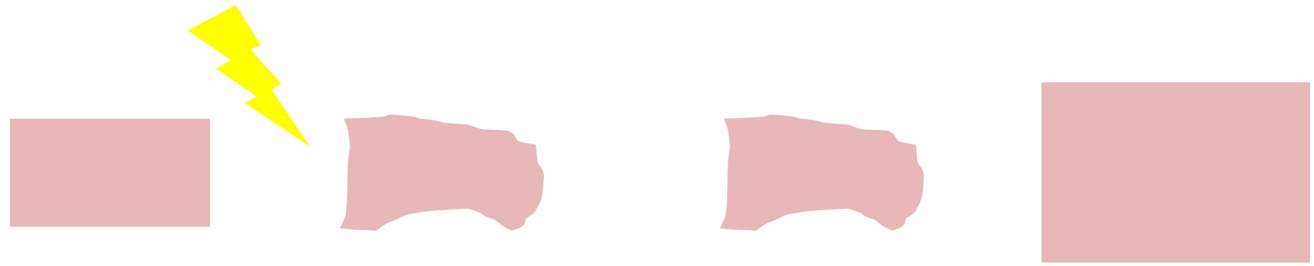
The *Fitness-Fatigue Model* from Banister (1982) and recovery

Quick Recovery



? versus ?

Max Adaptation



The *Adaptation Perturbation Theory* from Hunt et al. (2008)

RECOVERY FOR PERFORMANCE IN RACKET SPORTS

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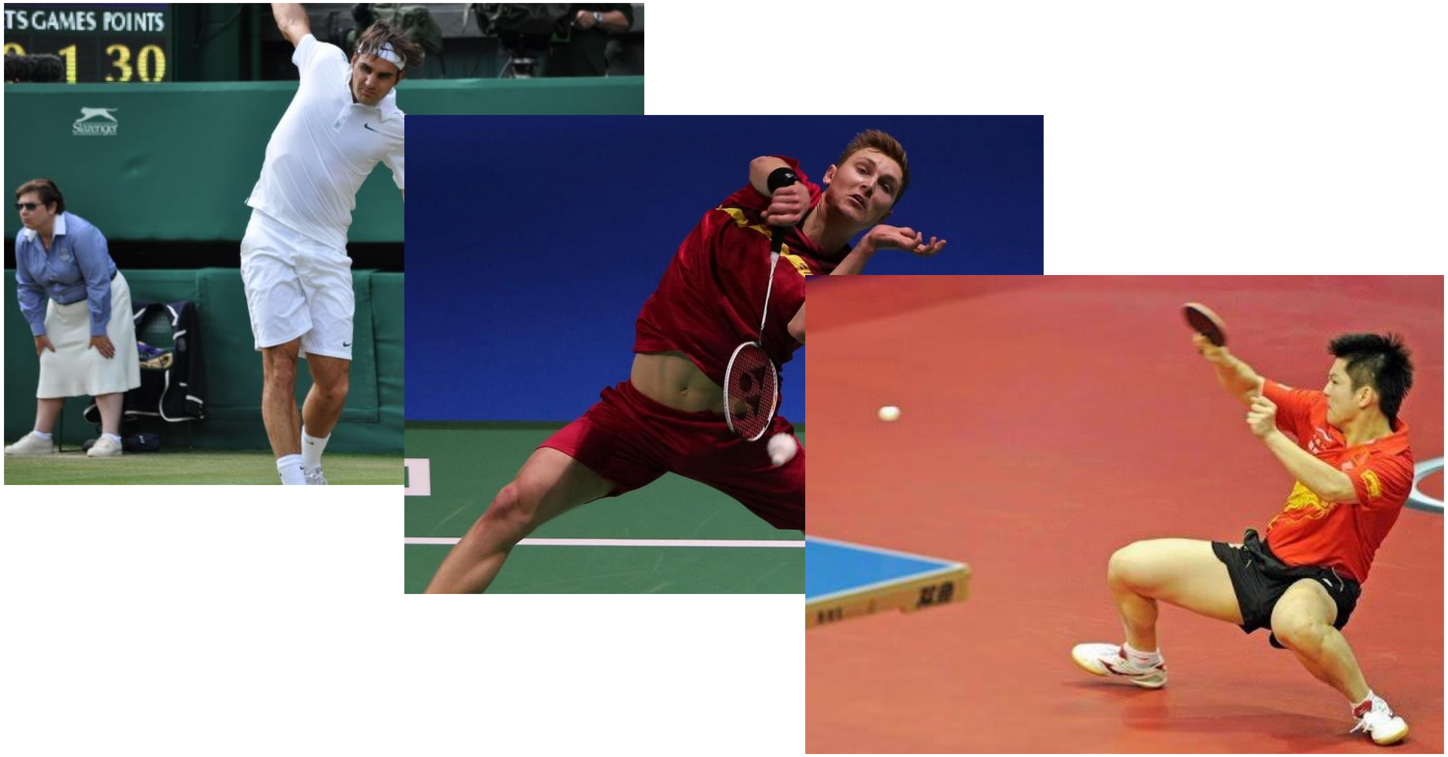


The **racket sports** are defined as sportive modalities in which two or four players use rackets to alternatively hit a ball or shuttlecock with the purpose of placing the missile in a certain position on a defined playing surface that the opponent is unable to successfully return (Lees, 2003).

Internal Load Match Play

Measurements	**Tennis** *(Fernandez-Fernandez, et al. 2007; Ferrauti et al. 2001; Ferrauti 1999)*	**Squash** *(Girard et al., 2007)*	**Badminton** *(Faude, et al. 2007; (Manrique & Gonzalez-Badillo 2003)*	**Table Tennis** *(Zagatto et al. 2010; Sperlich et al., 2011)*
Heart rate (% HRmax)	161 ± 5 bpm (86 % HRmax)	177 ±10 bpm (92±3 % HRmax)	174 ± 9 bpm (91 % HRmax)	164 ±14 bpm (82 ± 7 % Hrmax)
Blood lactate	2.0 ± 0.8 mmol/l junior females (1.2-4.6)	8.3 ± 3.4 mmol/l LAmax 12.1 ± 5.1	3.8 ± 0.9 mmol/l 4.7 ± 1.9 mmol/l	1.2-1.8 ±0.7 mmol/l LAmax 2.2 ±0.8
VO_2 (% VO_2max)	24.2 ± 2.0 ml/min/kg (55 ± 3.1 % VO_2max)	54.4 ± 4.8 ml/min/kg (86 ± 9 % VO_2max)	39.6 ± 5.7 ml/min/kg (64 % VO_2max)	23.5 ± 7.3 ml/min/kg
Energy Cost	CHO >60-70 % High Caloric Demands	CHO >60-70 %		
Environmental & Adrenergic Stress	Adrenaline Release Heat Stress	Adrenaline Release		

External Load Match Play

Measurements	Tennis *(Fernandez-Fernandez et al. 2007, 2009)*	Squash *(Sherman et al., 2004; Vučković et al. 2003; Girard et al. 2007)*	Badminton *(Abdullahi et al. 2017; Faude et al. 2007; Manrique & Gonzalez-Badillo 2003; Majumdar et al. 1997)*	Table Tennis *(Zagatto et al. 2010; Sperlich et al. 2011)*
Match duration	1.5 to over 4 h	40 min to over 2 h	35 ± 14 min	15 to 35 min
Effective playing time	21.7 ± 5.0 %	69.7 ± 4.7 %	31.2 ± 2.8 %	44.3 ± 23.7 %
Distance covered per match	3569 ± 532 m	254 to 1449 m	1763 ± 751 m	n.a.
Rally duration	6.4 ± 4.1 s	18.6 ± 4.6 s	5.5 ± 4.0 s	3.4 ± 1.7 s
Rest time	14.5 ± 5.2 s	8.0 ± 1.8 s	11.4 ±6.0 s	8.1 ± 5.1 s
Work to rest ratio	1 to 0.25	2.4 ± 0.6	0.5 ± 0.34	0.4 ± 0.2
Shots per rally (both players)	4.2 ± 2.6	n.a.	5.1± 3.9	3.9 ± 2.0
Activities	accelerations, decelerations, sprints, jumps, reactive stretch shortening cycles, eccentric overload, Intensive Hitting - trunk & upper body power actions			

Recovery demands in Racket Sports:

- Rehydration
- Glycogen restauration
- Muscle performance (after damage, inflammation)
- Mental recovery

RECOVERY FOR PERFORMANCE IN RACKET SPORTS

Alexander Ferrauti

1 THE FITNESS – FATIGUE RELATION

2 INTERNAL & EXTERNAL LOAD IN RACKET SPORTS

3 OVERVIEW ABOUT RECOVERY INTERVENTIONS

4 SCIENTIFIC EVIDENCE OF RECOVERY EFFECTS

5 REGman REGENERATIONSMANAGEMENT IM SPORT - FINDINGS

6 MONITORING OF FATIGUE & RECOVERY

7 PRACTICAL RECOMMENDATIONS FOR RACKET SPORTS

Recovery strategies without likely potential:

- Light emitting diode (LED) therapy (Camargo et al. 2011)
- Low frequency vibration
- Electromyostimulation
- Floating in salty water
- Vacuum therapy ...

