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EDITORIAL

Welcome to the Journal of Australian Strength and Conditioning *Supplement 2* for 2010. The ASCA is pleased to publish this document “Current Trends and Practices in Recovery” that was first presented as an ASCA Position Statement at the 2008 National Conference. The aim of this document is to provide Strength and Conditioning Coaches with a definitive recovery resource hence the name change from Position Stand to the current title which is being published as a ‘First Edition’ or working document with the aim of publishing a ‘Second Edition’ providing a updated resource for our members and coaches in the future.

I would like to take this opportunity, on behalf of the ASCA, of thanking the authors for their time and dedication to see this project through. It has been a long process however I am sure that our readers will find the information contained in this publication to be beneficial and useful in their task of seeking improved physical performance in their athletes and teams. I would also like to thank all the ASCA Members, ASCA Board Members and Editorial Panel for their input, feedback and comments throughout the review process.

Kind regards,
Susan Currell
National Executive Director

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ASCA
AUSTRALIAN STRENGTH & CONDITIONING ASSOCIATION

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November 12th - 14th 2010
Holiday Inn | Surfers Paradise

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CONFERENCE INFORMATION UPDATE!

Pre Conference Workshop

"Building and Rebuilding The Complete Athlete from the Ground Up"
Presented By

Vern Gambetta

Friday 12th November – 9am to 12pm
Places are limited and will be accepted on a first-in first-served basis
Further details can be found here

Delegates Information

This year's presenter list is headed up with Dr. Jay Hoffman (President NSCA) and Vern Gambetta (Director of Gambetta Sports Training Systems) who will be supported by a number of high profile coaches from Australia and overseas.

Information on how to register can be downloaded from here

Register Early and Receive Regular Updates on Presenters and Program

Call for Research Papers

The ASCA invites submission of research papers for poster presentation at this year's Conference. The aim is to provide opportunities for presentation of new research knowledge for conference delegates as well as the opportunity for researchers and students to present their work and receive feedback from some of the most highly respected Strength and Conditioning Specialists in Australia and overseas.

Application Form and Guidelines can be found here

Presenter Profiles

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ASCA Current Trends and Practices – Recovery – Science vs. Practice. . J. Aust. Strength Cond. Supplement (2)August, 2010 © ASCA

RECOVERY REVIEW – SCIENCE VS. PRACTICE

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OVERVIEW

Recovery has been identified as an important component of athletic performance. Despite the obvious popularity, there is a lack of scientific evidence for the validity of many recovery interventions. Because of this, the ability to prescribe discrete and specific recommendations for recovery interventions in elite sport is not feasible. Therefore, the aim of this review is to provide practitioners with current scientific information in the area of recovery and elite athlete performance, and where possible provide recommendations regarding usage.

It is important to consider that while scientific evidence for certain recovery interventions may be lacking this review does not dismiss the importance of anecdotal reports by elite athletes. As research in the area of recovery is in its infancy it would be inappropriate to suggest that certain recovery interventions may not be beneficial simply as a consequence of limited scientific investigation.

OBJECTIVE

To evaluate the scientific evidence and current practice of recovery interventions.

METHODOLOGY

Peer reviewed research in the area of recovery was examined to collate evidence regarding the effectiveness of popular recovery interventions. Following this, a number of recovery interventions were given a rating (LOW, MEDIUM, HIGH) based on the ***current scientific knowledge*** and the ***current*** *practice* in elite athlete populations. It was necessary to consider both parameters in this process, as a recovery intervention could be deemed an appropriate recovery practice if a) there is scientific evidence to support its usage or b) large numbers of athletes currently use the modality and there is no scientific evidence suggesting it is detrimental to performance. This if often the case with respect to recovery practices as there is currently little quality published scientific evidence specific to the area of recovery.

For the purpose of this review, interventions were examined from post-exercise recovery perspective only. Some interventions may have different applications during alternate time points and/or settings (e.g. pre or during exercise, rehabilitation, training phase).

INTRODUCTION

Professionalism in sport has provided the foundation for elite athletes to focus purely on training and competition. Furthermore, high performance sport and the importance of athletes' successful performances have led athletes and coaches alike to continually seek any advantage or edge that may improve performance. It seems that optimal recovery from training and performance may provide numerous benefits during repetitive high-level training and competition; and that the rate and quality of recovery in the high performance athlete may be as important as the training itself. Therefore, investigating different recovery interventions and their effect on fatigue, muscle injury, recovery and performance is important.

Adequate recovery has been shown to result in the restoration of physiological and psychological processes, so that the athlete can compete or train again at an appropriate level. Recovery from training and competition is complex and involves numerous factors and is typically dependent on the nature of the exercise performed and any other outside stressors that the athlete may be exposed to. Performance is affected by numerous factors and therefore, adequate recovery should consider such factors (See Table 1).

Table 1. Factors affecting athletic performance

Training/Competition	Volume, intensity, duration, type of training, degree of fatigue, recovery from previous training/competition
Nutrition	Carbohydrate, protein and other nutrient intake, fluid and electrolyte balance
Psychological stress	Stress from competition, home-sickness, anxiety
Lifestyle	Quality and amount of sleep, schedule, housing situation, leisure/social activities, relationship with team members, coach, friends and family, job or schooling situation
Health	Illnesses, infection, fever, injury, muscle soreness and damage
Environment	Temperature, humidity, altitude

RECOVERY INTERVENTIONS

ACTIVE RECOVERY

Background

Active recovery (low intensity exercise) is believed to be an integral component of physical recovery. Active recovery is usually in the form of walking, jogging, cycling or swimming at a low sub-maximal intensity. Anecdotal evidence suggests that active recovery reduces post-exercise muscle soreness and Delayed Onset Muscle Soreness (DOMS).

Research

While it is generally accepted that active recovery is superior to passive recovery; this assumption is based on the fact that enhanced blood lactate removal has been observed following active recovery compared to passive recovery (3, 28). Therefore, literature suggests active recovery is more efficient than passive recovery in improving the recovery process (58). However, as post-exercise blood lactate concentrations will return to resting levels with passive rest in a time period much shorter than that typically available for recovery, the relevance of this research to elite athletes is questionable (7).

Literature appears to both support and oppose the use of active recovery following exercise. Sayers et al. (72) used 26 male volunteers to investigate whether activity would affect the recovery of muscle function after high force eccentric exercise of the elbow flexors. The exercise regime consisted of 50 maximal eccentric contractions of the elbow flexors of the non-dominant arm. Sayers et al. (72) found that both light exercise and immobilization aided the recovery of maximal isometric force; also stating that recovery from soreness was aided by light exercise but delayed by immobilization. Gill et al. (35) investigated the effect of four (active recover, passive recovery, compression, and contrast water therapy) post-match recovery interventions in 23 elite rugby players. For the active recovery component, the athletes completed seven minutes of low intensity cycling (80-100 rpm, ~150 W) followed by their normal post-match routine (35). The authors concluded that the rate and magnitude of recovery was enhanced in the active recovery, contrast water therapy, and compression treatment groups, with an increase in creatine kinase clearance (35). Active recovery, contrast water therapy and compression were all significantly superior to passive recovery, with no differences observed between the effective recovery strategies. However, a study investigating the effect of three different interventions (massage, electrical stimulation, and light exercise) found no support for the use of massage, microcurrent electrical stimulation or light exercise to reduce or alleviate both soreness and force deficits associated with DOMS (88).

A combined recovery intervention including aspects of active recovery has demonstrated encouraging effects on lactate removal in a number of studies (43, 58, 87). However, McAinch et al. (52) examined the effect of active versus passive recovery on metabolism and performance during subsequent exercise. They found that when compared to passive recovery, active recovery between two bouts of intense aerobic exercise did not assist in the maintenance of performance nor did it alter either muscle glycogen content or lactate accumulation. The authors proposed there to be no rationale for the practice of active recovery following intense aerobic exercise (52).

Carter et al. (19) investigated the effects of mode of exercise recovery on thermoregulatory and cardiovascular responses; with data suggesting that mild active recovery may play an important role for post-exertional heat dissipation. However the mechanism(s) behind these altered responses during active recovery is unknown, hence further investigation is warranted (19).

While the research on the benefits of active recovery beyond lactate removal is equivocal, the role of active recovery in reducing DOMS and enhancing range of motion after exercise warrants further investigation. This is anecdotally reported to be one of the most common forms of recovery and utilised by the majority of athletes.

Current Level of Scientific Knowledge:	LOW
Current Practice:	HIGH

COMPRESSION CLOTHING

Background

Elastic compression garments externally compress the lower/upper limb through the use of pressure applied to the skin and musculature. Athletes commonly wear compression garments during long-haul air travel and recently it has become popular to wear during and/or following exercise. Historically, compression garments have been used in medical settings to treat various circulatory conditions, whereby these garments provide graduated compression by generating a pressure gradient, with the level of compression decreasing from the distal to proximal portion of the limb. Graduated compression garments have been reported to increase venous blood flow, venous return, and reduce swelling in both patients with venous insufficiencies (2) and healthy subjects (13). As a result of these findings and various manufacturers' claims that compression clothing can enhance recovery through improved peripheral circulation and venous return, and increased clearance of blood lactate (Bla) and markers of muscle damage such as creatine kinase (CK), the use of commercially available compression garments for exercise and recovery has increased exponentially in recent years. However, to date there is little evidence supporting these claims and therefore, the use of compression clothing for recovery.

Research

Duffield et al. (26) compared the effect of three different full-body compression garments and a control condition (no compression) on repeat-sprint and throwing performance in club-level cricket players. The compression garments were worn during and for 24 h post-exercise. Significantly lower blood CK concentrations and ratings of muscle soreness were observed 24 h post-exercise after wearing the compression garments, however, there were no differences observed between the three different compression brands. The authors proposed the reduction in CK to be due to the compression acting to limit the inflammatory response to acute muscle damage and reduce swelling.

