Recovery Trends: From Ice Baths to the Latest Gadgets

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1/27/19

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Learning Objectives

- At the conclusion of the program, participants will be able to prioritize and personalize recovery strategies to individuals or teams.
- The program will provide the knowledge for participants to be able to apply and educate athletes and coaches on recovery strategies.
- At the conclusion of the program, participants will be able to discriminate between recovery strategies that are well founded within the evidence and those based on theory.

PICO questions

1. In athletes, does cold water immersion have greater benefits than whole body cryotherapy in pain perception and performance outcomes such as countermovement jump? (Abaidia)
2. In athletes, does wearing compression garments reduce perceived muscle soreness and muscle swelling compared to passive recovery? (Marques-Jimenez)
3. In athletes, does contrast water therapy improve muscles soreness scores and reduce muscle strength loss compared to passive recovery? (Bieuzen)
4. In athletes, does post-exercise massage improve jump recovery, sprint performance compared to passive recovery? (Weerapong/Torres)

Recovery- Definition

- Characterized by different modalities of recovery such as regeneration and psychological strategies.
- Regeneration – physiological aspect of recovery

Kellmann 2018

Challenges with Recovery Research

- High heterogeneity among studies
- Most of the research is equivocal
- Most studies are lab based and short term
- Translation from lab to sport??
- Small sample sizes
- Adaptation to recovery methods not understood

Athlete Perceptions of Recovery

Broad Athlete Population (Crowther 2017)
- Stretching considered most effective.
- Active recovery thought to be least effective
- Generally Poor Knowledge overall

College setting (Murray 2018)
- CWI most popular and believed in
- Less than half believed in using compression
- 2/3 relied on how they fell to measure recovery.
- 1/4 on based on performance
- 2/3 did not believe in or use contrast therapy
- 1/4 believe in foam rolling *very little supporting evidence*

Crowther 2017, Murray 2018

Coaches Perceptions of Recovery

- **Coaches** (Simjanovic 2009)
  - Apply recovery based on their own experience
  - Time and cost key factors
  - Effectiveness measured by instinct and general observations

★ Negative impressions influence outcomes and so do positive (Higgins 2011)

Types of Recovery

- Cryotherapy
  - Cold water immersion (CWI), Contrast, Ice Bags, Whole Body Cryotherapy (WBC)
- Intermittent Pneumatic Compression (IPC)
- Recovery Garments
- Phototherapy/Laser/Heat
- Massage
- Electrical Stimulation
- Active Recovery
- Passive Recovery

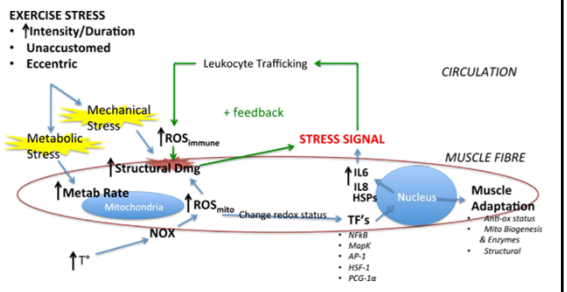
Primary Outcomes

- Biomarkers
- Pain
- Performance

Biomarkers of Muscle Damage

- Interleukins (IL)
  - Pro-inflammatory
  - Anti-inflammatory
- C-Reactive Protein (CRP)
- Creatine Kinase (CK)
- Lactate Dehydrogenase (LAD)
- Blood Lactate (BLa)
- Myoglobin

Exercise Stress



White 2013

Perceived Signs of Muscle Damage/ Pain

- Delayed Onset Muscle Soreness (DOMS)
  - Full physiological cause not known
  - Greater in eccentric-based exercise
- Measured in a variety of scales
  - VAS
  - Likert
  - Meta-Analysis with standardize scores
- Rate of perceived recovery (RPR)

Performance measures

- Maximal Voluntary Contractions (MVC)
- Isometric/Isokinetic testing
- Counter Movement Jump (CMJ)
- Sprint speeds
- Time to fatigue
- Power outputs

Cryotherapy

Types of Cryotherapy

- Cold Water Immersion
  - Temps below 15°C
- Whole Body Cryotherapy
  - Temps from -30°C to -195°C
- Contrast Therapy
  - Alternating Hot and Cold Temps via whirlpool
- Ice Bags

Cryotherapy - MOA

- Reduction of intramuscular temperature/metabolism
- Limit ROS and subsequent damage
- Reduce inflammation pathways
- Vasoconstriction to limit edema formations
- Reduce nerve conduction velocities

❖Full effect cryotherapy and recovery not fully understood

White 2013

Cryotherapy - Challenges

- No Set dosage
  - Time
  - Submersion depth
  - Temperature
- Variety of cooling techniques
- Variety of exercise performed

