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## How can we improve recovery in our athletes – a review of 5 commonly used modalities.

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The risk of injury to an athlete is a constant source of concern for both the athlete, the trainer, and the physiotherapist. Injury occurs when the demands placed on the athlete's body exceeds the capacity of the athlete's body. This can occur from a one-off traumatic mechanism, such as when a player lands in an awkward position and the force exceeds the capacity of the body's soft tissue to withstand this force and the ligament tears. Alternatively, the repeated application of low-level stress to the athlete's soft tissue exceeds the tissues capacity and an overuse type injury occurs. In both scenarios, the key mechanism is that the demand on the tissue exceeds the capacity of the tissue.

A significant body of research evidence exists exploring the potential role of a range of factors in affecting this capacity versus demands relationship, subsequently increasing or decreasing an athlete's risk of suffering an activity related injury. These risk factors have been divided into extrinsic factors, which are external to the individual, such as the type of sport, equipment and playing environment, and intrinsic factors, which are factors inherent to the individual athlete. These factors can be further characterised into modifiable and non-modifiable risk factors, depending on our ability to change them. Non-modifiable risk factors such as previous injury, age, gender, and ethnicity cannot be changed whilst risk factors such as physical fitness, strength, and flexibility can be changed. (Pizzari et al, 2020). These intrinsic risk factors can be seen to influence the capacity of the athlete to cope with the applied demands

This capacity of the body to deal with applied demands can change over relatively short time periods. Following a period of stressful physical activity, the body requires a period of time to allow it to recover. During this normal post exercise 'recovery' period, the body's capacity to withstand any applied stresses is reduced. This underpins the recommendation that athletes provide adequate rest days between training or games to allow this recovery to occur.

Whilst this recovery period is a normal post exercise phenomenon it represents a modifiable risk factor as a number of strategies have been reported to help reduce this period of reduced capacity, allowing safe return to physical activity (i.e. capacity to deal with the applied demands of the sport). These strategies range from passive approaches, where the athlete is a passive recipient of an intervention (ice, massage, medications, etc) through to active approaches such as stretching. Despite a range of strategies reported, which ones are the safest and most effective remains unclear.

The following reviews were undertaken by students of an Advanced Evidence Based Practice course to explore the evidence associated with a range of commonly used recovery strategies, including cold therapy, compression garments, massage, non-steroidal anti-inflammatory drugs and the use of whole body cryotherapy chambers. Summaries of the evidence are presented in the following one page summaries.

Table 1 summarises the specific evidence review findings related to the studies that were identified

**Conclusion**

The message is clear that of the five reviewed there is no one magical recovery strategy, with each demonstrating potential benefits. In order of strength of evidence cold water immersion appears to be the most effective, followed by whole-body cryotherapy, NSAIDs (although concerns are raised about potential side effects), compression garments, with massage the least likely to assist recovery. The variable relationship between objective measures (muscle performance and blood markers of inflammation) and subjective measures (self-report DOMS and feelings of fatigue) mean that the optimal choice may be dependant on the athlete's preference.

| Recovery strategy | Evidence | Risk of bias | Interventions | Outcome Measures | Findings | Conclusions |
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| NSAIDs | 5 RCTs (n=129) | Low | Celecoxib vs placebo<br>• 100mg immediately and 12-hours post-exercise (Khoshkhahesh et al. 2013)<br><br>• 200mg morning and evening for 9 days (Paulsen et al. 2013), | • Inflammatory markers - Total leukocytes, neutrophils, monocyte and lymphocyte counts,<br>• C-reactive protein (CRP)<br><br>• Muscle function (force-generation), DOMS and swelling<br>• Radionuclide imaging: leukocytes, immunohistochemistry, blood sampling and CK<br>• Muscle biopsy | • No effect on exercise-induced inflammation, muscle damage, or lipid peroxidation<br><br>• Reduces DOMS and PGE2 concentration but doesn't influence recovery and adaptation after eccentric exercise | • Some evidence of effect on DOMS<br>• Doesn't appear to change performance measures |
| | | | Ibuprofen vs placebo<br>• 400 mg every 8 hours within a period of 48 hours (Tokmakdis et al. 2003). | • DOMS<br>• Blood Samples - white blood cell count and creatine kinase activity<br>• Maximal concentric strength<br>• Knee Flexion ROM<br>• Vertical jump performance | • Decrease in DOMS but no change in muscle function. | |
| | | | Flurbiprofen<br>• Two 40mg flurbiprofen patches 12 hours prior to exercise (Semark et al. 1999) | • DOMS<br>• sprint test<br>• Blood samples - serum creatine kinase plasma lactate concentration. | • No effect on DOMS.<br>• No effect on acceleration<br>• No effect on serum creatine kinase activity or plasma lactate concentration | |
| | | | Ketoprofen<br>• 100mg applied.to quadriceps muscle every 8 hours while (Cannavino et al. 2003) | • DOMS<br>• MedX Fatigue response test | • Decrease in DOMS<br>• No differences in strength index scores | |