Similarly, wearing a lower-limb compression garment for 12 h following an elite level rugby match resulted in an 84.4% recovery in interstitial CK concentration 84 h post-match (compared to 39% recovery following passive recovery) (35). Furthermore, Ali et al. (4) found wearing a knee-length compression sock during a 10 km run to significantly reduce perceived muscle soreness and frequency of reported soreness, especially in the lower extremities, 24 h after the run. These results suggest that the potential ergogenic value of compression clothing may lie in their ability to assist recovery to improve/maintain subsequent exercise performance. However, none of these studies report any data on changes in exercise performance on ensuing days.

In an attempt to substantiate this claim, Duffield et al. (27) investigated the effect of lower-limb compression clothing on recovery from a simulated team game exercise protocol, performed on two consecutive days. The compression clothing was worn during and for 15 h after the simulated team game exercise. No differences were observed in blood lactate or CK concentrations between the compression and control groups post-exercise on day one. Despite a reduction in perceived muscle soreness post-exercise on day one in the compression group compared with the control group, there was no difference in exercise performance (speed and power) between the groups on day two. The authors conclude that there appear to be perceptual benefits from wearing compression clothing post-exercise, reducing feelings of muscle soreness and potentially improving readiness to engage in training (27). This in itself may be of benefit to athletes. Similarly, wearing full-length, lower-limb compression clothing for 12 h following resistance exercise, was found to have no effect on subsequent exercise performance (speed, agility, power and strength), flexibility, plasma CK and myoglobin concentrations, swelling or perceived muscle soreness (33). In addition, Montgomery et al. (59) investigated the effect of wearing a full-length lower-limb compression garment on recovery during and after a three-day basketball tournament. Participants wore the compression clothing for an 18 h recovery period following each game. No effect was observed on exercise performance (agility, speed and power), flexibility, swelling, or perceived muscle soreness (59).

A lower recovery blood lactate concentration has been observed when compression stockings were worn during and after exercise when compared to clothing worn during exercise only or not at all (9). However, as no plasma volume shifts were observed, it was suggested that the lower values were due to lactate being retained in the muscular bed, rather than an enhance rate of lactate removal (9). Kraemer et al. (45) found the use of compression sleeves worn post-muscle damage to reduce CK concentration 72 h post-exercise, in addition, prevent the degree of loss of elbow extension, decrease subjects' perception of soreness, reduce swelling, and promote recovery of force production.

In summary, the limited amount of research in the area of compression specifically for recovery purposes has shown that wearing compression clothing during and after exercise may reduce post-exercise blood lactate and CK concentrations as well as perceived muscle soreness. However, to date, there is little evidence to suggest that wearing compression clothing is any more effective than other recovery interventions at maintaining or improving subsequent exercise performance. When interpreting these findings, it is important to consider the limitations of the research. None of the studies referred to have measured the compressive forces (mmHg) applied to the underlying musculature by the compression garment. Therefore, there is no data to suggest that the compression clothing being worn by the participants are exerting graduated compression on the musculature. For a compression garment to provide the ideal graduated compression it needs to be custom fit to the contours of an individuals' limbs, which cannot be achieved from height/weight based measurements used by many leading brands. Furthermore, in the studies that observed a reduction in perceived muscle soreness post-exercise, the placebo effect cannot be accounted for as a placebo condition was not included (i.e. wearing a garment that provides no compression or a lower level of compression). Compression clothing is being widely used for recovery by a number of elite athletes and teams both in Australia and around the world. A large amount of quality research needs to be completed out before more specific guidelines can be provided.

Practical Recommendations

Compression garments have become a very popular and commonly implemented recovery intervention. While quality literature in the area of compression and recovery is scarce, the following guidelines are based on current knowledge and patterns of use

- Utilise compression post-exercise for recovery
- Duration: while there is limited research in this area it can be assumed that the longer an athlete can wear compression for post-exercise, the better
- Sizing: garments must be fitted correctly to ensure best fit
- Garment choice (e.g. tights vs. shorts etc): current research would suggest that full length tights or lower limb-garments to be the most effective
- At present, it is recommended that athlete's travel in a medical grade compression
- Garment care: Place all compression garments in a laundry bag or hand wash, do not use a hot water wash or fabric softener, do not put compression garments in a dryer, and take care putting the garments on – work them up the leg rather than just pulling from the top.

Current Level of Scientific Knowledge:	LOW
Current Practice:	HIGH

HYDROTHERAPY

Despite the widespread incorporation of hydrotherapy into an athlete's post-exercise recovery regime, information regarding these interventions is largely anecdotal. Some of the physiological responses to water immersion are well researched and understood, however, in terms of post-exercise recovery; the underlying mechanisms are poorly understood. The benefits to subsequent performance have not been clearly established. The human body responds to water immersion with changes in cardiac response, peripheral resistance, and changes in blood flow (93). In addition, both hydrostatic pressure and temperature of the immersion medium may influence the success of different hydrotherapy recovery interventions (93).

Immersion of the body in water can result in an inward and upward displacement of fluid from the extremities to the central cavity due to hydrostatic pressure. As identified by Wilcock et al. (93), the resulting displacement of fluid may bring about an increase in the translocation of substrates from the muscle. Therefore, post-exercise oedema may be lessened and muscle function maintained. In addition, another physiological response to water immersion is an increase in stroke volume, which has been shown to result in an increase in cardiac output.

While the effects of hydrostatic pressure exerted on the body during water immersion may be beneficial, the temperature of water the body is exposed to is also thought to influence the success of such recovery interventions. The main physiological effect of immersion in cold water is a reduction in blood flow due to peripheral vasoconstriction (54). In contrast, immersion in hot water increases blood flow due to peripheral vasodilation (12,44).

COLD WATER IMMERSION

Background

Cryotherapy (meaning 'cold treatment' - normally in the form of an ice-pack) is the most commonly used strategy for the treatment of acute soft tissue sports injuries, due to its ability to reduce the inflammatory response and to alleviate spasm and pain (30,54,55). Multiple physiological responses to various cooling methods have been observed, including a reduction in heart rate and cardiac output, and an increase in arterial blood pressure and peripheral resistance (76,93). Other responses include decreases in core and tissue temperature (29,47,56,96), acute inflammation (95), pain (6,85), and a better maintenance of performance (17, 97). Merrick et al. (55) also suggest that cryotherapy is an effective method for decreasing skin/muscle/intra-articular temperatures, inflammation, blood flow, muscle spasm, and pain.

Research

The use of cryotherapy in the treatment of muscle damage and exercise-induced fatigue has been investigated with varying findings. Eston and Peters (30) investigated the effects of cold water immersion (of the exercised limb in 15°C for 15 min) on the symptoms of exercise-induced muscle damage following strenuous eccentric exercise. The muscle-damaging exercise consisted of eight sets of five maximal isokinetic contractions (eccentric and concentric) of the elbow flexors of the dominant arm (0.58 $rad \cdot s^{-1}$ and 60 s rest between sets). The measures used to assess the presence of exercise-induced muscle damage included plasma CK concentration, isometric strength of the elbow flexors, relaxed arm angle, local muscle tenderness, and upper arm circumference. Eston and Peters (30) found CK activity to be lower and relaxed elbow angle to be greater for the cold water immersion group on days two and three following the eccentric exercise, concluding that the use of cold water immersion may reduce the degree to which the muscle and connective tissue unit becomes shortened after strenuous eccentric exercise.

In a recent study, Bailey et al. (6) investigated the influence of cold water immersion on indices of muscle damage. Cold water immersion (or passive recovery) was administered immediately following a 90 min intermittent shuttle run protocol; rating of perceived exertion (RPE), muscular performance (maximal voluntary contraction of the knee extensors and flexors) and blood variables were monitored prior to exercise, during recovery, and post-recovery for seven days. The authors concluded that cold water immersion was a highly beneficial recovery intervention, finding a reduction in muscle soreness, a reduced decrement of performance, and a reduction in serum myoglobin concentration one hour post-exercise (6). However, further values across the seven day collection period were not cited and CK response was unchanged regardless of intervention. Lane and Wenger (46) investigated the effects of active recovery, massage, and cold water immersion on repeated bouts of intermittent cycling separated by 24 h. Cold water immersion had a greater effect compared to passive recovery, active recovery, and massage on recovery between exercise bouts, resulting in enhanced subsequent performance. This is an important investigation as most studies in cold water immersion research have been conducted using muscle damage models or recovery from injury. Despite these promising results, some studies have found negligible changes when investigating the recovery effects of cold water immersion (64,73,94).

In a randomised controlled trial Sellwood et al. (73) investigated the effect of ice-water immersion on DOMS. Following a leg extension exercise task (5 × 10 sets at 120% concentric 1RM) participants performed either 3 × 1 min water exposure separated by one minute in either 5°C or 24°C (control) water. Pain, swelling, muscle function (one-legged hop for distance), maximal isometric strength, and serum CK were recorded at baseline, 24, 48, and 72 h post-damage. The only significant difference observed between the groups was lower pain in the sit-to-stand test at 24 h post-exercise in the ice-water immersion group (73). In accordance with Yamane et al. (94) only the exercised limb was immersed at a temperature of 5°C. In this study, ice-water immersion was no more beneficial than tepid water immersion in the recovery from DOMS. Paddon-Jones and Quigley (64) induced damage in both arms (64 eccentric elbow flexions), and then one arm was immersed in 5°C water for 5 × 20 min, with 60 min between immersions, while the other served as a control. No differences were observed between arms during the next six days for isometric and isokinetic torque, soreness, and limb volume (64). In the aforementioned studies, cold water immersion appeared to be an ineffective treatment, specifically when immersing an isolated limb in 5°C water.