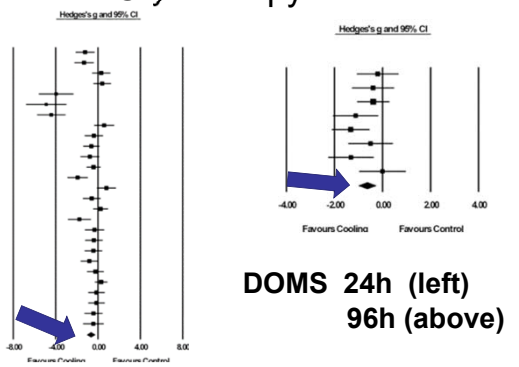
Cryotherapy - Biomarkers

- No Effects in first 24h on (Dupuy 2018)
  - Blood Lactate
  - CK levels
  - IL6
  - CRP

Similar results in Poppendieck 2013

Dupuy 2018, Poppendieck 2013

Cryotherapy - Pain



DOMS 24h (left)
96h (above)

Hohenauer 2015

Cryotherapy - Pain

- No correlation on temperature and DOMS (Hohenauer 2015)
- Greater effect sizes with for weight bearing sports (Halson 2011)

Hohenauer 2015, Halson 2011

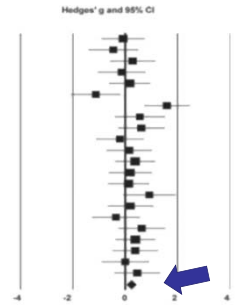
Cryotherapy - Performance

- Effect size improvement (Hedges' *g*)
  - Sprint (2.6%, *g=.69*)
  - Endurance (2.6%, *g=.19*)
  - Jump (3.0%, *g=.15*)
  - Strength (1.8%, *g=.10*)

Poppendieck 2013

Cold Water Immersion

CWI – Biomarker- CK



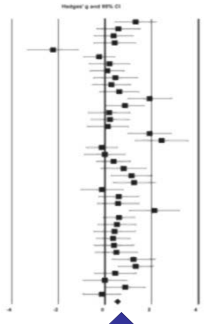
Leeder 2012

CWI - Biomarkers

- CK Levels- Small positive changes (Leeder)
- No significant changes with IL-6 /CRP
- HRV – CWI at 9ºC and 15ºC inc Parasympathetic reactivation
  9ºC more effective on vagal tone (Choo 2018)

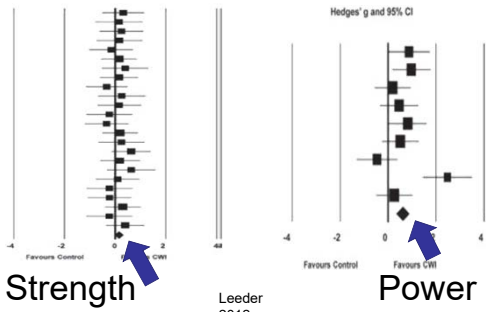
Leeder 2012

CWI – Pain DOMS



Leeder 2012

CWI - Performance



Leeder 2012

CWI - Performance

- Improves muscle power at all time points (24,48,72h)
- Does not improve strength outcomes
- Why??
  - Strength based on cross-section area
  - Power involves excitation-relaxation kinetics
  - CWI affects nerves...so….?

Leeder 2012

CWI - Application

- The ideal temps appears to be between for DOMS 11-15ºC for 11-15 min (Machado 2016, 2017)
- Whole Body vs extremity immersion on performance
  (5.1%, *g=.62*) vs (1.1%, *g=.10*) (Poppendieck 2013)

CWI- Key study #1

- Simulated Collision Sport Activity
- 3 groups – control, tackling+passive (TPASS), tackling+CWI (TCWI)
- Measurement points Before Ex, After Ex, After Recovery, 2h and 24h after recovery
- TCWI- reduced muscle soreness @2hr only
- Increased MVC and EMG activity
- Lower BLa in TPASS
- No effect on other biomarkers (CK, pH, CRP)

Pointon 2012

CWI - Key Study #2

- Dunne et al.
  - Exhaustive run ->recovery->exhaustive run #2
- 15m of CWI (8 or 15ºC) = lowered core temp
- improved time to failure
- HR was overall lower until they reached failure point
- Practical application: Wrestlers, Swimmers and Runners

Dunne 2012

CWI - Key Study #3

- #1: 12 weeks of training (CWI v Active)
- Rare study w. repeated bouts of CWI
- CWI attenuated muscle mass and strength

- #2: Crossover design w. SL strength ex.
  - Inc. satellite cells w active recovery

*neither study used a control so it is possible that active had positive role in gains

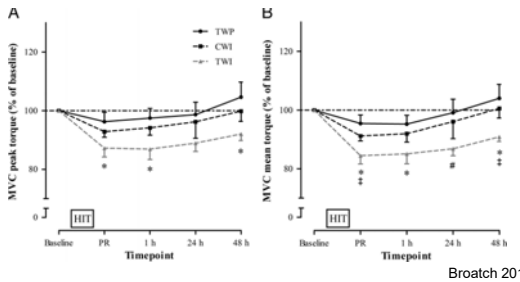
Roberts 2015

CWI #4 – Placebo effect???