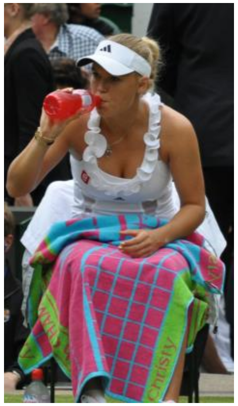
Nutrition and Fluid ingestion with clear potential

- Short chain CHO during training and match play
- Medium chain CHO between training units and matches
- Post exercise ingestion of flavoured milk is recommended (Gilson et al. 2010)
- 1-2 h post Exercise CHO rich meal with co-ingestion of proteins

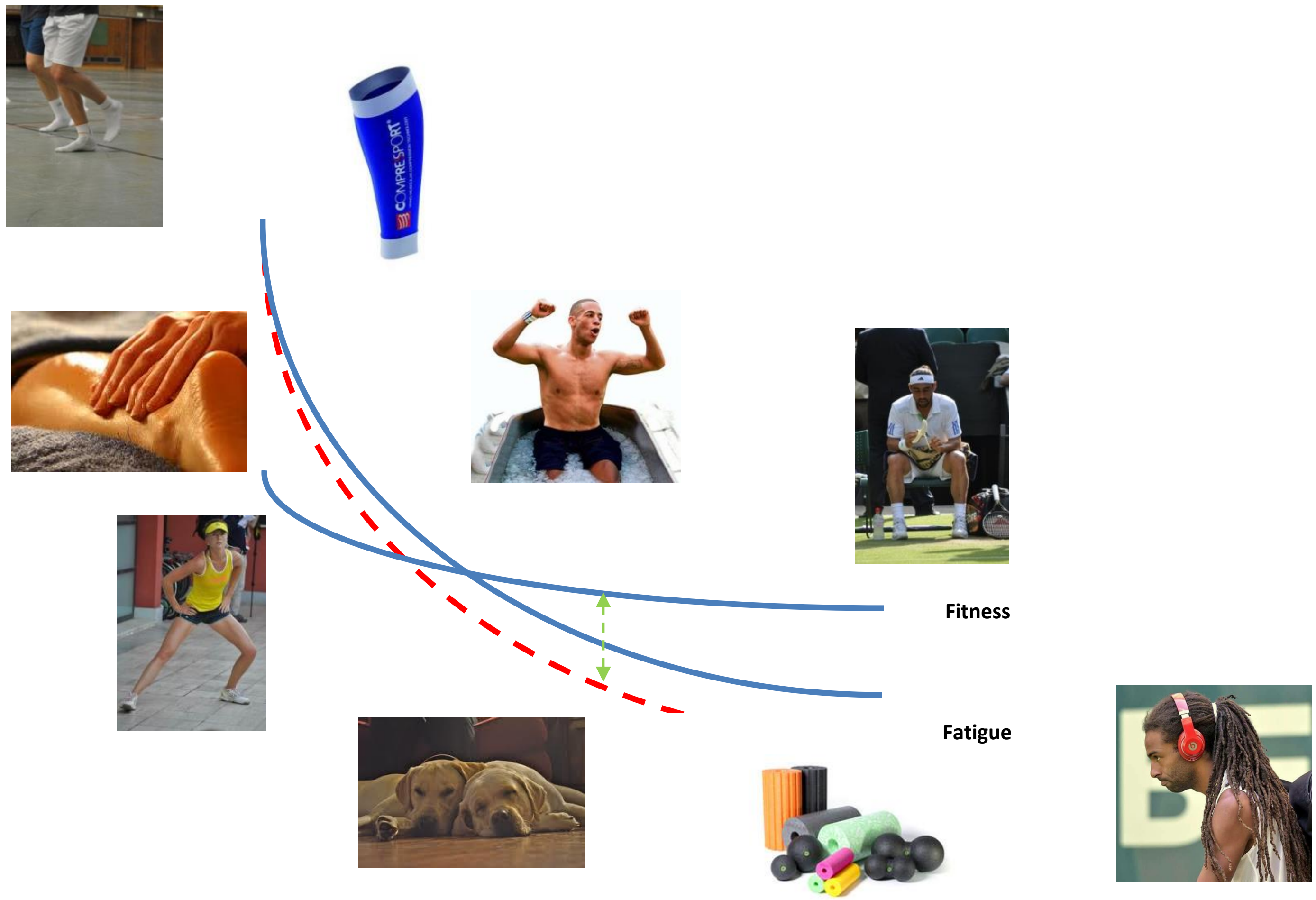
  Protein consumption stimulates muscle protein synthesis, is important for a positive protein balance, decreases CK levels (Ferguson-Stegall et al. 2011).

- Daily supplementation of tart cherry juice , tomato juice

  Anti-inflammatory and anti-oxidant effects by blunting the secondary muscle damage response (e.g. IL-6, IL-1, TNF-alpha, CRP) (Howatson et al. 2010).


3 OVERVIEW ABOUT RECOVERY INTERVENTIONS



The *Fitness-Fatigue Model* from Banister (1982) and recovery

Hausswirth & Mujika, 2013

Energy Metabolism	LA Elimination
	Glycogen Content
Muscle Function	Temperature
	DOMS, CK
	CRP, IL-1, IL-6, TNF a
Neuromuscular	Pain Perception
	Contractility
Mental Performance	Cognitive Performance
	Wellbeeing
Performance	**Post <30 min**
	Post >24 h

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RUHR-UNIVERSITÄT BOCHUM

RUB

International Journal of Sports Physiology and Performance, 2013, 8, 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

Purpose: Cooling after exercise has been investigated as a method to improve recovery during intensive training or competition periods. As many studies have included untrained subjects, the transfer of those results to trained athletes is questionable. ***Methods:*** Therefore, the authors conducted a literature search and located 21 peer-reviewed randomized controlled trials addressing the effects of cooling on performance recovery in trained athletes. ***Results:*** For all studies, the effect of cooling on performance was determined and effect sizes (Hedges' g) were calculated. Regarding performance measurement, the largest average effect size was found for sprint performance (2.6%, $g = 0.69$), while for endurance parameters (2.6%, $g = 0.19$), jump (3.0%, $g = 0.15$), and strength (1.8%, $g = 0.10$), effect sizes were smaller. The effects were most pronounced when performance was evaluated 96 h after exercise (4.3%, $g = 1.03$). Regarding the exercise used to induce fatigue, effects after endurance training (2.4%, $g = 0.35$) were larger than after strength-based exercise (2.4%, $g = 0.11$). Cold-water immersion (2.9%, $g = 0.34$) and cryogenic chambers (3.8%, $g = 0.25$) seem to be more beneficial with respect to performance than cooling packs (–1.4%, $g = -0.07$). For cold-water application, whole-body immersion (5.1%, $g = 0.62$) was significantly more effective than immersing only the legs or arms (1.1%, $g = 0.10$). ***Conclusions:*** In summary, the average effects of cooling on recovery of trained athletes were rather small (2.4%, $g = 0.28$). However, under appropriate conditions (whole-body cooling, recovery from sprint exercise), postexercise cooling seems to have positive effects that are large enough to be relevant for competitive athletes.

Keywords: cryotherapy, cold-water immersion, regeneration

Jump Performance

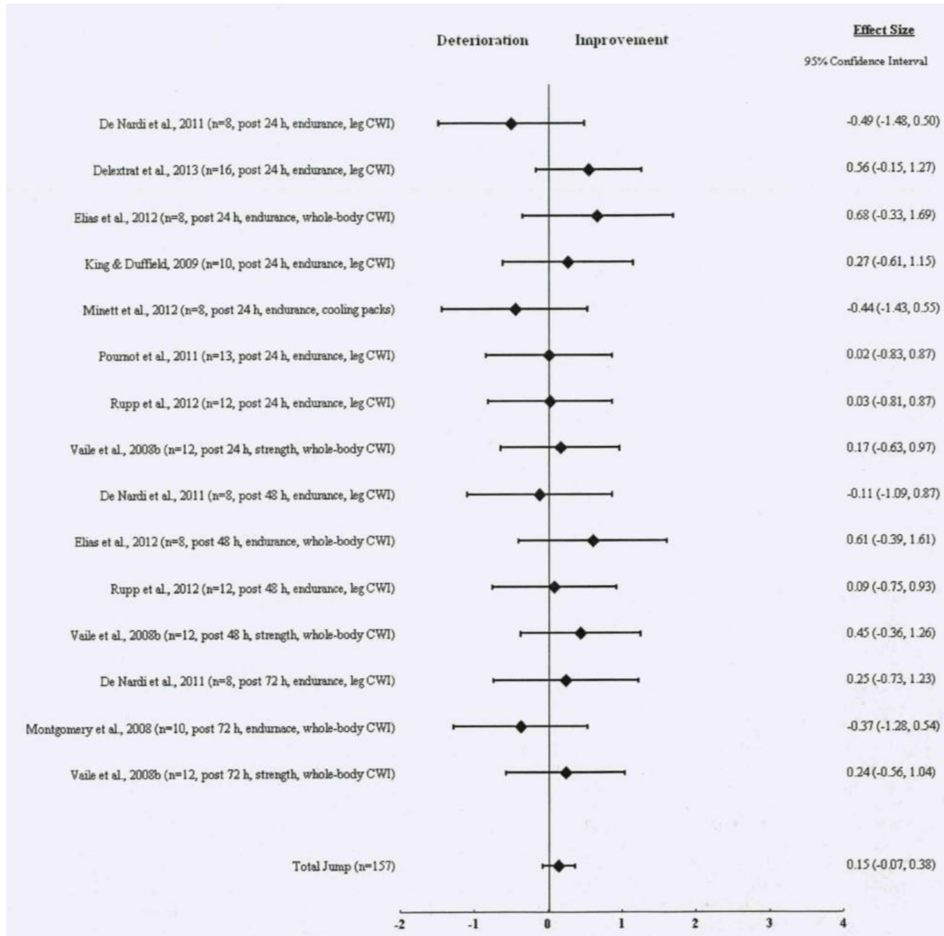


Figure 5 — Effects of cooling after exercise on recovery of jump performance. For each study, the number of subjects (n) and the timing of the posttest (multiple timings possible) are given, as well as the type of exercise to induce fatigue and the cooling method. CWI indicates cold-water immersion.