Only one study has investigated the effect of cold water immersion on training adaptation. Yamane et al. (94) investigated the influence of regular post-exercise cold water immersion following cycling or handgrip exercise. Exercise tasks were completed 3-4 times per week for 4-6 weeks, with cooling protocols consisting of limb immersion in 5°C (leg) or 10°C (arm) water. The control group showed a significant training effect in comparison to the treatment group, with the authors concluding that cooling was ineffective in inducing molecular and humoral adjustments associated with specified training effects (e.g. muscle hypertrophy, increased blood supply, and myofibril regeneration).

Despite these findings, the majority of research supports the notion that cold water immersion is an effective treatment intervention for the reduction of symptoms associated with DOMS (30), repetitive high intensity exercise (6,46), and muscle injury (15). A more refined investigation into the individual components of a specific recovery protocol is needed to reveal the effect of varying the duration of exposure, the temperature, and the medium used, whether it be ice, air, or water. In addition, training studies are required to investigate the effectiveness of such interventions on training adaptations.

***Current Level of Scientific Knowledge**:*	MEDIUM
***Current Practice**:*	MEDIUM-HIGH

HOT WATER IMMERSION (SPA)

Background

The use of heat as a recovery tool has been recommended to increase the working capacity of athletes (84) and assist the rehabilitation of soft tissue injuries and athletic recovery (15,21). The majority of hot water immersion protocols are performed in water greater than 37°C, resulting in a rise in muscle and core body temperature (12,91). The physiological effects of immersion in hot water remain to be elucidated. One of the main physiological responses associated with exposure to heat is increased peripheral vasodilation, resulting in increased blood flow (12,93).

Research

The effect of hot water immersion on subsequent performance is also poorly understood. Only one study has investigated the effect of hot water immersion on post-exercise recovery. Viitasalo et al. (84) incorporated three 20 min warm (~37°C) underwater water-jet massages into the training week of 14 junior track and field athletes. The results indicated an enhanced maintenance of performance (assessed via plyometric drop jumps and repeated bounding) following the water treatment, indicating a possible reduction in DOMS. However, significantly higher CK and myoglobin concentrations were observed following the water treatment, suggesting either greater damage to the muscle cells or an increased leakage of proteins from the muscle into the blood. Viitasalo et al. (84) concluded that combining underwater water-jet massage with intense strength training increases the release of proteins from the muscle into the blood, while enhancing the maintenance of neuromuscular performance.

There is a lack of supporting evidence for these findings and the use of hot water immersion for recovery has received minimal research attention. Despite the hypothesised benefits of this intervention, anecdotal evidence suggests that hot water immersion is not widely prescribed on its own or as a substitute for other recovery interventions. Additionally, speculation surrounds the possible effects, timing of recovery and optimal intervention category (e.g. following which type or intensity of exercise), for the use of hot water immersion. Finally, there has been minimal focus on acute fatigue and performance.

Current Level of Scientific Knowledge:	LOW
Current Practice:	LOW-MEDIUM

CONTRAST WATER THERAPY (HOT/COLD)

Background

During contrast water therapy participants' alternate between heat exposure and cold exposure by immersion in warm and cold water respectively. It has frequently been used as a recovery intervention in sports medicine (40) and is now commonly used within the sporting community. Although research investigating contrast water therapy as a recovery intervention for muscle soreness and exercise-induced fatigue is limited in comparison to cold water immersion, several researchers have proposed possible mechanisms that may support its use. Higgins and Kaminski (40) suggested that contrast water therapy can reduce oedema through a "pumping action" created by alternating peripheral vasoconstriction and vasodilation. Contrast water therapy may bring about other changes, such as increased or decreased tissue temperature, increased or decreased blood flow, changes in blood flow distribution, reduced muscle spasm, hyperaemia of superficial blood vessels, reduced inflammation, and improved range of motion (62). Active recovery has traditionally been considered a superior recovery intervention to passive recovery. Contrast water therapy may elicit many of the same benefits of active recovery, and may prove to be more beneficial, given the reduced energy demands required to perform it (93).

Research

Contrast water therapy has been found to effectively decrease post-exercise lactate levels (20,37,61,71). After a series of Wingate tests, it was found that blood lactate concentrations recovered at similar rates when using either contrast water therapy or active recovery protocols, and that, after passive rest blood lactate removal was significantly slower (71). Coffey et al. (20) investigated the effects of three different recovery interventions (active, passive and contrast water therapy) on four hour repeated treadmill running performance. Contrast water therapy and active recovery reduced blood lactate concentration by similar amounts after high intensity running. In addition, contrast water therapy was associated with a perception of increased recovery. However, performance during the high intensity treadmill running task returned to baseline levels four hours after the initial exercise task regardless of the recovery intervention performed.

In a more recent study investigating the effect of contrast water therapy on the symptoms of DOMS and the recovery of explosive athletic performance, recreational athletes completed a muscle-damaging protocol on two separate occasions in a randomised cross-over design (83). The two exercise sessions differed only in recovery intervention (contrast water therapy or passive recovery/control). Following contrast water therapy, isometric force production was not significantly reduced below baseline levels throughout the 72 h data collection period, however, following passive recovery, peak strength was significantly reduced from baseline by 14.8 ± 11.4% (83). Strength was also restored more rapidly within the contrast water therapy group. In addition, thigh volume measured immediately following contrast water therapy was significantly less than that following passive recovery, indicating lower levels of tissue oedema. These results indicate that symptoms of DOMS and restoration of strength are improved following contrast water therapy compared to passive recovery (80,83). However, Hamlin (37) found contrast water therapy to have no beneficial effect on performance during repeated sprinting. Twenty rugby players performed two repeated sprint tests separated by one hour; between trials subjects completed either contrast water therapy or active recovery. While substantial decreases in blood lactate concentration and heart rate were observed following contrast water therapy, compared to the first exercise bout, performance in the second exercise bout was decreased regardless of intervention (37). Therefore, while contrast water therapy appears to be beneficial in the treatment of DOMS, it may not hasten the recovery of performance following high intensity repeated sprint exercise.

The physiological mechanisms underlying the reputed benefits remain unclear. Temperatures for contrast water therapy generally range from 10-15°C for cold water and 35-38°C for warm water. It is evident that contrast water therapy is being widely used; however, additional research needs to be conducted to clarify its optimal role and relative efficacy.

***Current Level of Scientific Knowledge**:*	MEDIUM
Current Practice:	MEDIUM

Cold water immersion vs. hot water immersion vs. contrast water therapy?

Only recently have the three aforementioned recovery interventions been compared to each other examining exercise-induced muscle damage and acute fatigue models.

A group of three independent studies examined the effects of three hydrotherapy interventions on the physiological and functional symptoms of DOMS. A total of 38 strength trained males completed two experimental trials separated by eight months in a randomised crossover design; one trial involved passive recovery, the other a specific hydrotherapy protocol for a 72 h period post-exercise; either: (1) cold water immersion (*n*=12), (2) hot water immersion (*n*=11) or (3) contrast water therapy (*n*=15) (83). For each trial, subjects performed a DOMS-inducing leg press protocol followed by either passive recovery or one of the hydrotherapy interventions for a total of 14 min. Performance was assessed via weighted squat jump and isometric squat, additionally, perceived pain, thigh girths and blood variables were measured prior to, immediately after, and at 24, 48 and 72 h post-exercise. Overall, cold water immersion and contrast water therapy were found to be effective in reducing the physiological and functional deficits associated with DOMS, including improved recovery of isometric force and dynamic power and a reduction in localised oedema (83). While hot water immersion was effective in the recovery of isometric force, it was ineffective for recovery of all other markers compared to passive recovery.

In another recent study the effects of three hydrotherapy interventions on next day performance recovery following strenuous training was investigated. A total of 12 male cyclists completed four experimental trials differing only in recovery intervention: cold water immersion, hot water immersion, contrast water therapy, or passive recovery. Each trial comprised five consecutive exercise days (105 min duration, including 66 maximal effort sprints). Additionally, subjects performed a total of 9 min sustained effort (time trial). After completing each exercise session, athletes performed one of the four recovery interventions (in a randomised cross over design – randomly assigned to each trial). Performance (average power), core temperature, heart rate (HR), and rating of perceived exertion (RPE) were recorded throughout each session. Sprint (0.1–2.2%) and TT (0.0–1.7%) performance were enhanced across the five-day trial following both cold water immersion and contrast water therapy, when compared to hot water immersion and passive recovery. Additionally, differences in core body temperature were observed between interventions immediately and 15 min post-recovery; however, no significant differences were observed in HR or RPE regardless of day of trial/intervention. Overall, cold water immersion and contrast water therapy improved recovery from high-intensity cycling when compared to hot water immersion and passive recovery, with athletes better able to maintain performance across a five-day period (82).

Summary

Although all three of these hydrotherapy interventions are being used for recovery from high intensity exercise there are few consistencies in the advice and methodology of such interventions. Future research is required to confirm optimal water temperatures, duration of exposure, and the number and timing of rotations completed during the protocol. In addition, the efficacy of hydrotherapy as a recovery tool for differing types of activity (e.g. strength vs. endurance, single day vs. multiple days) is also needed.

POOL RECOVERY

Background

Pool recovery sessions are commonly used by team sport athletes to recover from competition. Almost all Australian Rules, Australian Rugby League and Australian Rugby Union Teams utilise pool recovery sessions to perform active recovery in a non-weight bearing environment. These sessions are typically used to reduce muscle soreness and stiffness and therefore are thought to be effective in sports that involve eccentric muscle damage and/ or contact. Sessions often include walking and stretching in the pool as well as some swimming.