- 30 physically active males 24±5 YO
- 4 Wingate Sprints
- Followed by treatment
- Divided into 3 groups
  - CWI: 10.3°C x 15m
  - TWI: 34.7°C x 15m
  - TWP: Same as above w. the additional of soap

Broatch 2014

CWI Key Study #4– Placebo effect???



Broatch 2014

CWI Key Study #4 – Placebo effect???

- No difference in biomarkers IL6, Lymphocyte, neutrophils, white blood cell

- After the recovery intervention and at 1h, TWI group, significantly self reported being
  - Less physical ready
  - Less mentally ready

Broatch 2014

Contrast Therapy

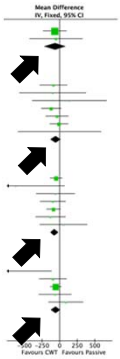
Contrast - MOA

- Similar to CWI
- With the concept of vascular pumping
- Inc blood limb flow following warm water immersion and dec w CWI (Fiscus 2005)

Contrast Therapy – CK/Mb

CK

- <6h
- 24h
- 48h
- 72h

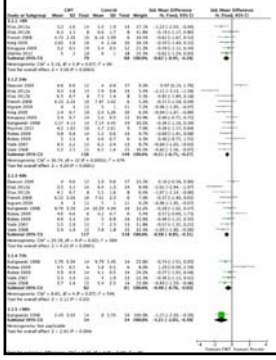


Lower Mb Levels at 48h (French 2008, Biuezen 2013)

No Change in CRP or IL6

Biuezen 2013

Contrast Therapy - Pain



- Effective at all time points up to 96h

Biuezen 2013)

Contrast Therapy - Performance

- Consistently showed less strength and power loss at all time points

Biuezen 2013

CWI and Contrast Therapy - However

- Meta-Analysis with Team Sport CWT/CWI
- Biomarker – not enough results
- Pain- No effect on muscle soreness for CWT/CWI
- Performance
  - CWT no effect on CMJ (1,24,48,72h)
  - CWI effect on CMJ only at 24h (no 1,48,72h)

Higgins 2017

Whole Body Cryotherapy

Whole Body Cryotherapy

- Increased popularity
- Lacks FDA clearance
- Optimal protocol is unknown
- Secondary term – Partial body Cryotherapy (PBC)

WBC - MOA

- Proposed – Similar to other cryotherapies
- With added affect of stronger initial sympathetic response followed by parasympathetic response (shock value)

WBC - Biomarkers
Multiple Session –Post trail running

	1 Session	Multiple Session
CRP	Lower with WBC	Lower with WBC 48h CRP returned to baseline
IL-1ra	Increase in WBC	Earlier Decrease WBC
IL-1β	Lower in WBC	No difference
IL-6, IL10, TNF-α	No difference	No difference
CK – Not measured		

No Change in CK levels in Hausswirth 2011
Rugby players dec on CK/LAD after 5 d tx (Banfi 2009)

Pournot 2011

Whole Body Cryotherapy - Pain

- WBC @48h post-marathon dec soreness (Wilson 2018)
- No effect post-eccentric protocol (Costello 2010)
- Insufficient Evidence - Cochrane Review (Costello 2015)

Whole Body Cryotherapy - Performance

- Mixed Results
- Harmful Post Marathon Race: Peak torque, Knee ext/ MVIC/Reactive strength index (Wilson 2018)
- 1 application 24h post activity – no MVC diff (Costello 2012)
- 3 applications 0,24,48h.