Sprint Performance

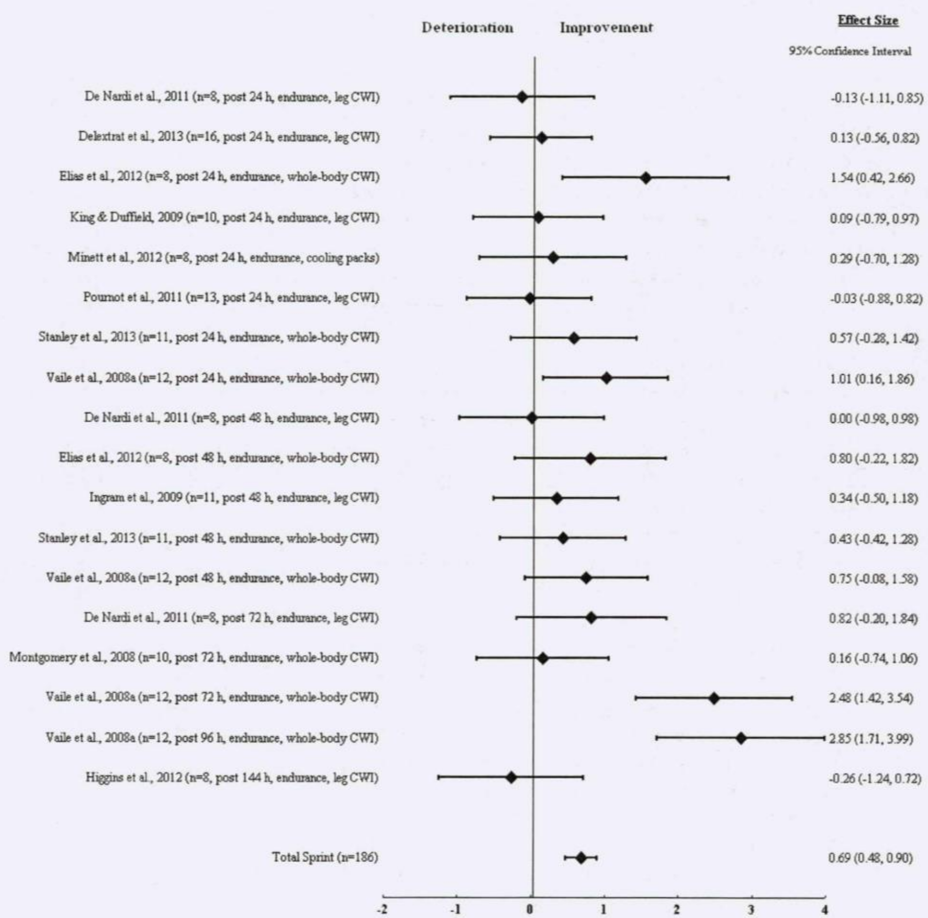
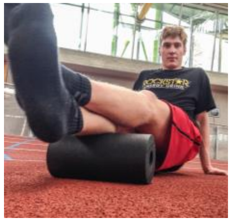
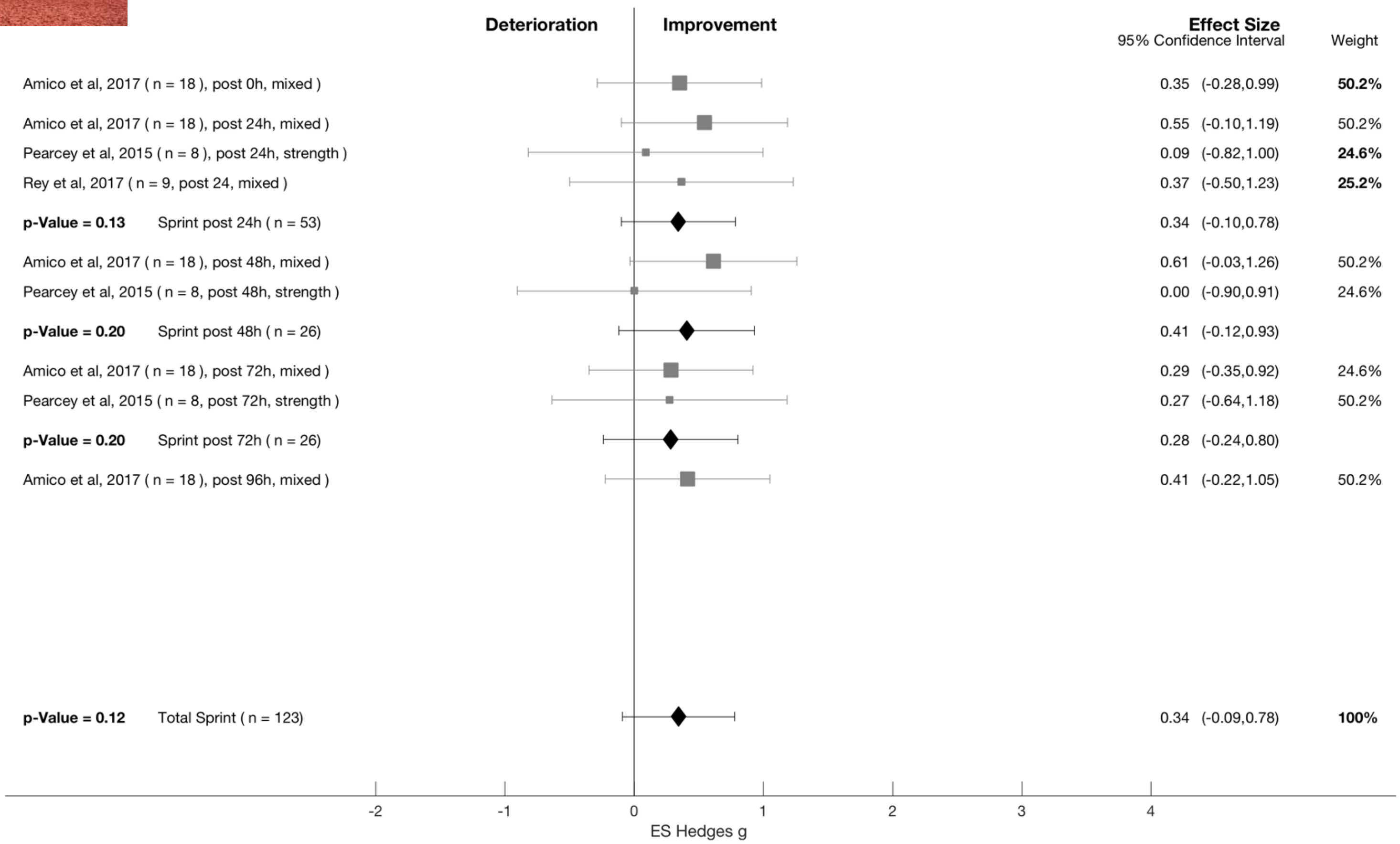


Figure 4 — Effects of cooling after exercise on recovery of sprint performance. For each study, the number of subjects (n) and the timing of the posttest (multiple timings possible) are given, as well as the type of exercise to induce fatigue and the cooling method. CWI indicates cold-water immersion.

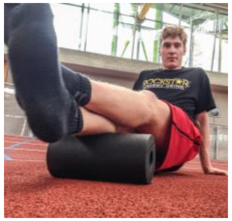
Sprint Performance

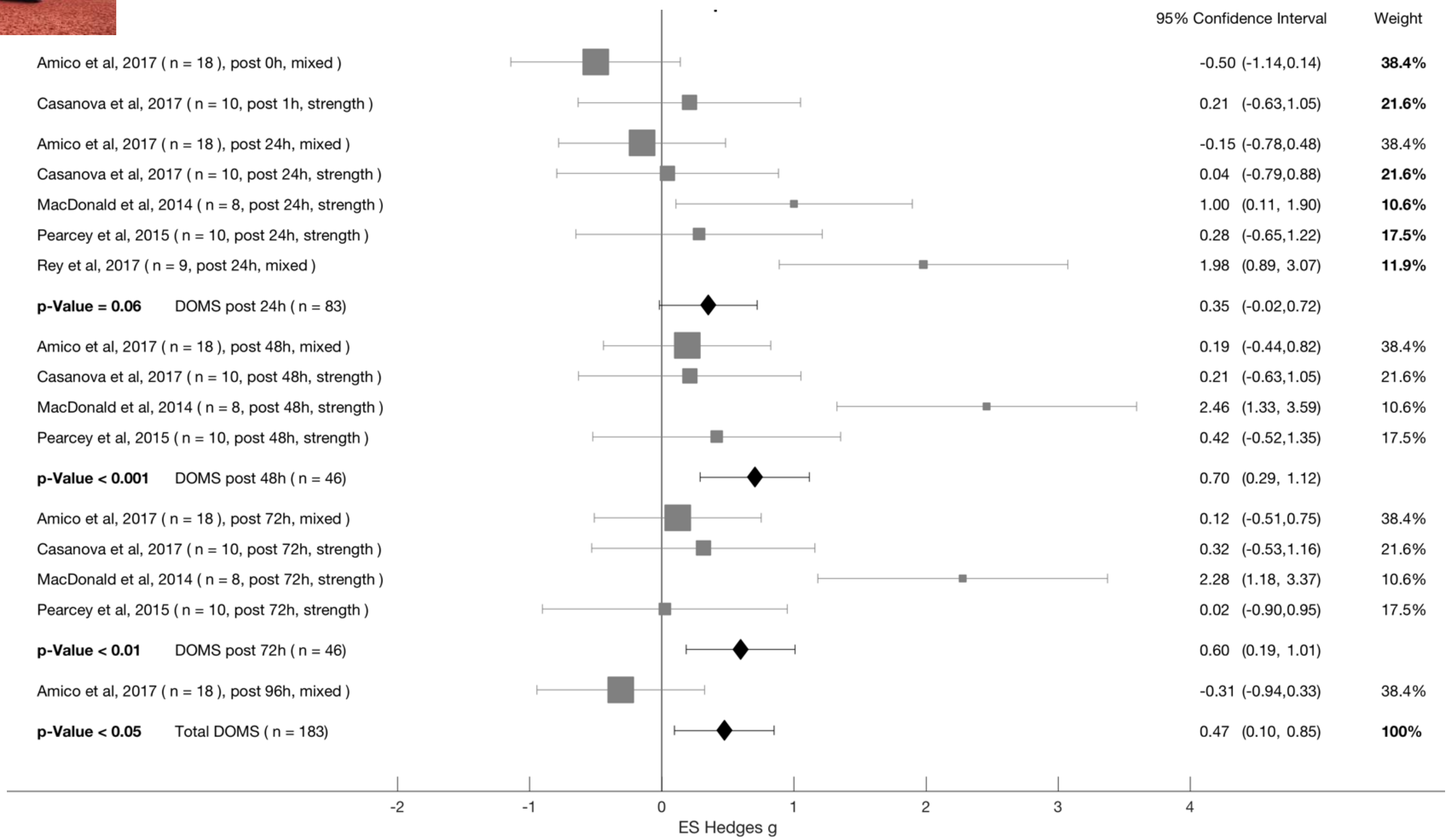




Döweling et al. (in preparation)