Research

Dawson et al. (22) investigated the use of pool walking as a recovery strategy immediately post a game of Australian Rules Football. Pool walking was compared to contrast therapy, stretching and no recovery (control) in terms of subjective ratings of muscle soreness, flexibility (sit and reach), power (6 second cycling sprint and vertical jumps), which were measured 15 hr post game (15 hr). For all four recovery strategies muscle soreness was increased at 15 hr, however only pool walking resulted in a significant reduction in subjective soreness. There was a trend for lower flexibility and power scores at 15 hr, however this was only significant in the control trial. While there were no differences between the three recovery interventions with respect to flexibility and power, players subjectively rated pool walking as the most effective and preferable. The authors speculate that the active, light intensity exercise with minimal impact stress or load bearing, combined with the hydrostatic pressure, may explain why the pool walking enhanced recovery (22).

Current Level of Scientific Knowledge:	LOW
Current Practice:	MEDIUM- HIGH

Practical Recommendations - Hydrotherapy

Current knowledge and understanding of hydrotherapy recovery interventions can be used to implement a best case recovery program. While it is acknowledged that further research is required to confirm such applications, the following recommendations are based on current scientific information (81). The following recommendations are stated in the Modern Athlete and Coach (81).

- Where possible, full body immersion (excluding head and neck) should be implemented. More often than not exercise tasks involve the majority of the body; therefore, a full body recovery application is ideal. Partial immersion of the body may limit changes and result in a redistribution of blood flow, therefore reducing some of the potential and proven benefits of water immersion. Additionally, partial immersion reduces the hydrostatic pressure exerted on the body and may reduce the effectiveness of the hydrotherapy intervention (81).
- Recovery interventions should aim to be practical and time efficient. Hydrotherapy interventions of 10-15 min duration appear to be effective (81).
- There is much conjecture regarding the optimal water temperature for various hydrotherapy protocols and little consistency between research investigations, often leading to contradictory findings. However, current knowledge suggests water temperatures of 10-15°C (cold) and 38-42°C (hot) to be effective. If athletes are performing a continuous cold water immersion protocol it is recommended to use a slightly warmer temperature (e.g. 15°C). This is perceptually more comfortable (enhancing compliance), has been shown to effectively lower core body temperature, and enhance the recovery of performance in certain settings. However, if an athlete is performing an intermittent cold water immersion protocol, a cooler temperature (e.g. 10-12°C) may be more effective given the shorter exposure time (81).
- An important outcome of hydrotherapy may be to reduce post-exercise core body temperature. Investigations into contrast water therapy have indicated that a 1:1 (hot:cold) ratio may be ideal in stabilising core temperature following exercise. In addition, isolated hot water immersion (e.g. spa 38-42°C) has been shown to increase core temperature; therefore it is currently recommended that protocols should avoid inclusion of more hot water exposure than cold water exposure (81).

- It is important to recognise individual responses to various recovery interventions. Not every athlete will respond in the same way, and this should be acknowledged, particularly in team sport environments where a group of athletes often perform the same recovery protocol, regardless of game time, position, physiological status, body mass and composition (81).

MASSAGE

Background

Massage is another technique commonly utilized to enhance recovery from training and/or competition. Massage is defined as 'a mechanical manipulation of body tissues with rhythmical pressure and stroking for the purpose of promoting health and well being' (34). While massage is also used prior to training and/or competition and as a treatment for injury, for the purpose of this review, massage will be discussed in the context of recovery only.

Massage is suggested to have numerous physiological benefits including: decrease in muscle tension and stiffness, increased healing rate of injured muscles and ligaments, reduced muscle pain, swelling and spasm, increased joint flexibility, increased range of motion, increased blood flow, decreased lactate concentrations, increased skin and muscle temperature, decreased anxiety, increased relaxation, enhanced immune and endocrine function and increased performance (5,10,89).

Research

Despite the widespread use of massage, and the anecdotally reported positive benefits, there remains little quality scientific evidence to support or contest the above claims.

Effect of Massage on Performance

Concentric Exercise

A very small number of studies have investigated the effect of massage performed post-exercise on performance measures. Forearm massage was shown to improve hand grip strength when applied immediately after 3 min of maximal hand exercise (14). Two other studies have examined massage in combination with other recovery strategies on performance outcomes (46,58). Lane et al. (46) reported increased cycling power output following massage therapy when compared to passive recovery. The massage was 15 min in duration and was performed on the quadriceps, hamstring and calf muscles. The massage techniques included: deep effleurage (2.5 min per leg), compressions (1 min per leg), deep muscle stripping (2 min per leg), jostling (1 min per leg), and cross-fiber frictions (1 min per leg). However, active recovery and cold water immersion were superior to massage in terms of recovery from high intensity cycling. Monedero and Donne (58) also examined a combination of massage and active recovery in high intensity cycling performance and reported no effect of massage alone on enhancing performance in cyclists. However, massage and active recovery significantly increased performance above passive recovery and isolated massage.

Eccentric Exercise

Massage therapy following eccentric exercise that resulted in DOMS is a commonly used recovery treatment. Weber et al. (88) investigated massage, aerobic exercise, microcurrent stimulation or passive recovery on recovery of force from eccentric exercise. There were no significant effects of any of the treatment modalities on soreness, maximal isometric contraction and peak torque production. Hilbert et al. (41) reported no effect of massage administered 2 hr after a bout of eccentric exercise on peak torque produced by the hamstring muscle, however muscle soreness ratings were decreased 48 hr post-exercise. Dawson et al. (23) saw no effect of massage immediately following a marathon on quadriceps peak torque output or soreness. Farr et al. (32) also reported no effect of 30 min leg massage on muscle strength in healthy males, although soreness and tenderness ratings were lower 48 hr post-exercise. However, a significant improvement in vertical jump performance was reported after a high intensity exercise in college female athletes (51).

As can be observed from the above information, there are very few investigations which have examined the effect of massage on performance. There are also a wide range of massage techniques utilized and outcome measures examined. However, there may be some evidence to suggest that massage post eccentric exercise may reduce muscle soreness. It may also be possible that performance measures were made at inappropriate times and benefits in performance may be seen 24-96 hr post-exercise, when inflammatory processes are at their peak. Many studies investigating massage and its relevance to recovery have examined the mechanisms of massage and thus there is slightly more research in this area when compared to that of performance.

Possible Mechanisms of Massage Therapy

It is highly likely that massage effects occur through more than one mechanism. Mechanisms such as Biomechanical, Physiological, Neurological and Psychophysiological have been proposed (For comprehensive Review see (89)). Other research has also examined immunological and endocrine parameters. Each of these areas will be discussed briefly below.

Biomechanical Mechanisms

The biomechanical model primarily relates to increasing muscle-tendon compliance through mechanical pressure on the muscle tissue (89). This is thought to occur by mobilizing and elongating shortened or adhered connective tissue (89). One study has examined the effect of massage on passive stiffness and reported no change when compared to passive rest (77). However, two studies (63,92) have reported increased range of motion in response to massage. Nordschow et al. (63) reported an increase in lumbar range of motion following massage of the back and lower limbs and Wiktorsson et al. (92) reported increased ankle dorsiflexion following massage of the legs.

Physiological Mechanisms

It has been suggested that superficial skin friction may increase local heating and thus potentially blood flow. Also the mechanical pressure may stimulate the parasympathetic nervous system, causing changes in hormones, heart rate and blood pressure (89). There is a small amount of scientific literature reporting increased skin and muscle temperature (2.5 cm deep) after massage treatment (25,49). However, this increase does not appear to translate into increased blood flow. Shoemaker et al. (74) reported no change in blood flow following massage of the forearm and quadriceps measured via pulsed Doppler ultrasound velocimetry. This same group also reported no change in arterial or venous blood velocity when comparing a massage and control leg in same individuals (79).

Massage has been shown to reduce cortisol concentrations in dance students (48). However, while there is almost no evidence in elite athletes, reductions in cortisol and serotonin are commonly reported following massage in a large number of patient populations (depression, anxiety, HIV, low back pain) (89). A recent study also demonstrated that massage following high intensity exercise had a positive effect on salivary IgA rate, indicating that massage may negate some of the immunosuppressive effects of acute exercise (5). In this study however, massage had no influence on cortisol concentrations.

Neurological Mechanisms

A reduction in neuromuscular excitability may occur with massage due to the stimulation of sensory receptors (89). One study has reported decreased H-reflex amplitude during massage (60). It has been suggested that this occurred as a result of decreased spinal reflex excitability through inhibition via muscle or other deep tissue mechanoreceptors (89).

The reduction in pain following massage may occur via the activation of the neural gating mechanism in the spinal cord (gate control theory of pain). Skin receptor information may block the information to the brain from the pain receptors. Additionally, massage is often used to reduce muscle spasm which causes muscle pain. The spasm is thought to activate pain receptors and/or compress blood flow casing ischemia (89). A realignment of muscle fibres as a consequence of massage is thought to reduce the muscle spasms. However, while this theory is quite well accepted, there is no scientific evidence to support it.

Psychophysiological Mechanisms

Improved mood and/or reduced anxiety as a consequence of massage have been reported in several studies. A lowered anxiety and depressed mood was reported in dance students who received a 30-minute massage twice a week for four weeks (48). Hemmings et al. (39) compared massage, supine resting or touching control during a period of training in boxers. Massage improved the Profile of Mood State questionnaire subscales of tension and fatigue.

Summary of Massage effects on Recovery

While there is limited scientific support for the use of massage as a Recovery tool consideration must be given to the lack of literature in the area, the general poor quality of the literature and the differences in techniques utilized. Additionally, many of the outcome measures of the above mentioned studies are often not deemed critical by experienced practitioners. Further research should focus on utilizing appropriate study design and techniques and appropriate performance outcomes. Further investigations into muscle fiber alignment, muscle tone and muscle spasm are also warranted. Due to the insufficient research available and the anecdotal benefits of massage, this recovery technique should still be considered by athletes as a possible recovery tool.