Improved MVC w/in 1h (Hausswirth 2011)

WBC- Application

- WBC: Single session
  - Best w/in 6 hrs of activity
- WBC: Multiple session needed for
  - LDH/CK decreases
  - CRP decrease trend
  - Increase IL-10 trend
  - MVC

Ice Bag

- Very Little Supporting Evidence for it.
- Avg effect size was negative on performance (Poppendieck)
- Repeated Ice – increased CK and Myoglobin (Tseng 2013)
  - Baseball pitchers after eccentric arm exercises

Intermittent Pneumatic Compression

RecoveryPump

Normatec

AirRelax

*not an endorsement

IPC - MOA

- Also termed external pneumatic compression (EPC)
- Brief History - Initially used for DVT post-surgical (Chen 2001)
  - Temporary vascular occlusion
  - Upon release – Blood flow cause turbulence
  - Endothelial receptors
  - Nitric synthase -> Nitric oxide
  - Nitric oxide - Major vasodilator

End result: Increased blood flow/venous retun (Liu 1999 Chen 2001)

- Does it reduce swelling post-exercise? One UE article from 1995 (Chelborn 1995)

IPC - Biomarkers

- No change in CK (Haun 2017)(Cochrane 2013)
- Enhanced BLa reduction (Hanson 2013, Martin 2015)
  - BLa removal similar to active recovery (Hanson 2013)
- A few small changes in protein and gene expression used after 3d HIIT training (Haun 2017)

Haun 2017, Cochrane 2013

IPC - Performance

- Preconditioning with IPC devices does not improve BLa or performance power measures via Wingate(peak/avg power) (Martin 2015)
- No Effect on VJ or MVC after eccentric exercise (Cochrane 2013)
- No Effect on 2nd Wingate right after recovery session (Martin 2015)
- No effect on 6km time trial (Haun 2017)

Martin 2015

IPC - Pain

- DOMS – no clear evidence
  - May have an effect days 2/3 based on comparison with compression garments (Winke 2018)
- No significant effect on muscle soreness (PPT) after 3 days of HIIT or back squats*** vs sham (Haun 2017a,b)
- *** While statistically "non-significant" Back squats had a very large effect sizes indicating likely attenuation of PPT

Compression Garments

Recovery/Compression Garments

- Specialty companies
  - 2XU,Skinz
- Mainstream apparel companies
  - Nike, Adidas, UnderArmour
- 2 types
  - General compression
  - Graduated compression

*not an endorsement

Compression Garments- MOA

- Reduced muscle oscillation
- Increased blood flow/velocity
- Less space for swelling
- Improved peripheral circulation/venous return
- Increase arterial perfusion
- Can be worn during sports

Marques-Jimenez 2016

Compression Garments- Biomarkers

- Paradoxically increased BLa
- Reduced LDH
- No effect on CK
- Reduced Muscle Swelling

Marques-Jimenez 2016

Compression Garments – Performance/ Pain

- Improved Power and Strength especially at 24 hour mark
- Muscle Soreness
  - Consistently reduced pain scores
  - Irrespective of time points

Marques-Jimenez 2016

Compression Garments - Application

- Important to wear right after 12-48h
- Longer is better
- ½ college athletes don't believe in them (Murray 2018)
  - Yet consistent evidence in their value

Marques-Jimenez 2016

Heat therapy

Heat Therapy - MOA

- HWI, hot pack, US, Microwave Diathermy
- Increases
  - Expression of heat shock proteins
  - Positive gene expression
  - Mitochondrial biogenesis
  - Anti-inflammatory effects
- Attenuates cellular damages / protein degradation

McGorm 2018

Heat Prior

- Example outcomes include
  - Hot pack/wrist: dec pain, improved ROM (Khamwong 2012)
  - Sauna/wrist: improved ROM, less strength deficits (Khamwong 2015)
  - HWI/jump: less dec in MVC, less CK, less soreness @1d/2d (Skurydas 2008)
  - -- MD/elbow: less swelling and pain (Evans 2002)

  (compared to active warm up)

McGorm 2018

Heat After – Biomarker, Performance, Pain

- Generally small benefits
- HWI after 5 d cycling
  - No effect on performance vs passive/CWI
  - Did lower avg HR
- HWI: Leg press + Tx at 24,48,72h
  - Small attenuated of squat force

Vaile 2008, Vaile 2008

Heat Therapy – Application

- Does recovery start pre-competition??
- Most of us have heard the old mantra that the best warm-up is active
- Heat after exercise for recovery did not have same positive effects as prior

Phototherapy

Phototherapy - MOA

- AKA Photobiomodulation therapy, light therapy, Laser
  - Cellular photoreceptors
  - Light energy transferred chemical energy in plasma

  Results increased
  - mitochondrial activity/ATP synthesis
  - Membrane permeability
  - Low levels of Reactive Oxygen Species (ROS)
  - Increased Respiratory chain Inc muscle cell oxygen

Borsa 2013, Leal-Junior 2015

Phototherapy - MOA

- Blood lactate is lower
  - enhanced conversion of lactate to pyruvate
- Less reliance on the anaerobic and glycolytic pathways

Borsa 2013

Phototherapy- Biomarker

- Systematic Review (Borsa 2013)
- 10 Studies
  - Various Light types
    - Single- and cluster-diode laser
    - Single- and cluster-diode LED
    - Wavelengths 640-850 nm
  - Found consistent lower BLa, CRP, LDH