Pain Perception





Döweling et al. (in preparation)

SYSTEMATIC REVIEW ARTICLE
Front. Physiol., 26 April 2018 | https://doi.org/10.3389/fphys.2018.00403

An Evidence-Based Approach for Choosing Post-exercise Recovery Techniques to Reduce Markers of Muscle Damage, Soreness, Fatigue, and Inflammation: A Systematic Review With Meta-Analysis

Olivier Dupuy*, Wafa Douzi, Dimitri Theurot, Laurent Bosquet and Benoit Dugué

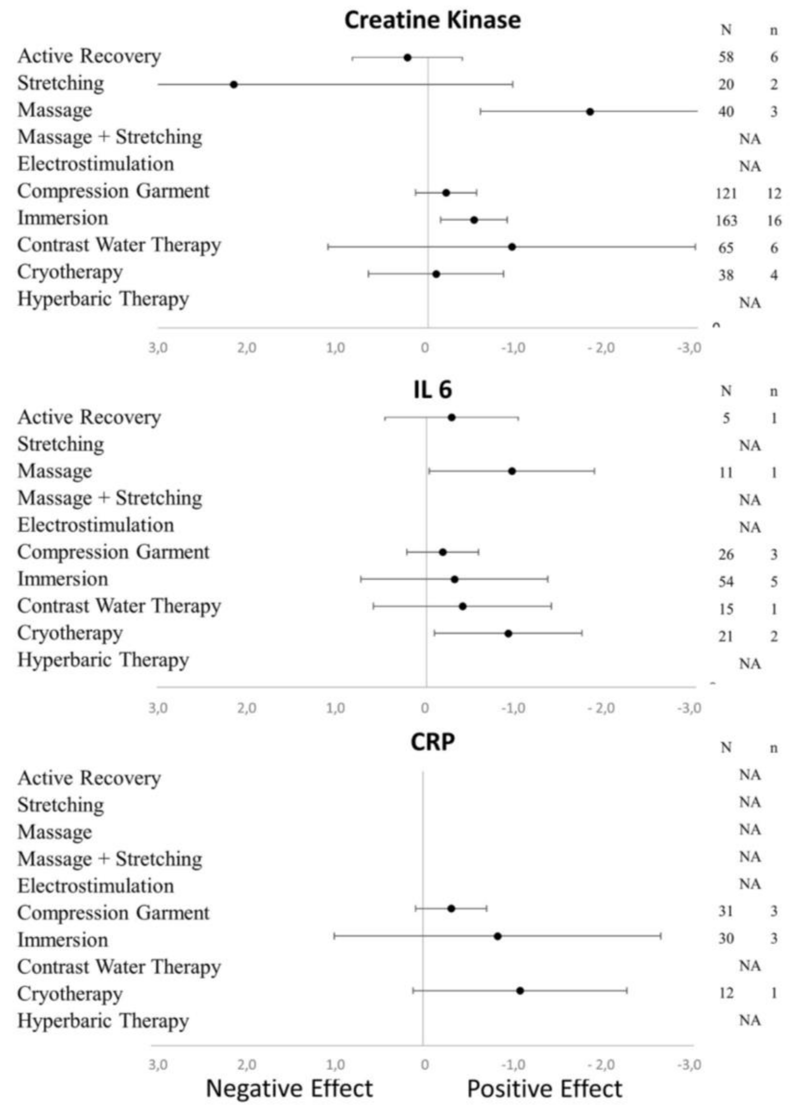
Laboratoire MOVE (EA6314), Faculty of Sport Sciences, University of Poitiers, Poitiers, France

Introduction: The aim of the present work was to perform a meta-analysis evaluating the impact of recovery techniques on delayed onset muscle soreness (DOMS), perceived fatigue, muscle damage, and inflammatory markers after physical exercise.

Method: Three databases including *PubMed, Embase*, and *Web-of-Science* were searched using the following terms: ("recovery" or "active recovery" or "cooling" or "massage" or "compression garment" or "electrostimulation" or "stretching" or "immersion" or "cryotherapy") and ("DOMS" or "perceived fatigue" or "CK" or "CRP" or "IL-6") and ("after exercise" or "post-exercise") for randomized controlled trials, crossover trials, and repeated-measure studies. Overall, 99 studies were included.

Results: Active recovery, massage, compression garments, immersion, contrast water therapy, and cryotherapy induced a small to large decrease ($-2.26 < g < -0.40$) in the magnitude of DOMS, while there was no change for the other methods. Massage was found to be the most powerful technique for recovering from DOMS and fatigue. In terms of muscle damage and inflammatory markers, we observed an overall moderate decrease in creatine kinase [SMD (95% CI) = −0.37 (−0.58 to −0.16), I^2 = 40.15%] and overall small decreases in interleukin-6 [SMD (95% CI) = −0.36 (−0.60 to −0.12), I^2 = 0%] and C-reactive protein [SMD (95% CI) = −0.38 (−0.59 to−0.14), I^2 = 39%]. The most powerful techniques for reducing inflammation were massage and cold exposure.

Conclusion: Massage seems to be the most effective method for reducing DOMS and perceived fatigue. Perceived fatigue can be effectively managed using compression techniques, such as compression garments, massage, or water immersion.



Dupuys et al. 2018

RECOVERY FOR PERFORMANCE IN RACKET SPORTS

Alexander Ferrauti

Recovery Management in Sports

Multicenter, Longterm Project, 2013-2020, 2,5 Mio €

Prof. Dr. Michael Kellmann, Sport Psychology
Prof. Dr. Alexander Ferrauti, Training and Exercise Science

Prof. Dr. Tim Meyer, Sports Medicine and Training Science

Prof. Dr. Mark Pfeiffer, Training Science

RUHR-UNIVERSITÄT BOCHUM
FAKULTÄT FÜR SPORTWISSENSCHAFT

REGman - Open 2015

Ein Herren-Einzel-Turnier unter sportwissenschaftlichen Fragestellungen im Rahmen des BISp-Projekts „Regenerationsmanagement im Sport"

- **1000€** Antrittsgeld und **3000€** Preisgeld! (zur Verfügung gestellt von der ITF)
- individuelle Leistungsdiagnostik für jeden Teilnehmer!
- zwölf garantierte Tennismatches - aufgeteilt auf zwei Turnierblöcke!

Wann: Block 1: 20.05. - 29.05.2015
Block 2: 12.08. - 21.08.2015
Meldeschluss: 01.05.2015

Wo: Fakultät für Sportwissenschaft
Sportanlagen Halle Markstraße (HMA)

Anmeldung: Thimo Wiewelhove
thimo.wiewelhove@rub.de
0234 3225969

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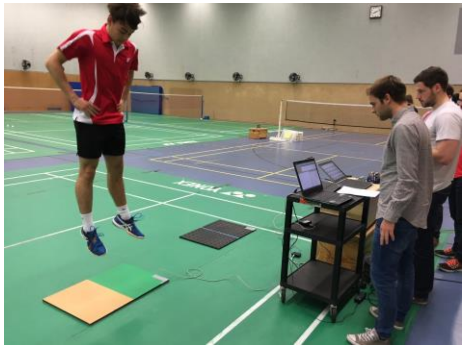

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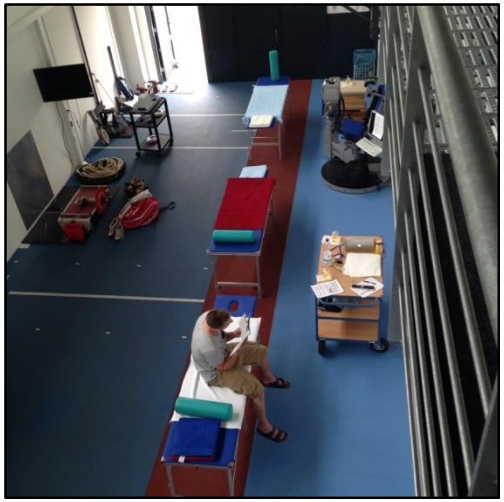