Current Level of Scientific Knowledge:	LOW
Current Practice:	HIGH

SAUNA

Background

The number of athletes that utilise the sauna for purely recovery purposes (i.e. not for weight loss) varies around the world. European athletes tend to use the sauna more than Australian, US, UK and Asian athletes. Saunas are often used by athletes with the belief that saunas will induce perspiration (thereby decreasing levels of toxins in the blood), increase blood flow, and reduce muscle tension. Whilst in a sauna, cardiovascular liability is increased as a result of peripheral vasodilatation and the shunting of blood to the periphery during exposure to high ambient temperatures, and as a result heart rate is increased and blood pressure responses can be variable (65).

Research

There is very limited research examining the effects of heat exposure in a sauna on recovery from exercise. Only one investigation has examined the effect of increased temperature, through the use of sauna exposure, on performance (38). The results demonstrated that 30 minutes exposure in 65-75 °C and 15% relative humidity resulted in significant hemodynamic stress (increased blood pressure and heart rate). Additionally, heat exposure was detrimental to muscular endurance, with muscular strength and power showing varying results (38).

Current Level of Scientific Knowledge:	LOW
Current Practice:	LOW

SLEEP

Background

The relationship between sleep, recovery, and enhanced athletic performance is increasing in interest as the understanding of the function of sleep improves. A range of cognitive impairments and metabolic, immunologic and physiologic processes are negatively affected by sleep deprivation (70).

Although there is almost no scientific evidence to support the role of sleep in enhancing recovery, elite athletes and coaches often identify sleep as a vital component of the recovery process. In a recent study, athletes and coaches ranked sleep as the most prominent problem when they were asked about the causes of fatigue/tiredness (31). Sleep characteristics ranked first when athletes were asked about the aspects of the clinical history that they thought were important.

Research

The Effect of Altered Sleep on Performance in Athletes

Sleep Deprivation

There are a limited number of studies which have examined the effects of sleep deprivation on athletic performance. From the available data it appears that two phenomena exist. Firstly, the sleep deprivation must be greater than 30 hr to have an impact on performance and secondly, that sustained or repeated bouts of exercise are affected to a greater degree than one-off maximal efforts (11,69).

Souissi et al. (75) measured maximal power, peak power and mean power pre and post 24 and 36 hr of sleep deprivation. Up to 24 hr of waking, anaerobic power variables were not affected; however, they were impaired after 36 hr without sleep. Bulbulian et al. (16) examined knee extension and flexion peak torque before and after 30 hr of sleep deprivation in trained men. Isokinetic performance decreased significantly following sleep deprivation. In support of the contention that the effects of sleep deprivation are task specific, Takeuchi et al. (78) reported that 64 hr of sleep deprivation significantly reduced vertical jump performance and isokinetic knee extension strength, however isometric strength and 40 m sprint performance were unaffected.

While the above studies provide some insight into the relationship between sleep deprivation and performance, most athletes are more likely to experience acute bouts of partial sleep deprivation where sleep is reduced for several hours of consecutive nights.

Partial Sleep Deprivation

A small number of studies have examined the effect of partial sleep deprivation on athletic performance. Reilly and Deykin (66) reported decrements in a range of psychomotor functions after only one night of restricted sleep, however gross motor function such as muscle strength, lung power and endurance running were unaffected. Reilly and Hayles (67) reported similar effects in females following partial sleep deprivation, with gross motor functions being less affected by sleep loss than tasks requiring fast reaction times. From the available research it appears that sub-maximal prolonged tasks may be more affected than maximal efforts particularly for the first two nights of partial sleep deprivation (68).

From the available literature it appears that performance in maximal efforts may be unaffected by partial sleep deprivation, however repeated sub-maximal efforts may be reduced.

Reilly and Percy (68) found a significant effect of sleep loss on maximal bench press, leg press and dead lifts, but not maximal bicep curl. Sub-maximal performance however, was significantly affected on all four tasks and to a greater degree than maximal efforts. The greatest impairments were found later in the protocol, suggested an accumulative effect of fatigue from sleep loss.

Napping

Athletes suffering from some degree of sleep loss may benefit from a brief nap, particularly if a training session is to be completed in the afternoon or evening. Waterhouse et al. (86) are one of the only groups to investigate the effects of a lunchtime nap on sprint performance following partial sleep deprivation. Following a 30 min nap, 20 m sprint performance was increased (compared to no nap), alertness was increased, and sleepiness was decreased. Napping may be beneficial for athletes who have to routinely wake early for training or competition and for athletes who are experiencing sleep deprivation.

Extended Sleep

Another means of examining the effect of sleep on performance is to extend the amount of sleep an athlete receives and determine the effects on subsequent performance. Mah et al. (50) instructed six basketball players to obtain as much extra sleep as possible following two weeks or normal sleep habits. Faster sprint times and increased free-throw accuracy was observed at the end of the sleep extension period. Mood was also significantly altered, with increased vigour and decreased fatigue. The same research group also increased the sleep time of swimmers to 10 hr per night for 6-7 weeks. Following this time 15 m sprint, reaction time, turn time, and mood all improved. The data from these small studies suggest that increasing the amount of sleep an athlete receives, may significantly enhance performance.

Possible Mechanisms

A link between sleep deprivation and impaired neuroendocrine and immune function (8) has been proposed as a number of critical metabolism and immune processes are known to occur during different stages of sleep. Daytime napping has recently been shown to result in beneficial changes in cortisol and interleukin-6, which are associated with inflammation. The neuroendocrine and immune systems are thought to be highly involved in fatigue the overtraining syndrome (36) and thus a relationship between fatigue, sleep and underperformance most likely exists.

Practical Recommendations

- Maintain a regular sleep-wake cycle/routine
- Create a comfortable, quiet, dark and temperature-controlled bedroom
- Avoid alcohol, caffeine, large meals and large volumes of fluid prior to bedtime
- Skin warming/core cooling- through hydrotherapy or warm baths and cold fluid ingestion
- Utilise a ‘to-do’ list or diary to ensure organisation and unnecessary over-thinking whilst trying to sleep
- Investigate relaxation/breathing techniques

Current Level of Scientific Knowledge:	LOW
Current Practice:	N/A

STRETCHING

Background

Stretching is one of the most commonly used recovery interventions post training. However, there is limited efficacy for the use of this modality in enhancing recovery immediately post-exercise (the benefits of stretching at other times i.e. pre-exercise and for other purposes i.e. increased range of motion will not be discussed in this review). The rationale for stretching during the recovery period is not clear, however a number of theories exist: to reduce muscle soreness and stiffness, to prevent injury and to relax the muscle.

Research

The majority of research has focused on the effects of static research on the signs and symptoms of DOMS. Jayaraman et al. (42) examined the effects of static stretching and/or heat application on 32 untrained male subjects following eccentric knee extension exercise. This group used strength testing, pain ratings and multi-echo magnetic resonance imaging (MRI) to examine the recovery of the thigh muscle. Both static stretching and heat application occurred 36 hours post-exercise to avoid any detrimental effects during the acute injury phase. The stretching treatment consisted of standing quadriceps, prone quadriceps, standing hamstring, seated hamstring, standing calf and wall squat stretch. Results from the study demonstrated that neither heat application nor static stretching increased muscle recovery (indicated by changes in MRI). Additionally, there were no differences between treatments and control for swelling, pain and recovery of strength. The authors concluded that the data from the MRI technique indicated that static stretching did not increased recovery of damaged muscle fibres after eccentric exercise and that the prescription of static stretching will not enhance recovery after eccentric exercise.

Similar results have been reported in studies examining the effects of post-exercise stretching on signs and symptoms of DOMS (18,53,90). Each of these studies reported no effect of static stretching on enhancing recovery. However, two early studies both reported a reduction in pain sensation following static stretching after eccentric exercise (1,24).

One study has compared static stretching, active recovery and passive recovery following fatiguing leg extension and leg flexion (57). Subjects performed three sets of leg extension and leg flexion at 50% MVC, where each set was to failure. A 5 min recovery period was applied isometric knee extension was performed to fatigue. In the 5 min recovery period, subjects either rested passively, performed light cycling at 10 W or performed isometric quadriceps femoris contraction against resistance (applied by a physiotherapist). Subjects were then asked to perform an isometric knee extension at 50% MVC until fatigue. The results suggest that the most effective strategy was active recovery. Subsequent MVC's were significantly greater in the trial where active recovery was performed in comparison to stretching or passive recovery.

In summary, there is no evidence to date to suggest that stretching immediately post-exercise enhances the recovery of performance; however, there is also no evidence to suggest there is a detrimental effect. A very small amount of evidence suggests that stretching may reduce the sensation of pain after eccentric exercise.

Current Level of Scientific Knowledge:	LOW
Current Practice:	HIGH

OTHER RECOVERY ELEMENTS

While this review does not extend beyond primarily common physical recovery interventions, additional practices (such as nutritional and psychological recovery tools) are important to ensure maximal physiological and psychological recovery.

EXAMPLES OF PRACTICAL APPLICATION

From a recovery perspective, sporting competitions provide many unique challenges, often resulting in recovery becoming a blend between recovery science and practicality. This section of the review provides typical real-life scenarios to illustrate some potential difficulties with prescribing and implementing recovery during sporting competitions and offers practical guidance and suggestion to counteract these challenges.

Competition Scenario:

Rugby Sevens Tournament – Day 1

A normal Rugby Seven's match consists of two halves of seven minutes with a one minute half-time break. Typically, athletes are required to play three matches in a day with the time between the completion of one game and the start of the next varying between 90-150 min.

Possible Post-Game Recovery Session:

- Active Recovery (5-10 min at a low intensity)
    - Cycle Ergometer
- Static stretching
    - Objective of static stretching is to return recruited muscles to resting length not to gain flexibility
    - Recommendation: 10-15 sec holds repeated 2-3 times on major muscle groups recruited during competition
- Nutritional strategies (beyond the scope of this review)
- Cold Water immersion
    - 5-6 x (1 min cold: 1 min out)
- Compression
    - Wear full length compression tights or medical grade compression socks

Guidelines

Recovery Interventions

Compression

- Wear compression garment immediately post cold water immersion; continue to wear for as long as possible, removing prior to the warm up of next game.
- Following the final game of the day, wear compression garment for the remainder of the day or right through until the following morning.