  Post-exercise

Phototherapy - Biomarker

- In systematic review compared to placebo
- Lower CK (6 of 6 studies)
- Lower LDH (7 of 10 studies)
- Lower Lactate (7 of 10 studies)
- Lower CRP (7 of 10 studies)
- Similar findings in Borsa

Leal-Junior 2015

Phototherapy – Performance/Pain

- Performance: Few Studies
  - MVC - attenuation of post-exercise decrease or increased time to fatigue (Baroni 2010, De Marchi 2012)
  - Inc VO_{2max} (De Marchi 2012)
- Pain: no clear evidence that it affects DOMS (single and multiple treatments)

(Craig 1996,1999, Baroni 2010,Demarchi 2017*)

Phototherapy - Application

Pay attention to dosage for desired affect
Too little = no effect
Too much = cellular inhibition
50 J needed for large muscle groups
Skin pigmentation
-Melatonin absorbs light
-Lower intensity, increase duration and energy
Probe angle and distance
Wave length

Hyperbaric Oxygen

- Funny pic

Hyperbaric Oxygen - Biomarkers

- Male Jiu-Jitsu athletes
- Crossover design
- No effect on cortisol, testosterone, LDH, aspartate- and alamine aminotransferase,
- No change on RPE
- Some change on rate of perceived of recovery (RPR)
- Placebo effect??

Branco 2016

Hyperbaric Oxygen – Performance/Pain

- Hyperbaric oxygen therapy does not effect recovery from DOMS
- Potentially may increase Pain scores

- Overall, lack of high quality studies
- 100% O_2 at increased pressure has side effects: Ear drum rupture, oxygen toxicity, etc

Mekjavic 2000, Bennett 2005,

Neuromuscular Electrics Stimulation (NMES)

NMES - MOA

- Using an electric current for
  - Muscle strengthening
  - Increase circulation
  - Pain control
  - Edema control
  - Increase or decrease neural activity
- A variety of types, currents, waveforms and frequencies

NMES – Biomarker

- Biomarker
  - Trend towards positive effect on CK/BLa levels (Babault 2011)
  - Mostly in LFES (produces a contraction)
  - No diff than active recovery (Malone 2014)

NMES – Pain

- Pain
  - Mixed results across multiple types (Babault 2011)
  - Strong evidence that it does help with pain v passive (Malone 2014)
  - but not vs Active recovery (Malone 2014)

NMES - Performance

- Performance
  - No diff v Passive in meta analysis (Malone 2014)
  - No diff on Wingate peak power, mean power, fatigue index (Malone 2012)
  - Possibly less effective than active (Malone 2014)

NMES - Devices

Many of the newer devices lack specific independent validation in the literature

especially as it relates to athletic population

Massage

Massage

- Most research into Western/Swedish massage
- Most benefits are theoretical.
- General lack of empirical evidence esp as it relates to recovery

Weerapong 2005

Massage - MOA

- Biomechanical: ROM, stiffness
- Physiological: blood flow, hormones
- Neurological: pain, tension, spasm
- Psychological: relaxation, anxiety

- Synchronicity between groups

Weerapong 2005

Massage - MOA

Inc ROM?
- A few studies – poor methodology

Inc skin/muscle temp?
- Yes but short lasting, not deep
- Does that actually increase blood flow?

Inc blood flow? Enhance venous return?
- difficult to measure microcirculation

Weerapong 2005

Massage-Biomarker

- BLa- generally no benefit (Weerapong 2005); cool down superior (Bale 1991)
- No effect on neutrophils (Hilbert 2003)
- Reduced inflammation by limiting cytokine production (Crane 2012)
  *biopsy study

Massage – Biomarkers

- Decreased serum CK levels 24h,48h,72h
  – Continuum from 0 to 72 hours (Guo 2017)
- Hormones/Cortisol? small, weak evidence of decrease in cortisol (Weerapong 2005)
- Parasympathetic? Few studies, some evidence on dec BP+ HR, inc HRV, inc endorphins (Weerapong 2005)

Massage - Pain

- Biomechanical
  – Stiffness? small amt of evidence improves active stiffness
  – Joint ROM? Few studies that it improves it
- Neurological
  – small evidence of reduction in spasm and tension
  – H-reflex: returns to baseline at termination
  – Pain reduction:
- Psychological - clear evidence that massage in general improves pain, mood, perceived recovery (Poppendieck 2016)

Weerapong 2005

Massage- Pain

- DOMS: Clear benefits at 24,48,72h (Guo 2017)
- Alternatively: Improvement only at 24h. Not at 1h, 48h**,72h (Torres 2012)
  – @48h (p=.07)