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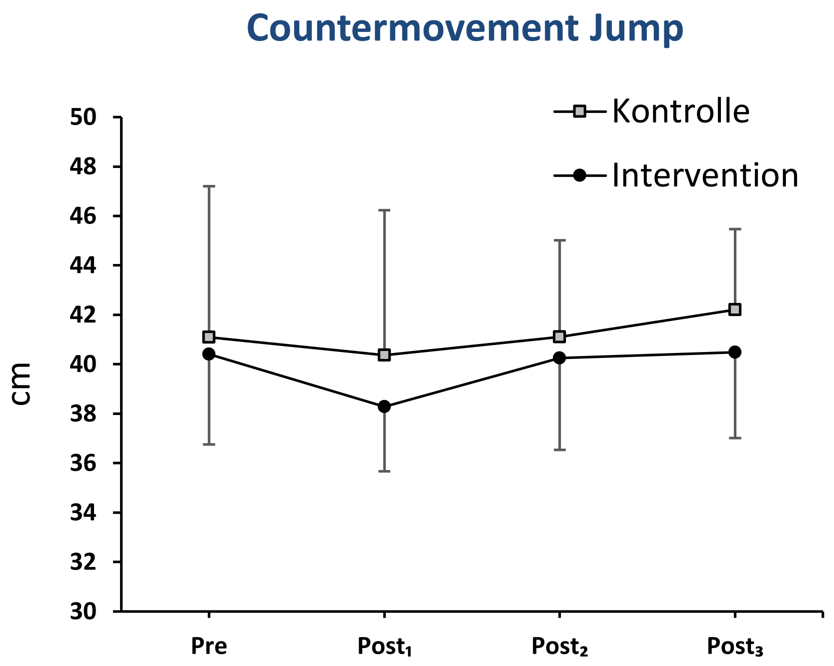
Countermovement Jump
Kontrolle
Intervention
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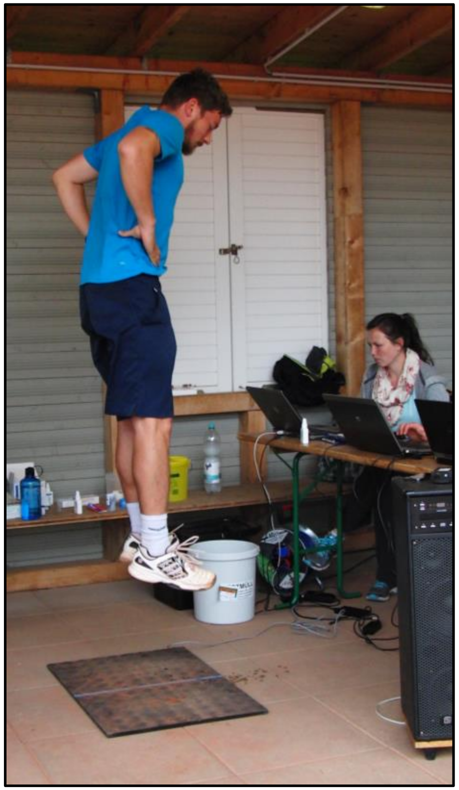
Pre
Post1
Post2
Post3



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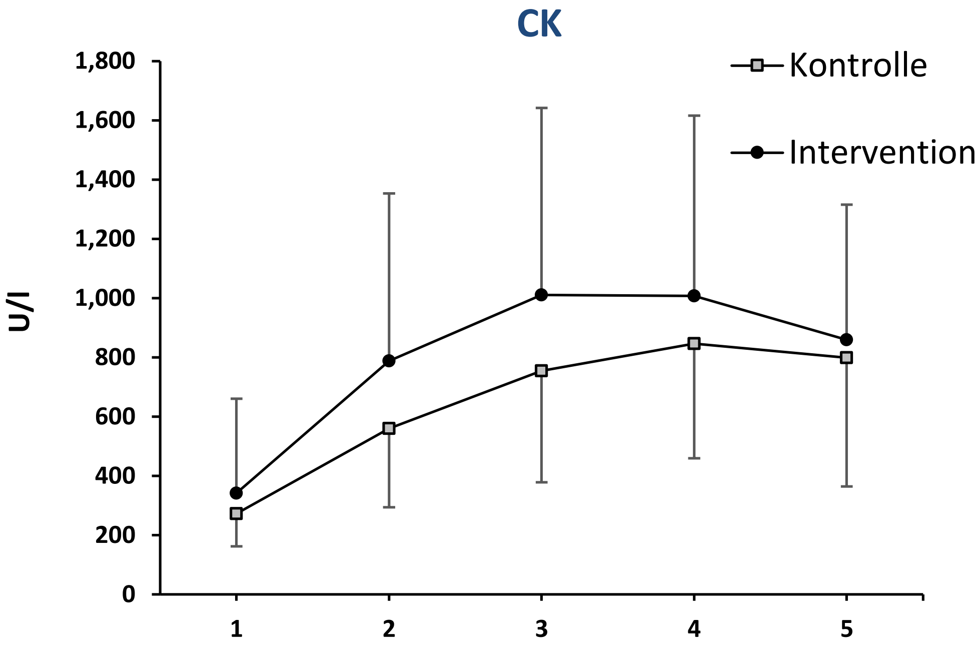
CK
Kontrolle
Intervention
U/l
1,800
1,600
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1,200
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800
600
400
200
0
1
2
3
4
5

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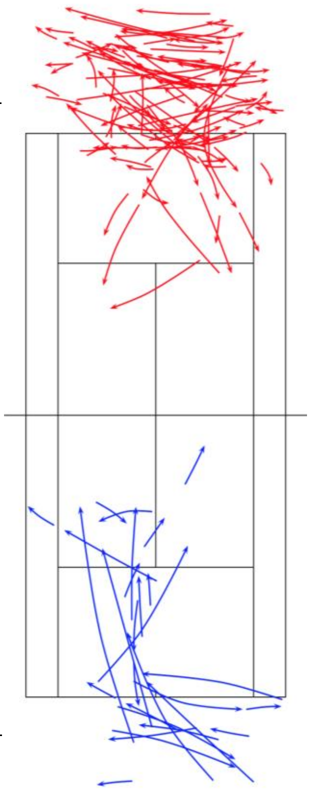
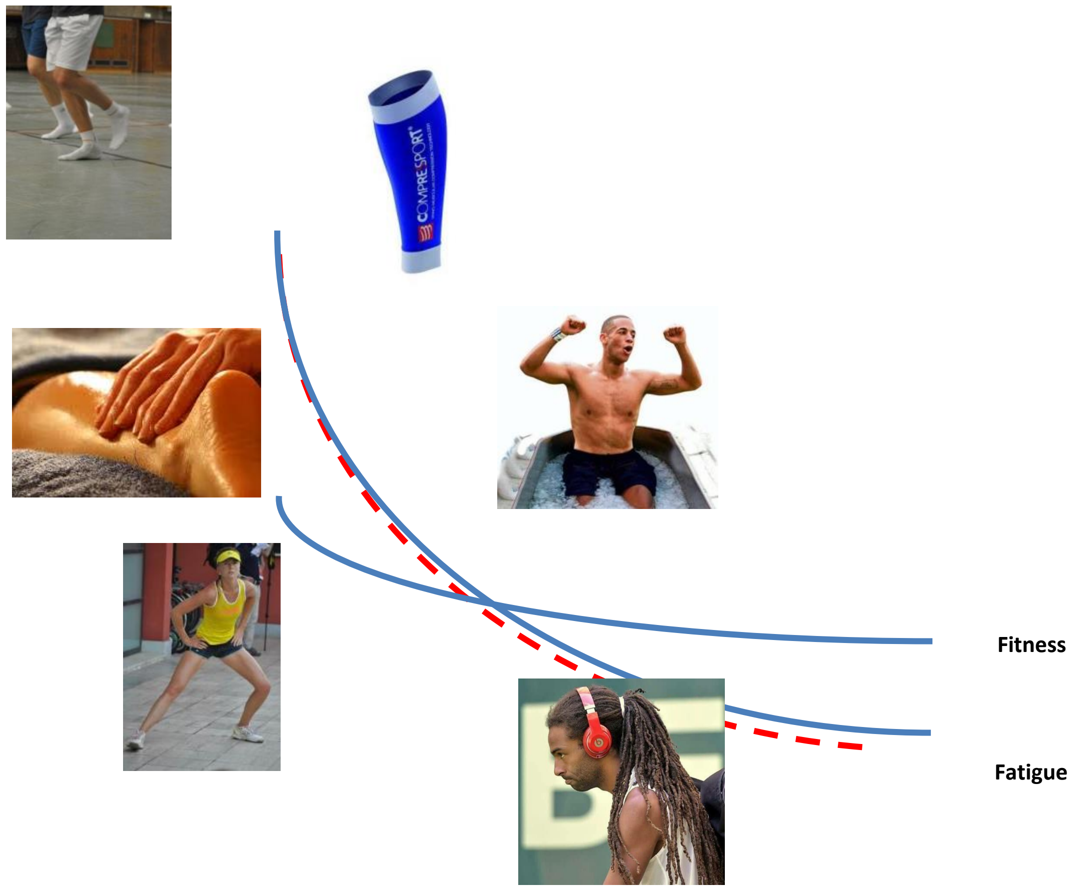
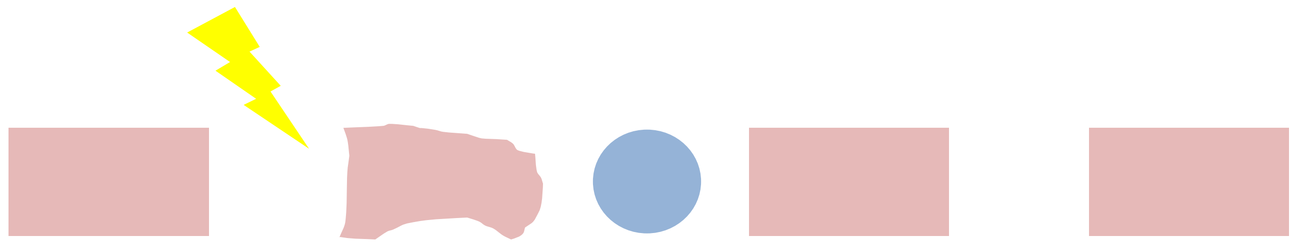
Parameter	Intervention	Control	*p*	*d*
Bewegungsanalyse				
Laufdistanz (Netto-Spielzeit) [m]	2526 ± 1061	2558 ± 1068	0.92	0.03
Anzahl der Sprints [n]	98 ± 51	119 ± 68	0.27	0.49
Im Sprint zurückgelegte Distanz [m]	273 ± 139	321 ± 158	0.24	0.32
Spielanalyse				
Gewonnene Punkte [n]	99 ± 26	96 ± 19	0.73	0.13
Asse und Servicewinner [n]	4.1 ± 4.1	3,3 ± 2,3	0.52	0.24
Doppelfehler [n]	4.9 ± 3.6	4.1 ± 3.7	0.30	0.22
Fehler [n]	63 ± 13	63 ± 19	0.96	0.00
Gewinnschläge [n]	27 ± 13	25 ± 13	0.54	0.15