Cold Water Immersion

- Optimal temperature 12-15°C
- Where possible utilise full body immersion
- Complete post-game shower before cold water immersion session
- Ensure that cold water immersion is completed 70 min before the start of the next game

Active Recovery / Static Stretching

- Strictly low intensity
- For recovery, the primary purpose of post-exercise static stretching is to relax the muscle, as opposed to gain flexibility.

Despite a number of different methods available to improve recovery and subsequent performance, under competitive circumstances resource availability and space restrictions may limit and hence dictate recovery interventions that can be utilised post-game. Furthermore, competing teams are often limited to how long they can remain in the change rooms post-game; sometimes this can be as minimal as 25 min.

Challenge: Resource Availability/Space Limitations

In most circumstances accessibility to inflatable ice baths, chilling machines, pools and cycle ergometers is unlikely at competition venues. Importantly, rather than neglecting recovery altogether, consideration needs to be given to alternate resources which can achieve a similar outcome and still provide a competitive advantage.

Alternative resources for performing cold water immersion

- Showers
- Plastic tubs / wheelie bins managed with ice
- Neighboring facilities (swimming pool, ocean) or hotel facilities

Alternative for Active Recovery

- Incorporate active recovery/static stretching on field immediately post game

Challenge: Time Constraints

In comparison to conventional rugby union there are several variations in laws which apply to Rugby 7's. Most applicable to recovery and meeting demanding post- game time constraints are;

- Seven players per team on the field (instead of 15)
- Five substitutes, with only three interchanges

Therefore, only 10 players will accrue game time and quite possibly 5-7 players will play majority of the game.

It is possible to group players according to accumulated game time as this will allow focused recovery attention on players who spent most time on the field and have accumulated the most fatigue. Those players who have had minimal game time may participate in a more succinct recovery regime, allowing greater focus on recovery for the players who had the higher level of game participation. Managing recovery for a reduced number of athletes enables a speedier exit from the change rooms post-game. This is recommended when time restraints may hinder appropriate recovery for the entire group.

Practical Suggestion

ACCUMULATED GAME TIME		
0-5 min	**6-10 min**	**11-14 min**
Active Recovery	Active Recovery	Active Recovery
Static Stretching	Static Stretching	Static Stretching
Compression	Cold Water Immersion 3 x(1min cold:1min out)	Cold Water Immersion 5-6 x(1min cold:1min out)
	Compression	Compression

Competition Scenario Two

Tennis Tournament - Played in Heat

The stresses of physical exertion are often complicated by hot/humid environmental conditions. Tennis matches are often performed in extreme heat placing a heavy burden on the mechanisms that regulate body temperature. Although the body can effectively thermoregulate in neutral conditions, the mechanisms of thermoregulation can be inadequate when athletes are exposed to extreme conditions. Competing under such conditions necessitates specific post-competition recovery attention to dissipate the heat gained from the environment, along with the heat produced by the active muscles.

Post Match Suggestions

Purpose of Recovery Session

- Decrease core body temperature
- Decrease sweat rate
- Enhance thermal comfort
- Enhance onset of sleep
- Reduce sensations of pain and fatigue

Possible Protocols

- 10 min ice bath - full body
- 10 min pool / 5 min cold shower 25-28°
- 5 min cold shower - full body x 2
- 20-30 min pool / ocean - full body
- 3-5 min cold shower

Post Recovery Session

- Do not have a hot shower immediately post-recovery
- Dry off, put sufficient clothing on and try to stay in an air conditioned environment
- Maintain Hydration

Training Scenario

Training in preparation for elite sports performance consists of repetitive phases of high load strength and conditioning training and recovery. Intense training with inadequate and/or inappropriate recovery builds an accumulation of fatigue rather than optimal performance and adaptation. Importantly, athletes need to frequently undertake recovery during a training week to allow for adequate physiological and psychological restoration in order to achieve super-compensation and minimise the risks associated with overtraining.

Possible Post-Training Recovery Session:

- Active Recovery Options (5-10 min low intensity)
  - Cycle Ergometer
  - Whirlpool / Swimming Pool / Beach
  - Walking / Light Jogging

- Static stretching
  - Objective of static stretching is to return recruited muscles to resting length not to gain flexibility
  - Recommendation: 10-15 sec holds repeated 2-3 times on major muscle groups recruited during training session

- Contrast Water immersion Options
  - 1min Hot (38-40ºC): 1 min Cold (12-15 °C) - Repeat 7 times

    Or
  - 2min Hot (38-40ºC): 2 min Cold (12-15 °C) - Repeat 3-5 times

    Or
  - Contrast Shower - 1min Hot: 1 min Cold - Repeat 3-7 times

- Compression
  - Wear full length compression tights or medical grade compression socks