Weerapong 2005

Massage - Performance

- No clearly defined benefit on muscle strength and function (Weerapong 2005)
- Trends improved muscle strength outcomes (Torres 2012)(Poppendieck 2016)
  *not statistically significant, small effect
- Improved max isometric force + peak torque (Guo 2017)
- No clear effect on Jump (Power) (Poppendieck 2016)
- Improves sprint performance (Poppendieck 2016)
- Closer to sprint the better

Massage - Application

- Poppendieck meta-analysis – Performance
- Overall effect sizes were small
- Massages 5-12m had greater effects than longer massages >12m. No effect >15m
- Less effect on trained athletes
- Greater effects after endurance or sprint exercises compared to strength exercises
- Massage after mixed exercise elicited greatest effect sizes on performance.
- (both were short term)

Poppendieck 2016

Massage - Application

- Average performance improvement 3.3%
- Runners only need .5%/ endurance 1% change to have significant improvement (Hopkins 1999, 2001)
- Some studies showing massage in short term then quick exercise.
- Most effective during short recovery periods on performance
- Benefit: was it recovery or warm up for next activity?

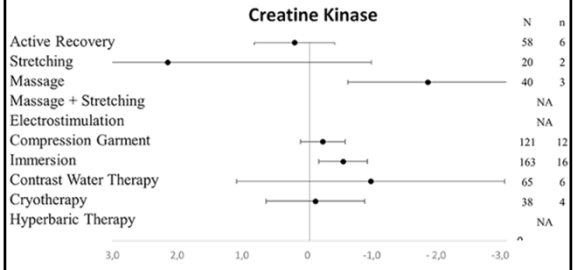
Poppendieck -

Massage - Application

- Large intersection between psychological and physiological benefits.
- Despite this, there is also the concepts of an athlete that feels better performs better.

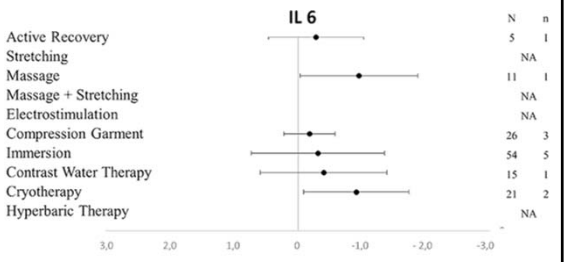
Comparisons / Key Studies

Biomarkers – Various recovery options



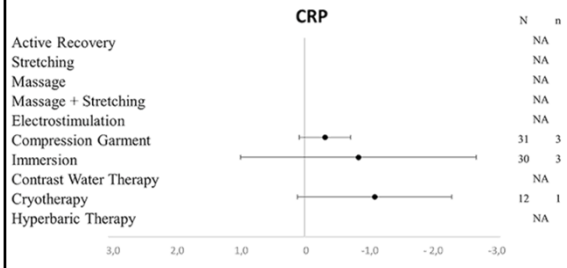
Dupuy 2018

Biomarkers – Various recovery options



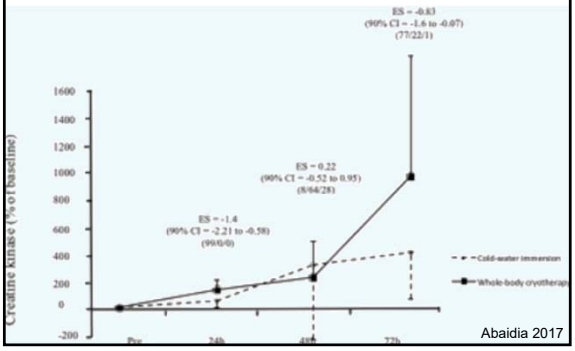
Dupuy 2018

Biomarkers – Various recovery options



Dupuy 2018

CWI vs WBC on CK levels



Abaidia 2017

CWI vs WBC – Blood Flow

- Subjects raised core temp to 38ºC
- 10 min CWI 8ºC v 2 min -110ºC

CWI = greater reductions in blood flow/tissue temps

Thigh/ calf blood flow (via laser Doppler flowmetry)
Superficial Femoral artery (duplex US)

Lower temps at skin, superficial, deep
Similar rectal temps bw CWI and WBC

Mawhinney 2017

CWI vs WBC – Pain/Performance

- CWI
  - Lower soreness scores
  - Higher perceived recovery
  - Improved SL/DL CMJ scores at 72h
  - Lower CK Levels 24/72h