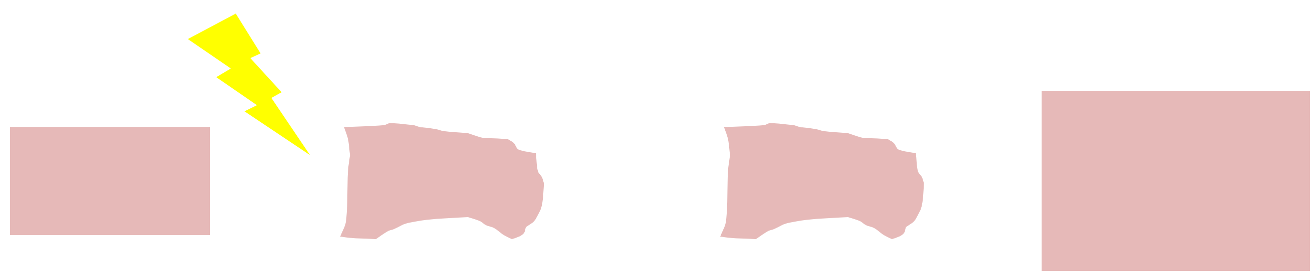
The *Fitness-Fatigue Model* from Banister (1982) and recovery

Quick Recovery



? versus ?

Max Adaptation



The *Adaptation Perturbation Theory* from Hunt et al. (2008)

frontiers in Physiology

ORIGINAL RESEARCH
published: 18 April 2018
doi: 10.3389/fphys.2018.00415

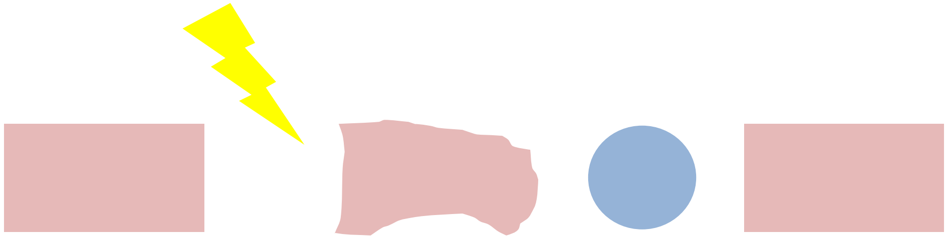
Check for updates

Active Recovery After High-Intensity Interval-Training Does Not Attenuate Training Adaptation

Thimo Wiewelhove[1], Christoph Schneider[1], Alina Schmidt[1], Alexander Döweling[1], Tim Meyer[2], Michael Kellmann[1,3], Mark Pfeiffer[4] and Alexander Ferrauti[1]*

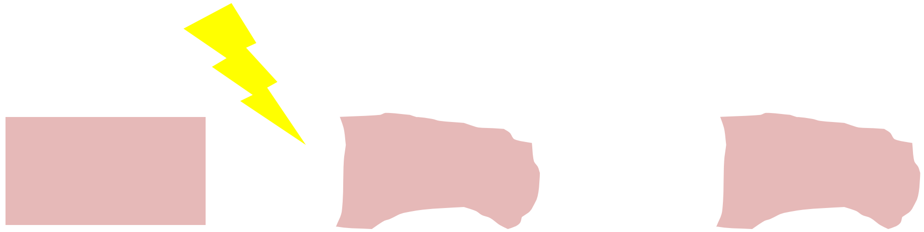
[1] Faculty of Sport Science, Ruhr-University Bochum, Bochum, Germany, [2] Institute of Sports and Preventive Medicine, Saarland University, Saarbrücken, Germany, [3] School of Human Movement Studies and School of Psychology, The University of Queensland, Brisbane, QLD, Australia, [4] Institute of Sports Science, Johannes Gutenberg University, Mainz, Germany

Quick Recovery



Small positive effects on endurance with Active Recovery
(Wiewelhove et al. 2018)

Max Adaptation

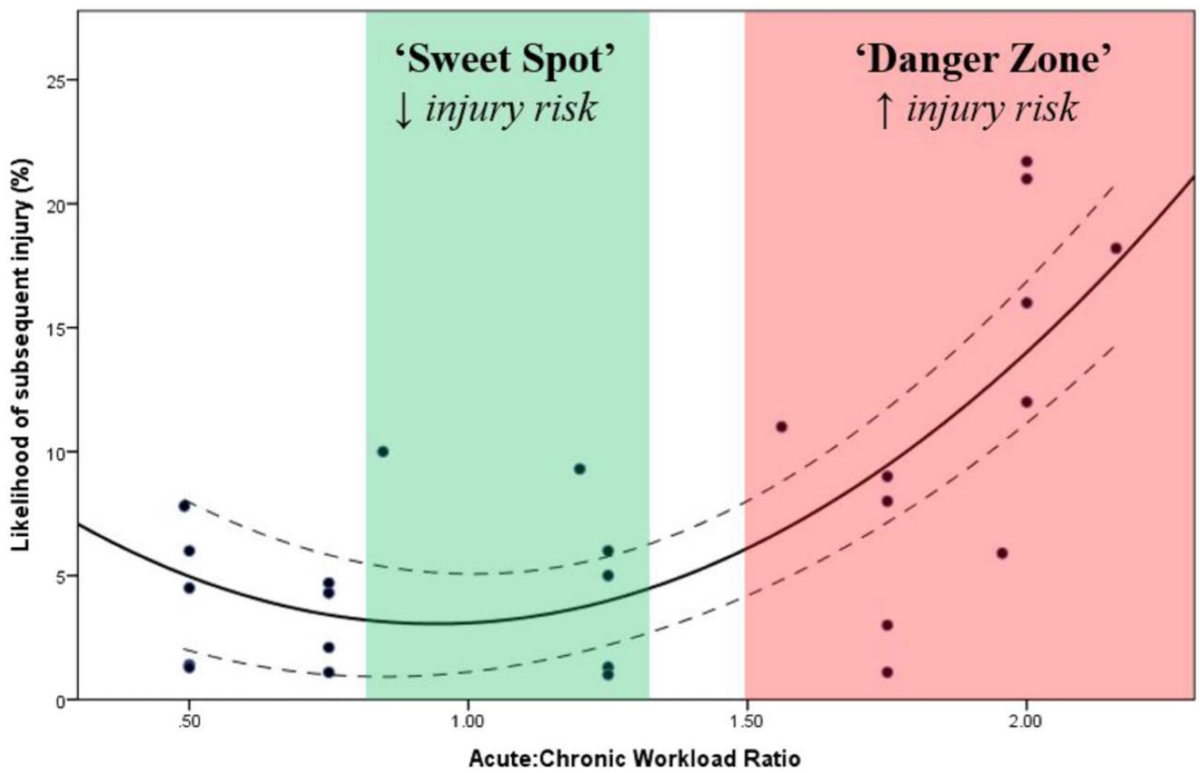


Small positive effects on strength without CWI
(Skorski, in preparation)

RECOVERY FOR PERFORMANCE IN RACKET SPORTS

Alexander Ferrauti

Monitoring of Training & Competition Load



Blanch & Gabbett 2015; Gabbett 2016

Multivariate Monitoring of Recovery Markers

Psychological Ratings:

- POMS: Profile of Mood States-
- EBF-Sport
- TQR: Total Quality Recovery
- DALDA: Daily Analysis of Life Demands for Athletes
- **DOMS: Delayed Onset Muscle Soreness**
- **Sleep Duration & Quality**
- Cognitive Performance Tests

Performance Tests:

- SJ, DJ,RJ, **CMJ**
- Sprints, RSA
- Power Tests (Wingate, NMT Tests)
- MVIC, 1RM

Blood, Urine, Salvia

- Metabolic Markers: Urea, Glutamin, Insulin, IGF-1, Testosteron, Cortisol, T/C, ACTH, ACTH/C, GH
- Immunological Markers: CRP, IL-1, IL-6, TNF-alpha
- Muscle related Markers: **CK**
- Gene Expression: miRNA

Cardiac Regulation:

- HRV, HR-rest, HR-max, **HR-submax**

Neuromuscular Function:

- TMG

?