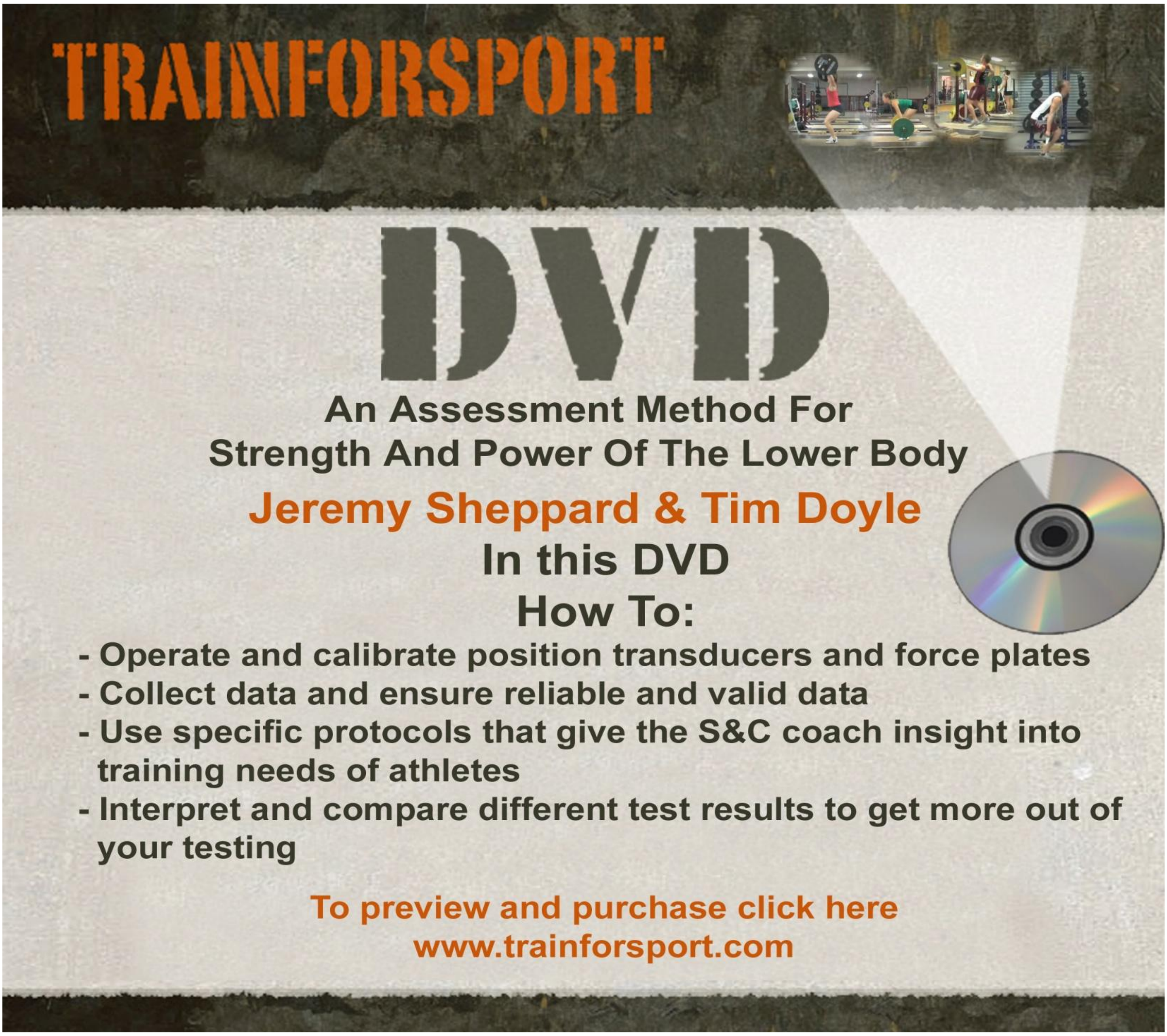
REFERENCES

1. Abraham, W.M. Factors in delayed muscle soreness. **Medicine and Science in Sports and Exercise**. 9: 11-20. 1977.
2. Agu, O., Baker, D. & Seifalian, A.M. Effect of graduated compression stockings on limb oxygenation and venous function during exercise in patients with venous insufficiency. **Vascular**. 12: 69-76. 2004.
3. Ahmaidi, S., Granier, P., Taoutaou, Z., Mercier, J., Dubouchaud, H. & Prefaut, C. Effects of active recovery on plasma lactate and anaerobic power following repeated intensive exercise. **Medicine and Science in Sports and Exercise.** 28: 450-6. 1996.
4. Ali, A., Caine, M.P. & Snow, B.G. Graduated compression stockings: physiological and perceptual responses during and after exercise. **Journal of Sports Sciences.** 25: 413-9. 2007.
5. Arroyo-Morales, M., Olea, N., Ruiz, C., del Castilo Jde, D., Martinez, M., Lorenzo, C. & Diaz-Rodriguez, L. Massage after exercise--responses of immunologic and endocrine markers: a randomized single-blind placebo-controlled study. **Journal of Strength and Conditioning Research**. 23: 638-44. 2009.
6. Bailey, D.M., Erith, S.J., Griffin, P.J., Dowson, A., Brewer, D.S., Gant, N. & Williams, C. Influence of cold-water immersion on indices of muscle damage following prolonged intermittent shuttle running. **Journal of Sports Sciences.** 25: 1163-70. 2007.
7. Barnett, A. Using recovery modalities between training sessions in elite athletes: does it help? **Sports Medicine**. 36: 781-96. 2006.
8. Basta, M., Chrousos, G.P., Vela-Bueno, A. & Vgontzas, A.N. Chronic Insomnia and Stress System. **Sleep Medicine Clinics**. 2: 279-291. 2007.
9. Berry, M.J. & McMurray, R.G. Effects of graduated compression stockings on blood lactate following an exhaustive bout of exercise. **American Journal of Physical Medicine**. 66: 121-32. 1987.
10. Best, T.M., Hunter, R., Wilcox, A. & Haq, F. Effectiveness of sports massage for recovery of skeletal muscle from strenuous exercise. **Clinical Journal of Sport Medicine.** 18: 446-60. 2008.
11. Blumert, P.A., Crum, A.J., Ernsting, M., Volek, J.S., Hollander, D.B., Haff, E.E. & Haff, G.G. The acute effects of twenty-four hours of sleep loss on the performance of national-caliber male collegiate weightlifters. **Journal of Strength and Conditioning Research.** 21: 1146-54. 2007.
12. Bonde-Petersen, F., Schultz-Pedersen, L. & Dragsted, N. Peripheral and central blood flow in man during cold, thermoneutral, and hot water immersion. **Aviation, Space, and Environmental Medicine**. 63: 346-50. 1992.
13. Bringard, A., Denis, R., Belluye, N. & Perrey, S. Effects of compression tights on calf muscle oxygenation and venous pooling during quiet resting in supine and standing positions. **The Journal of Sports Medicine and Physical Fitness**. 46: 548-54. 2006.
14. Brooks, C.P., Woodruff, L.D., Wright, L.L. & Donatelli, R. The immediate effects of manual massage on power-grip performance after maximal exercise in healthy adults. **Journal of Alternative and Complementary Medicine**. 11: 1093-101. 2005.
15. Brukner, P. & Khan, K. **Clinical Sports Medicine**. Sydney: McGraw-Hill Book Company Australia Pty Limited, 1993.
16. Bulbulian, R., Heaney, J.H., Leake, C.N., Sucec, A.A. & Sjoholm, N.T. The effect of sleep deprivation and exercise load on isokinetic leg strength and endurance. **European Journal of Applied Physiology and Occupational Physiology.** 73: 273-7. 1996.
17. Burke, D.G., MacNeil, S.A., Holt, L.E., MacKinnon, N.C. & Rasmussen, R.L. The effect of hot or cold water immersion on isometric strength training. **Journal of Strength and Conditioning Research**. 14: 21-25. 2000.
18. Buroker, K. & Schwane, J. Does post exercise static stretching alleviate delayed muscle soreness? **The Physician and Sportsmedicine**. 17: 318-322. 1989.
19. Carter, R., 3rd, Wilson, T.E., Watenpaugh, D.E., Smith, M.L. & Crandall, C.G. Effects of mode of exercise recovery on thermoregulatory and cardiovascular responses. **Journal of Applied Physiology.** 93: 1918-24. 2002.
20. Coffey, V., Leveritt, M. & Gill, N. Effect of recovery modality on 4-hour repeated treadmill running performance and changes in physiological variables. **Journal of Science and Medicine in Sport**. 7: 1-10. 2004.
21. Cornelius, W.L., Ebrahim, K., Watson, J. & Hill, D.W. The effects of cold application and modified PNF stretching techniques on hip joint flexibility in college males. **Research Quarterly for Exercise and Sport.** 63: 311-4. 1992.
22. Dawson, B., Cow, S., Modra, S., Bishop, D. & Stewart, G. Effects of immediate post-game recovery procedures on muscle soreness, power and flexiblity levels over the next 48 hours. **Journal of Science and Medicine in Sport.** 8: 210-21. 2005.
23. Dawson, L., Dawson, K. & Tiidus, P.M. Evaluating the influence of massage on leg strength, swelling, and pain following a half marathon. **Journal of Science and Medicine in Sport** . 3: 37-43. 2004.
24. DeVries, H. Quantitative electromyographic investigation of the spasm theory of muscle pain. A**merican Journal of Physical Medicine**. 45: 119-134. 1966.
25. Drust, B., Atkinson, G., Gregson, W., French, D. & Binningsley, D. The effects of massage on intra muscular temperature in the vastus

lateralis in humans. International **Journal of Sports Medicine**. 24: 395-9. 2003.

26. Duffield, R. & Portus, M. Comparison of three types of full-body compression garments on throwing and repeat-sprint performance in cricket players. **British Journal of Sports Medicine**. 41: 409-14. 2007.
27. Duffield, R., Edge, J., Merrells, R., Hawke, E., Barnes, M., Simcock, D. & Gill, N. The effects of compression garments on intermittent exercise performance and recovery on consecutive days. **International Journal of Sports Physiology and Performance.** 3: 454-68. 2008.
28. Dupont, G., Moalla, W., Guinhouya, C., Ahmaidi, S. & Berthoin, S. Passive versus active recovery during high-intensity intermittent exercises. **Medicine and Science in Sports and Exercise.** 36: 302-8. 2004.
29. Enwemeka, C.S., Allen, C., Avila, P., Bina, J., Konrade, J. & Munns, S. Soft tissue thermodynamics before, during, and after cold pack therapy. **Medicine and Science in Sports and Exercise**. 34: 45-50. 2002.
30. Eston, R. & Peters, D. Effects of cold water immersion on the symptoms of exercise-induced muscle damage. **Journal of Sports Sciences.** 17: 231-8. 1999.
31. Fallon, K.E. Blood tests in tired elite athletes: expectations of athletes, coaches and sport science/sports medicine staff. **British Journal of Sports Medicine**. 41: 41-4. 2007.
32. Farr, T., Nottle, C., Nosaka, K. & Sacco, P. The effects of therapeutic massage on delayed onset muscle soreness and muscle function following downhill walking. **Journal of Science and Medicine in Sport.** 5: 297-306. 2002.
33. French, D.N., Thompson, K.G., Garland, S.W., Barnes, C.A., Portas, M.D., Hood, P.E. & Wilkes, G. The effects of contrast bathing and compression therapy on muscular performance. **Medicine and Science in Sports and Exercise.** 40: 1297-306. 2008.
34. Galloway, S.D. & Watt, J.M. Massage provision by physiotherapists at major athletics events between 1987 and 1998. **British Journal of Sports Medicine**. 38: 235-6. 2004.
35. Gill, N.D., Beaven, C.M. & Cook, C. Effectiveness of post-match recovery strategies in rugby players. **British Journal of Sports Medicine**. 40: 260-3. 2006.
36. Halson, S.L. & Jeukendrup, A.E. Does overtraining exist? An analysis of overreaching and overtraining research. **Sports Medicine**. 34: 967-81. 2004.
37. Hamlin, M.J. The effect of contrast temperature water therapy on repeated sprint performance. **Journal of Science and Medicine in Sport**. 10: 398-402. 2007.
38. Hedley, A.M., Climstein, M. & Hansen, R. The effects of acute heat exposure on muscular strength, muscular endurance, and muscular power in the euhydrated athlete. **Journal of Strength and Conditioning Research.** 16: 353-8. 2002.
39. Hemmings, B., Smith, M., Graydon, J. & Dyson, R. Effects of massage on physiological restoration, perceived recovery, and repeated sports performance. **British Journal of Sports Medicine.** 34: 109-14. 2000.
40. Higgins, D. & Kaminski, T.W. Contrast therapy does not cause fluctuations in human gastrocnemius. **Journal of Athletic Training.** 33: 336-340. 1998.
41. Hilbert, J.E., Sforzo, G.A. & Swensen, T. The effects of massage on delayed onset muscle soreness. **British Journal of Sports Medicine.** 37: 72-5. 2003.
42. Jayaraman, R.C., Reid, R.W., Foley, J.M., Prior, B.M., Dudley, G.A., Weingand, K.W. & Meyer, R.A. MRI evaluation of topical heat and static stretching as therapeutic modalities for the treatment of eccentric exercise-induced muscle damage. **European Journal of Applied Physiology**. 93: 30-8. 2004.
43. Jemni, M., Sands, W.A., Friemel, F. & Delamarche, P. Effect of active and passive recovery on blood lactate and performance during simulated competition in high level gymnasts. **Canadian Journal of Applied Physiology**. 28: 240-56. 2003.
44. Knight, K.L. & Londeree, B.R. Comparison of blood flow in the ankle of uninjured subjects during therapeutic applications of heat, cold, and exercise. **Medicine and Science in Sports and Exercise.** 12: 76-80. 1980.
45. Kraemer, W.J., Bush, J.A., Wickham, R.B., Denegar, C.R., Gomez, A.L., Gotshalk, A.L., Duncan, N.D., Volek, J.S., Newton, R.U., Putukian, M. & Sebastianelli, W.J. Continuous compression as an effective therapeutic intervention in treating eccentric-exercise-induced muscle soreness. **Journal of Sport Rehabilitation**. 10: 11-23. 2001.
46. Lane, K.N. & Wenger, H.A. Effect of selected recovery conditions on performance of repeated bouts of intermittent cycling separated by 24 hours. **Journal of Strength and Conditioning Research.** 18: 855-60. 2004.
47. Lee, D.T., Toner, M.M., McArdle, W.D., Vrabas, I.S. & Pandolf, K.B. Thermal and metabolic responses to cold-water immersion at knee, hip, and shoulder levels. **Journal of Applied Physiology**. 82: 1523-30. 1997.
48. Leivadi, S., Hernandez-Reif, M. & Field, T. massage therapy and relaxation effects on university dance students. **Journal of Dance Medicine and Science**. 3: 108-12. 1999.
49. Longworth, J.C. Psychophysiological effects of slow stroke back massage in normotensive females. **ANS. Advances in Nursing Science.** 4: 44-61. 1982.
50. Mah C, M.K., Dement W. The effect of extra sleep on mood and athletic performance amongst collegiate athletes. In: **Sleep**. Minneapolis Minnesota, 2007.
51. Mancinelli, C.A., Davis, D.S., Aboulhosn, L., Brady, M., Eisenhofer, J. & Foutty, S. The effects of massage on delayed onset muscle soreness and physical performance in female collegiate athletes. **Physical Therapy.** 7: 5-13. 2006.
52. McAinch, A.J., Febbraio, M.A., Parkin, J.M., Zhao, S., Tangalakis, K., Stojanovska, L. & Carey, M.F. Effect of active versus passive recovery on metabolism and performance during subsequent exercise. **International Journal of Sport Nutrition and Exercise Metabolism**. 14: 185-96. 2004.
53. McGlynn, G.H., Laughlin, N.T. & Rowe, V. Effect of electromyographic feedback and static stretching on artificially induced muscle soreness. **American Journal of Physical Medicine.** 58: 139-48. 1979.
54. Meeusen, R. & Lievens, P. The use of cryotherapy in sports injuries. **Sports Medicine**. 3: 398-414. 1986.
55. Merrick, M., Ranin, J., Andres, F. & Hinman, C. A preliminary examination of cryotherapy and secondary injury in skeletal muscle. **Medicine and Science in Sports and Exercise**. 31: 1516-21. 1999.
56. Merrick, M.A., Jutte, L.S. & Smith, M.E. Cold modalities with different thermodynamic properties produce different surface and intramuscular temperatures. **Journal of Athletic Training**. 38: 28-33. 2003.
57. Mika, A., Mika, P., Fernhall, B. & Unnithan, V.B. Comparison of recovery strategies on muscle performance after fatiguing exercise. **American Journal of Physical Medicine and Rehabilitation**. 86: 474-81. 2007.
58. Monedero, J. & Donne, B. Effect of recovery interventions on lactate removal and subsequent performance. **International Journal of Sports Medicine**. 21: 593-7. 2000.
59. Montgomery, P.G., Pyne, D.B., Hopkins, W.G., Dorman, J.C., Cook, K. & Minahan, C.L. The effect of recovery strategies on physical performance and cumulative fatigue in competitive basketball. **Journal of Sports Sciences**. 26: 1135-45. 2008.
60. Morelli, M., Seaborne, D.E. & Sullivan, S.J. Changes in h-reflex amplitude during massage of triceps surae in healthy subjects. **The Journal of Orthopaedic and Sports Physical Therapy.** 12: 55-9. 1990.
61. Morton, R.H. Contrast water immersion hastens plasma lactate decrease after intense anaerobic exercise. **Journal of Science and Medicine in Sport**. 10: 467-470. 2006.