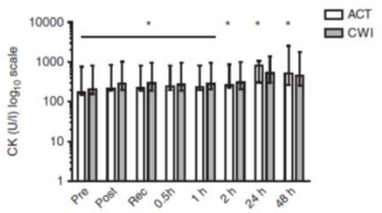
ADD IN POPPENDIECK 2013

- Direct comparison no difference in pain/performance) (Hohenhaur 2017)

Abaidia 2017, Hohenauer 2015, 2017

CWI vs Active

- No difference between CWI and Active recovery on minimizing inflammation (Peake 2017)



CWI vs. Contrast

- CWI better at lower CK Levels (Bieuzen 2013)
  - Remember overall effect size small w CWI
- CWI better at pain (Ingram 2008, Glascow (2014) (Next Slide)
- Contrast generally better at strength
  Contrast Meta diff v pass for strength (Bieuzen 2013)
  CWI Meta no diff v pass (Leeder 2012)
- In team sport setting CWI was better for strength and sprints
- CWI>Contrast but better compliance w. Contrast?

Contrast vs Others

- Compression: mixed results CK
  - One study favoring CWT (French 2008)
  - One study no difference (Gill 2006)
- Stretching: no difference
- Active: Better BLa w Active @ 72h (Gill 2006)
- Overall: superior to passive recovery, no major differences than other recovery strategies

Biuezen 2013

Comparison
Massage v cryotherapy

- Poppendieck vs. Poppendieck
- Pooled Performance outcome
  - Strength, endurance, jump, etc
- Massage effect size *g*=.19
- Cryotherapy effect size *g*=.28
- Effect Size considerer trivial (g<.20) or small (g= .20-.39)

Comparison:
Laser v. cryotherapy (ice bag)

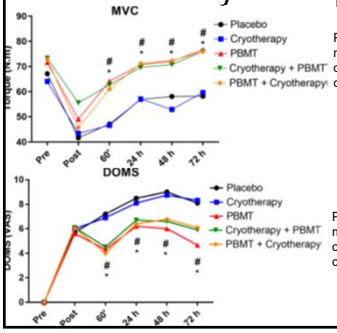
- 40 young subjects blinded into 5 groups
- placebo, ice, laser, ice+laser, laser+ice

- Biceps MVC protocol
- Tx 2m post-exercise

- Blood specimens @ baseline 5m, 60m, 24h, 48h, 72h

De Marchi et al. 2017

Comparison:
Laser v. cryotherapy (ice bag)



Pre and post-exercise MVC. Values are mean and error bars are SEM. #Different of placebo ($p < 0.05$); *different of cryotherapy ($p < 0.05$)

Pre and post-exercise DOMS. Values are mean and error bars are SEM. #Different of placebo ($p < 0.05$); *different of cryotherapy($p < 0.05$)

De Marchi et al. 2017

Comparison:
Laser v. cryotherapy (ice bag)

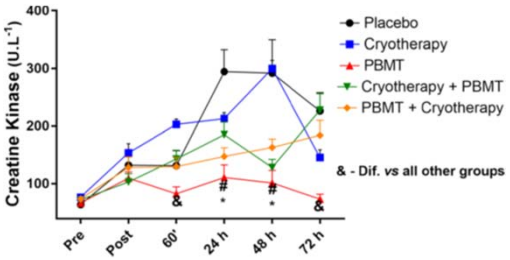


Fig. 4 Pre and post-exercise CK activity. Values are mean and error bars are SEM. #Different of placebo ($p < 0.05$); *different of cryotherapy ($p < 0.05$). &Different of the all other groups ($p < 0.05$)

De Marchi et al. 2017

Comparison: Laser v. cryotherapy (ice bag)

Key results

- No difference between placebo and ice for MVC, DOMS
- Laser improved MVC and DOMS
- Laser by itself improved CK levels
- Ice attenuate effects of the Laser CK levels in both combo groups.

Comparisons: Laser v. cryotherapy (CWI)

- Elite Futsal players
- Treatments 10m post – Wingate test
- 20m after the test/10m after treatment
- BLa and CK = Decreased ($p<.01$)
- CRP no change
- Drawback- only used 5m of CWI at 5°C (too cold and/or too short)
- Longer measurements not completed

Leal Junior 2011

Comparison – CK Levels

- Active/Garments/Contrast/Passive

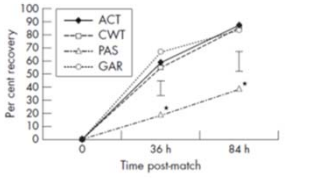


Figure 1 The percentage recovery post-rugby match as examined by interstitial creatine kinase activity at 0, 36, and 84 hours, grouped by recovery strategy. Error bars show the standard error of the differences (SED) at the respective time points. ACT, active recovery; CWT, contrast water therapy; GAR, compression garment; PAS, passive recovery. *Significantly different ($p<0.05$) from other interventions.