Psychological Ratings = Nº1 for Juniors

PLOS | ONE

RESEARCH ARTICLE

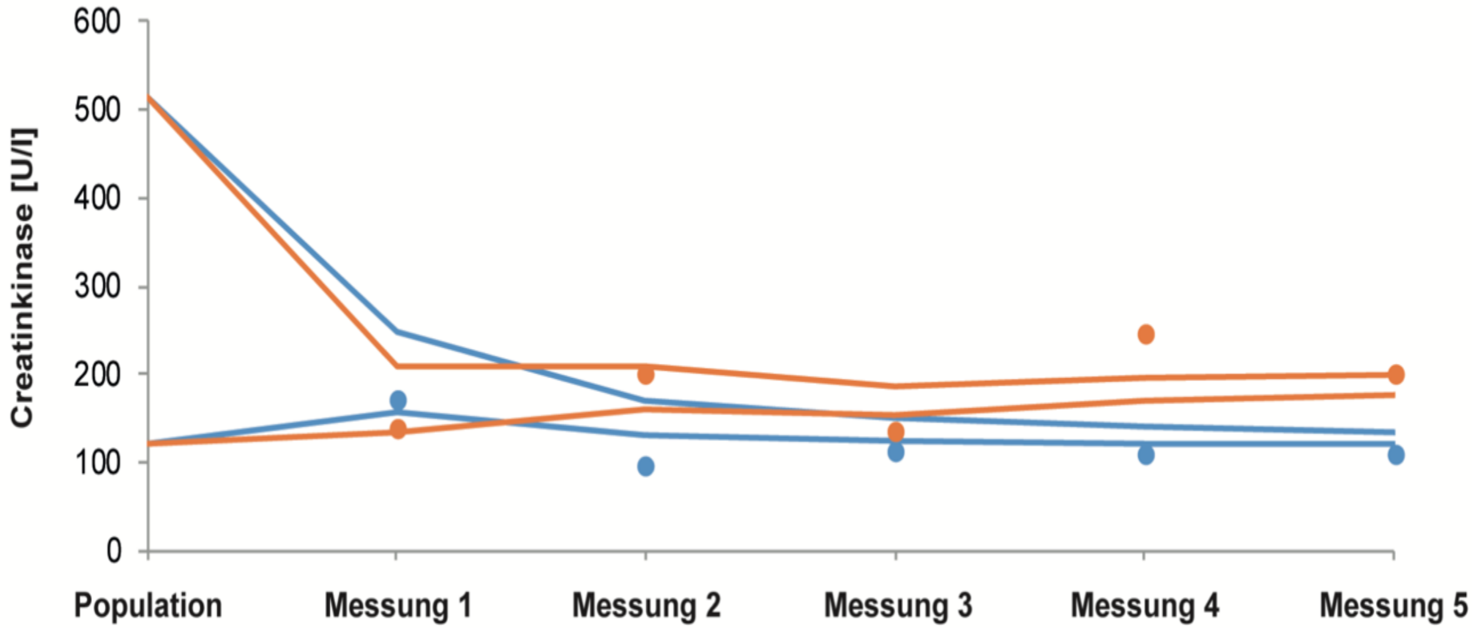
Blood-Borne Markers of Fatigue in Competitive Athletes – Results from Simulated Training Camps

Anne Hecksteden[1]*, Sabrina Skorski[1], Sascha Schwindling[1], Daniel Hammes[1], Mark Pfeiffer[2], Michael Kellmann[3,4], Alexander Ferrauti[3], Tim Meyer[1]

1 Institute of Sports and Preventive Medicine, Saarland University, Saarbruecken, Germany, **2** Institute of Sports Science, Johannes-Gutenberg University, Mainz, Germany, **3** Faculty of Sports Science, Ruhr-University of Bochum, Bochum, Germany, **4** Schools of Human Movement Studies and Psychology, The University of Queensland, Queensland, Australia

PLOS ONE | DOI:10.1371/journal.pone.0148810 February 18, 2016

Individualization of Blood-Borne Marker Ranges



Hecksteden et al. 2016

HR submax a potential HR marker in racket sports

TECHNOLOGY REPORT ARTICLE Provisionally accepted The full-text will be published soon. Notify me

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Heart Rate Monitoring in Team Sports – A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription

Christoph Schneider[1*], Florian Hanakam[1], Thimo Wiewelhove[1], Alexander Döweling[1], Michael Kellmann[1, 2], Tim Meyer[3], Mark Pfeiffer[4] and Alexander Ferrauti[1]

[1]Faculty of Sport Science, Ruhr-Universität Bochum, Germany

[2]School of Human Movement and Nutrition Sciences, The University of Queensland, Australia

[3]Institute of Sports and Preventive Medicine, Saarland University, Germany

[4]Institute of Sports Science, Johannes Gutenberg-Universität Mainz, Germany

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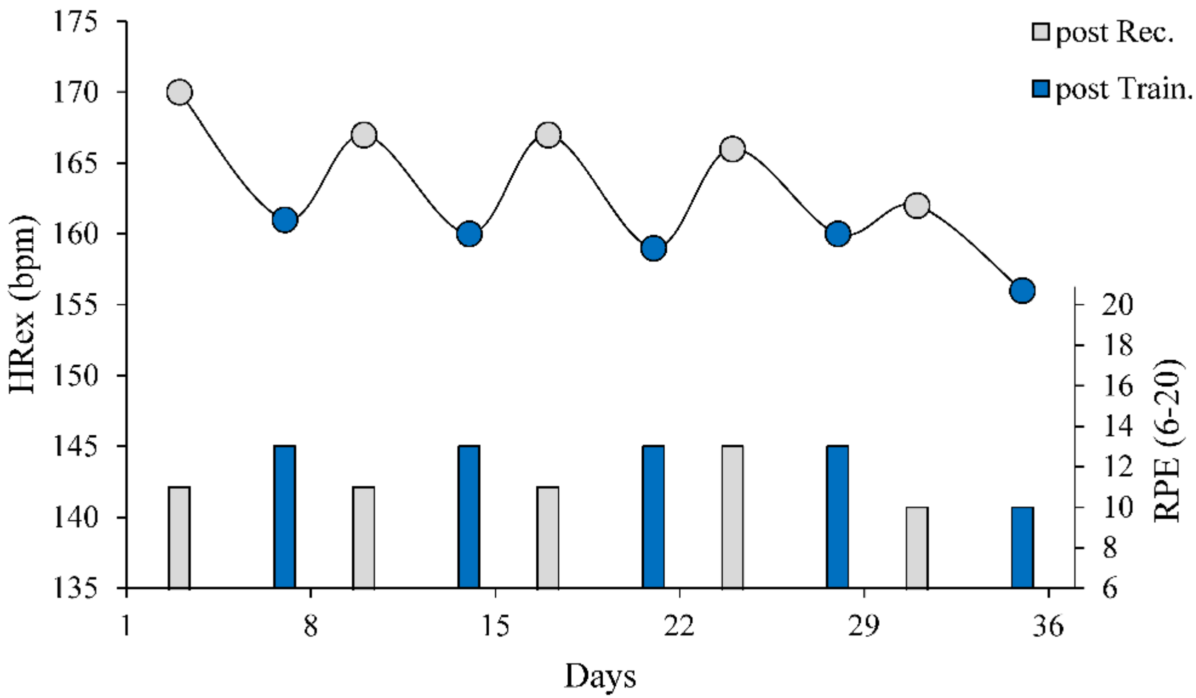
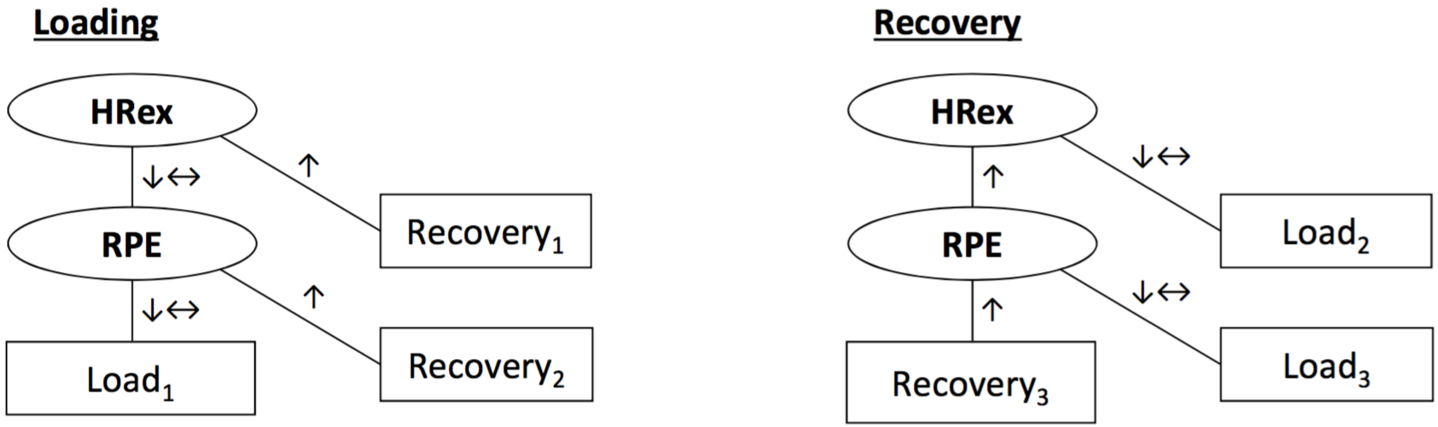
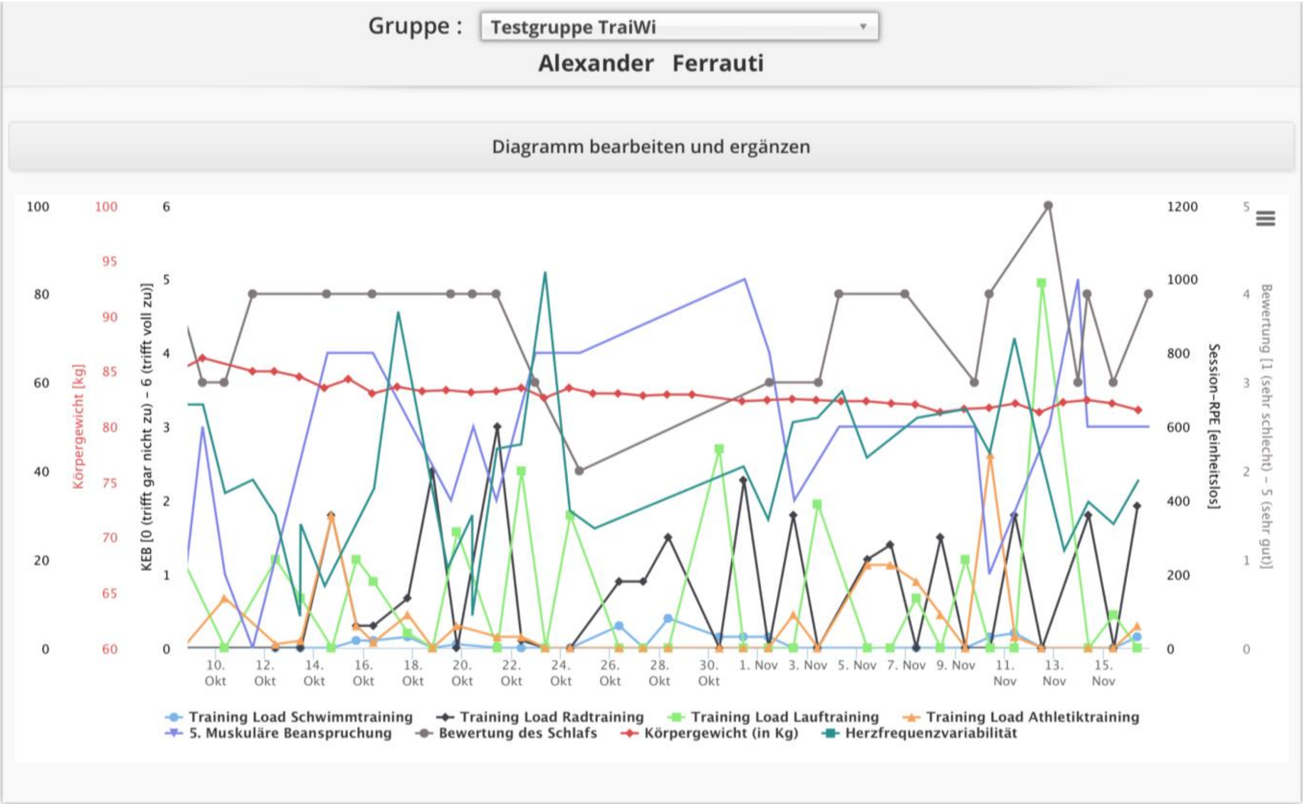