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| Cold Water Immersion | 6 RCTs (n=123) | Moderate | • 5 minutes CWI (10degC) x 2, separated by 2.5 minutes (Barber et al 2020) | • DOMS<br>• Creatine Kinase<br>• Counter jump<br>• Max Isometric contraction | • Reduced DOMS<br>• Improved recovery of muscle function | • Consistent evidence of effect on DOMS<br>• Variable evidence of effect on muscle performance |
| | | | • 14 minutes CWI (14 deg C) (Elias et al 2013) | • Sprint ability<br>• Countermovement jump<br>• DOMS<br>• Fatigue | • Improved sprint<br>• Improved Counter jump<br>• Reduce DOMS<br>• Reduced fatigue after 48 h | |
| | | | • 10 minutes at 15 deg C (Takeda et al 2014) | • Creatine Kinase<br>• Countermovement jump<br>• Cycling power | • No significant differences in blood markers or muscle function | |
| | | | • 10 minutes at 10 deg C (Tavares et al 2019) | • DOMS<br>• Counter jump<br>• Cortisol and interleukin-6 | • No significant differences in blood markers or muscle function/pain | |
| | | | • 9 minutes at 9 deg C x 2 separated by 1 min (Pointon and Duffield 2012) | • sEMG<br>• C-Reactive protein<br>• DOMS | • No effect on blood markers of muscle damage<br>• Reduced DOMS | |
| | | | • 5 minutes at 12-12 deg C x2 separated by 2.5 minutes (Higgins, Cimstein and Cameron 2013) | • Countermovement jump<br>• DOMS<br>• Flexibility | • Reduced DOMS<br>• No significant effect on other measures | |
| Whole-body cryotherapy chambers | 5 Studies (n=117) | Moderate | • 1 bout - 60 mins post ex - 30sec in -60°C and 150sec in -120° (Haq, Ribbans & Baross 2021) | • Pain during squat (VAS)<br>• Quad strength - Isokinetic dynamometer | • No significant difference | • Some evidence of effect on DOMS<br>• Variable evidence of change in muscle performance measures |
| | | | • 3 bouts – 1h, 24h and 48h post exercise - 180sec in -110°C (Hausswirth et al., 2011) | • DOMS (0-100 VAS)<br>• Quad strength - Isokinetic dynamometer<br>• plasma creatine kinase (CK) | • No significant difference in Plasma CK<br>• Quicker recovery up to 24 hours in DOMS and Strength | |

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| | | | • 4 bouts – post, 24h, 48h, 72h post exercise - 180sec in -110 to -140°C (head out) (Qu et al., 2020) | • DOMS (0-10 VAS)<br>• plasma creatine kinase (CK)<br>• vertical-jump height (VJH) | • Significantly reduced DOMS and CK levels<br>• Significantly improved VJH | |
| | | | • 1 bout 15 mins post - 180sec x 2 in -85°C (15 min gap) (Wilson et al., 2018) | • Pain during squat (0-10 VAS)<br>• Blood markers of inflammation<br>• plasma creatine kinase (CK)<br>• Quad strength - Isokinetic dynamometer<br>• Drop Jump | • No significant effect on blood markers<br>• Reduced muscle function test performance | |
| | | | • 1 bout 15 mins post exercise - 180sec x 2 in -85°C (15 min gap) (Wilson et al., 2019) | • Pain during squat (0-10 VAS)<br>• Quad strength - Isokinetic dynamometer<br>• Blood markers of inflammation<br>• plasma creatine kinase (CK) | • No significant differences | |
| Compression Garments | 6 Systematic Reviews | Moderate | • 3 RCTs (n=47) (Altarriba-Bartes et. al. 2020) | • Counter movement jump, 10-20m sprint, | • Moderate difference in jump performance - at 48h,<br>• No effects on 20-m sprint and muscle strength outcomes | Inconsistent results in terms of DOMS and muscle performance |
| | | | • 23 Studies (da Silva et al 2018) | • Vertical Jump<br>• VO2 Max<br>• RPE | • Not associated with improved performance in VJ, VO2max, VO2submax, [La], or RPE during high-intensity exercise | |

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| | | | • 12 studies (n=366) (Dupuy et al 2018) | • DOMS<br>• Perceived Fatigue<br>• Blood markers of inflammation<br>• plasma creatine kinase (CK) | • No significant difference in DOMS<br>• Significant reduction in perceived fatigue<br>• No effect on creatine kinase, interleukin-6 and C-reactive protein concentrations | |
| | | | • 20 studies (n=289) (Marqués-Jiménez et al 2015) | • Blood markers of inflammation<br>• plasma creatine kinase (CK)<br>• Selling<br>• Muscle strength | • No effect on creatine kinase<br>• Increase in blood lactate<br>• Improved strength/power<br>• Reduced swelling | |
| | | | • 12 studies (n= 205) (Hill et al 2014) | • DOMS<br>• Peak concentric torque<br>• Counter movement jump (CMJ)<br>• 5 m and 10 m sprint<br>• Peak quadriceps extensor force<br>• Peak hamstring flexor force<br>• Creatine kinase (CK)<br>• Peak elbow flexor power<br>• Isokinetic muscle strength<br>• Jump height | • Reduced CK level<br>• Improved strength<br>• Improved power<br>• reduced DOMS | |
| | | | • 21 studies (n=411) (Mota et. al. 2020) | • Muscle fatigue<br>• Muscle soreness<br>• Subsequent performance<br>• Running economy | • Muscle fatigue, muscle soreness and running economy all were positively impacted by the CG post exercise. | |
| Massage | 3 RCTs (n=81) | High to Moderate | • Deep soft tissue massage vs classic | • hamstring muscle length | • No significant difference | |

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| | | | massage (Hopper et al. 2005) | | | • No evidence of effectiveness in recovery |
| | | | • Sports massage (effleurage and pertrissage - kneading, circular lifting, pressing, spreading, thumb petrissage) (Delextrat et al. 2012) | • Perceptual of overall fatigue via VAS<br>• Countermovement jump<br>• Repeated-sprint ability test | • Reduced perceptual fatigue<br>• No difference in CMJ, or sprint ability | |
| | | | • Traditional Thai Massage (Sarakul, Eungpinichpong & Sripongngam 2016) | • Standing balance<br>• Visual analogue Scale (VAS)<br>• Basketball free throw accuracy | • No effect | |

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