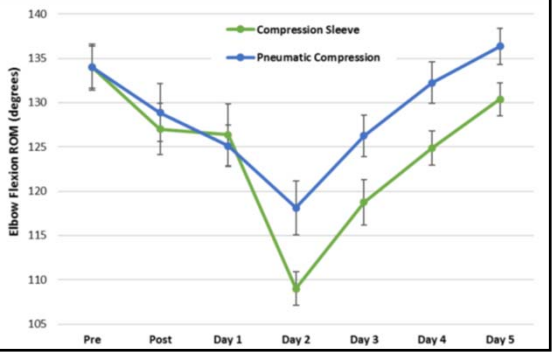
Gill 2006

IPC vs Compression Garment

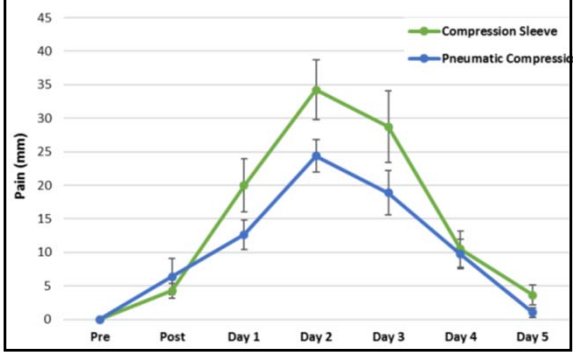
- 8 Subjects - Crossover design
- UE fatigue protocol
- 5d garment continuous or daily 20m IPC tx
- IPC had
  - Improved ROM reduction (47%)
  - Less Upper Arm swelling (15%)
  - Lower Peak pain (39%)
- Compression sleeve did not appear to be graduated (Adidas CS)

Winke 2018

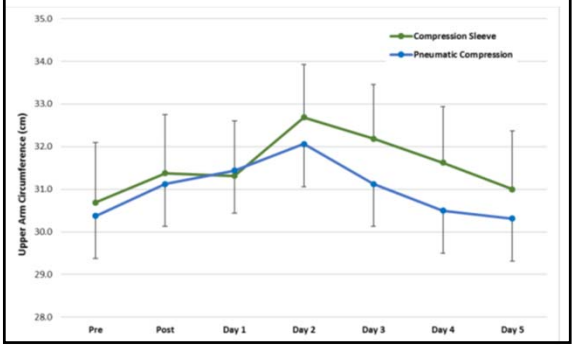
IPC vs Compression Garment



IPC vs Compression Garment



IPC vs Compression Garment



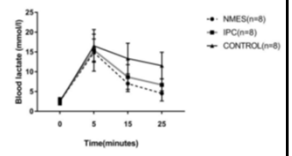
Comparison - IPC v NMES

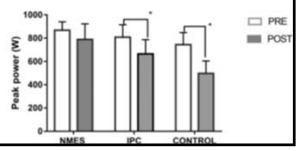
- College basketball players
- 3 groups: NMES, IPC, Control
- Repeated Sprint Test then 20min recovery

Sharma 2016

Comparison - IPC v NMES

- NMES- Greater BLa drop than IPC
- Both were effective in maintaining mean power but only NMES in peak power





Sharma 2016

Other Key Factors of Recovery to Consider

- Nutrition
- Hydration
- Sleep

Summary 1

Cold water immersion (CWI) consistently good for pain and maintaining power. Be cautious if trying to build strength. Target time is 11-15 minutes at 11-15ºC.

Whole Body Cryotherapy (WBC) has some potential but research is incomplete. It is not FDA approved and there are not consistent protocols. CWI generally offers equal or more benefits

Contrast is beneficial for DOMS and attenuating post-exercise strength/power losses.

Ice Bags are not beneficial to recovery.

Summary 2

- Intermittent Pneumatic Compression (IPC) increases circulation. The benefits of IPC other than BLa is lacking in the research.
- Recovery Garments are beneficial for pain, swelling, and performance. They need to be worn right away and for extended period of time to be effective.
- Phototherapy/Laser prior attenuates muscle damage thus improving recovery. Do not use in conjunction with cold.
- Heat can improve recovery outcomes if used prior.

Summary 3

- Massage physiological benefits are mostly theoretical and actual recovery benefits are mostly perceptual. 5-12 minutes is the target time.
- Electrical Stimulation should be pulsing to reduce BLa.
- Active Recovery is the best for BLa removal.

Guidance For ATs

- When using recovery target specific outcomes when possible.
- Be aware of what techniques that may work against each other.
- Be aware of and don't be afraid of the placebo effect and mind/body connection
- Consider time and money.
- Consider the effect size, sometimes a small effect can be quite helpful

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Thank you
Questions????

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