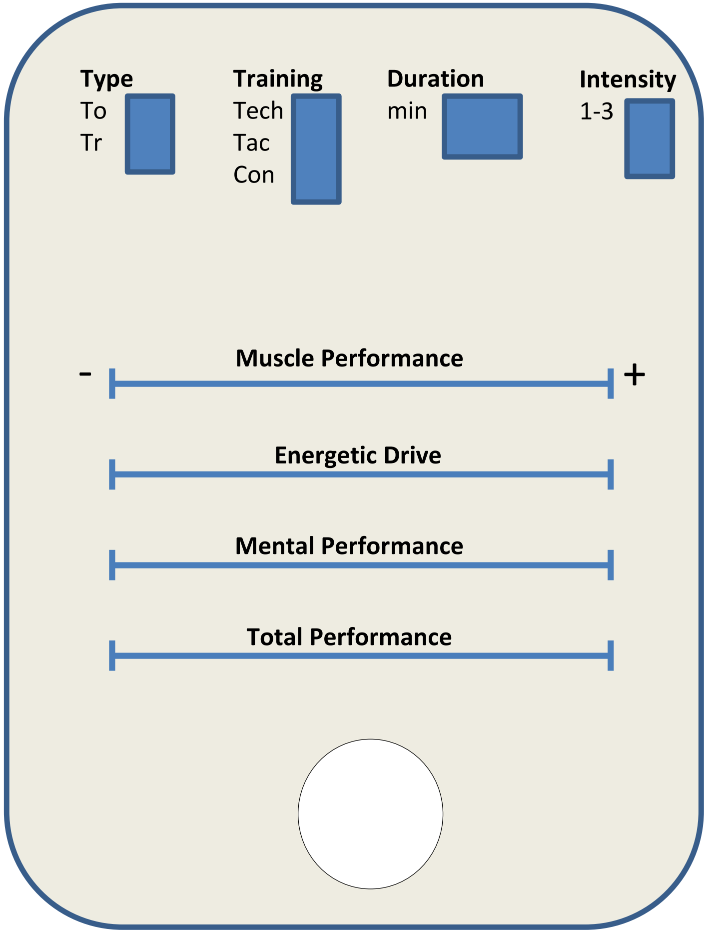
Multivariate Decision Making



Multivariate Decision Making



Intelligent Online-Tools



RECOVERY FOR PERFORMANCE IN RACKET SPORTS

Alexander Ferrauti

1 THE FITNESS – FATIGUE RELATION

2 INTERNAL & EXTERNAL LOAD IN RACKET SPORTS

3 OVERVIEW ABOUT RECOVERY INTERVENTIONS

4 SCIENTIFIC EVIDENCE OF RECOVERY EFFECTS

5 REGman REGENERATIONSMANAGEMENT IM SPORT - FINDINGS

6 MONITORING OF FATIGUE & RECOVERY

7 PRACTICAL RECOMMENDATIONS FOR RACKET SPORTS


Bundesinstitut
für Sportwissenschaft
Wir helfen
dem Sport
Tim Meyer, Alexander Ferrauti, Michael Kellmann, Mark Pfeiffer
Regenerationsmanagement
im Spitzensport
REGman – Ergebnisse und Handlungsempfehlungen

General advices

1. The efficiency of most recovery interventions in racket sports is lower than expected.
2. Recovery routines should be individualized according to players preferences, surrounding conditions and availability of methods.
3. Long term adaptation is not strongly affected by recovery.
4. A daily monitoring of training load and markers of fatigue is recommended for the fine tuning of training prescription.

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High evidence:	CHO plus protein consumption, hydration, sleep
Moderate evidence:	CWI, massage, roller massage
Low evidence:	active recovery, compression garments, others

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Short-term recovery (between tournament matches or training units)

CHO, hydration, roller massage, massage, active recovery, Power naps, relaxation strategies

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Future challenges fo research

Recovery of the upper extremities, recovery between points and during change of ends

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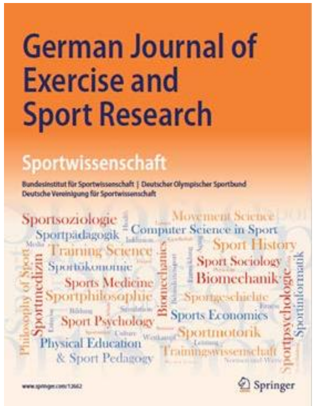

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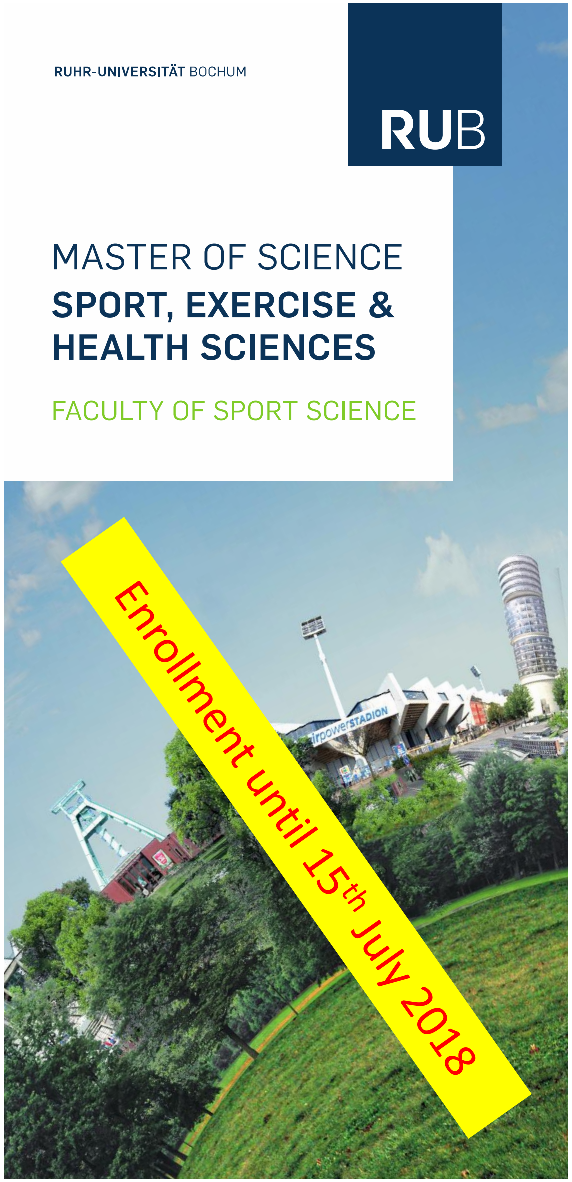
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Enrollment until 15th July 2018

Contact:

Ruhr-University Bochum
Germany

alexander.ferrauti@rub.de

RECOVERY FOR PERFORMANCE IN RACKET SPORTS

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Active Recovery

- Running, biking or swimming (15-30 min, 30-60 % VO_2max immediately after match)
- Blood lactate ↓ and pH (Fairchild et al. 2003)↑
- Glycogen synthesis (Fairchild et al. 2003)↓
- Sprint and Jumping performance (Andersson et al. 2008) ↔
- Muscle soreness, CK (Andersson et al. 2008) ↔
- Inflammatory response and oxidative stress markers (Andersson et al. 2010) ↔

Cold Water Immersion

- Not deeper than hip
- Cold water 10-15°C, 10-20 min
- Immediately after Exercise
- Venous blood return ↑

  Water temperature and hydrostatic pressure
- Inflammation from muscle damage ↓

(Nédélec et al. 2012)

Foam-Rolling

Biomechanical effects

Mechanical pressure on tissues

- ↓ **Tissue adhesion**
- ↑ Muscle compliance
- ↑ **Range of joint motion**
- ↓ Passive stiffness
- ↓ Active stiffness

Physiological effects

Changes in tissue or organ

- ↑ **Muscle blood flow**
- ↑ Skin blood circulation
- ↑ Parasympathetic activ.
- ↑ Relaxation hormones
- ↓ **Stress hormones**

Neurological effects

Reflex stimulation

- ↓ Neuromus. Excitability
- ↓ **Pain**
- ↓ Muscle tension/spasm

Psychological effects

Increased relationship between body and mind

- ↑ **Relaxation**
- ↓ Anxiety

(Weerapong et al. 2015)

German Volleyball Team (n=8)