62. Myrer, J.W., Draper, D.O. & Durrant, E. Contrast water therapy and intramuscular temperature in the human leg. **Journal of Athletic Training**. 29: 318-322. 1994.
63. Nordschow, M. & Bierman, W. The influence of manual massage on muscle relaxation: effect on trunk flexion. **Journal of the American Physical Therapy Association**. 42: 653-7. 1962.
64. Paddon-Jones, D.J. & Quigley, B.M. Effect of cryotherapy on muscle soreness and strength following eccentric exercise. **International Journal of Sports Medicine**. 18: 588-93. 1997.
65. Paolone, A.M., Lanigan, W.T., Lewis, R.R. & Goldstein, M.J. Effects of a postexercise sauna bath on ECG pattern and other physiologic variables. **Aviation, Space, and Environmental Medicine**. 51: 224-9. 1980.
66. Reilly, T. & Deykin, T. Effects of partial sleep loss on subjective states, psychomotor and physical performance tests. **Journal of Human Movement Studies.** 9: 157-170. 1983.
67. Reilly, T. & Hales, A., Effects of partial sleep deprivation on performance measures in females. In: **Contemporary Ergonomics**, E.D. McGraw, eds. Taylor and Francis: London, 1988. pp. 509-513.
68. Reilly, T. & Piercy, M. The effect of partial sleep deprivation on weight-lifting performance. **Ergonomics**. 37: 107-15. 1994.
69. Reilly, T. & Edwards, B. Altered sleep-wake cycles and physical performance in athletes. **Physiology and Behavior.** 90: 274-84. 2007.
70. Samuels, C. Sleep, recovery, and performance: the new frontier in high-performance athletics. **Neurologic Clinics.** 26: 169-80. 2008.
71. Sanders, J., **Effect of contrast-temperature immersion on recovery from short-duration intense exercise**. University of Canberra, 1996.
72. Sayers, S.P., Clarkson, P.M. & Lee, J. Activity and immobilization after eccentric exercise: I. Recovery of muscle function. **Medicine and Science in Sports and Exercise.** 32: 1587-92. 2000.
73. Sellwood, K.L., Brukner, P., Williams, D., Nicol, A. & Hinman, R. Ice-water immersion and delayed-onset muscle soreness: a randomised controlled trial. **British Journal of Sports Medicine.** 41: 392-7. 2007.
74. Shoemaker, J.K., Tiidus, P.M. & Mader, R. Failure of manual massage to alter limb blood flow: measures by Doppler ultrasound. **Medicine and Science in Sports and Exercise**. 29: 610-4. 1997.
75. Souissi, N., Sesboue, B., Gauthier, A., Larue, J. & Davenne, D. Effects of one night's sleep deprivation on anaerobic performance the following day. **European Journal of Applied Physiology.** 89: 359-66. 2003.
76. Sramek, P., Simeckova, M., Jansky, L., Savlikova, J. & Vybiral, S. Human physiological responses to immersion into water of different temperatures. **European Journal of Applied Physiology**. 81: 436-42. 2000.
77. Stanley, S., Purdam, C. & Bond, T. **Passive tension and stiffness properties of the ankle plantar flexors: the effects of massage.** In: XVIIIth Congress of the International Society of Biomechanics, Zurich. 2001.
78. Takeuchi, L., Davis, G.M., Plyley, M., Goode, R. & Shephard, R.J. Sleep deprivation, chronic exercise and muscular performance. **Ergonomics.** 28: 591-601. 1985.
79. Tiidus, P.M. & Shoemaker, J.K. Effleurage massage, muscle blood flow and long-term post-exercise strength recovery. **International Journal of Sports Medicine.** 16: 478-83. 1995.
80. Vaile, J., Gill, N. & Blazevich, A.J. The effect of contrast water therapy on symptoms of delayed onset muscle soreness (DOMS) and explosive athletic performance. **Journal of Strength and Conditioning Research**. 21: 697-702. 2007.
81. Vaile, J. & Gill, N. Hydrotherapy based recovery - latest research and practice. **Modern Athlete and Coach**. 46: 13-16. 2008.
82. Vaile, J., Halson, S., Gill, N. & Dawson, B. Effect of hydrotherapy on recovery from fatigue. **International Journal of Sports Medicine.** 29: 539-44. 2008.
83. Vaile, J., Halson, S., Gill, N. & Dawson, B. Effect of hydrotherapy on the signs and symptoms of delayed onset muscle soreness. **European Journal of Applied Physiology.** 102: 447-55. 2008.
84. Viitasalo, J.T., Niemela, K., Kaappola, R., Korjus, T., Levola, M., Mononen, H.V., Rusko, H.K. & Takala, T.E. Warm underwater water-jet massage improves recovery from intense physical exercise. **European Journal of Applied Physiology and Occupational Physiology.** 71: 431-8. 1995.
85. Washington, L.L., Gibson, S.J. & Helme, R.D. Age-related differences in the endogenous analgesic response to repeated cold water immersion in human volunteers. **Pain.** 89: 89-96. 2000.
86. Waterhouse, J., Atkinson, G., Edwards, B. & Reilly, T. The role of a short post-lunch nap in improving cognitive, motor, and sprint performance in participants with partial sleep deprivation. **Journal of Sports Sciences**. 25: 1557-66. 2007.
87. Watts, P.B., Daggett, M., Gallagher, P. & Wilkins, B. Metabolic response during sport rock climbing and the effects of active versus passive recovery. **International Journal of Sports Medicine.** 21: 185-90. 2000.
88. Weber, M.D., Servedio, F.J. & Woodall, W.R. The effects of three modalities on delayed onset muscle soreness. **The Journal of Orthopaedic and Sports Physical Therapy.** 20: 236-42. 1994.
89. Weerapong, P., Hume, P.A. & Kolt, G.S. The mechanisms of massage and effects on performance, muscle recovery and injury prevention. **Sports Medicine.** 35: 235-56. 2005.
90. Wessel, J. & Wan, A. Effect of stretching on the intesnity of delayed-onset muscle soreness. **Clinical Journal of Sport Medicine.** 4: 83-87. 1994.
91. Weston, C.F., O'Hare, J.P., Evans, J.M. & Corrall, R.J. Haemodynamic changes in man during immersion in water at different temperatures. **Clinical Science** (Lond). 73: 613-6. 1987.
92. Wiktorsson-Moller, M., Oberg, B., Ekstrand, J. & Gillquist, J. Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. **The American Journal of Sports Medicine.** 11: 249-52. 1983.
93. Wilcock, I.M., Cronin, J.B. & Hing, W.A. Physiological response to water immersion: a method for sport recovery? **Sports Medicine**. 36: 747-65. 2006.
94. Yamane, M., Teruya, H., Nakano, M., Ogai, R., Ohnishi, N. & Kosaka, M. Post-exercise leg and forearm flexor muscle cooling in humans attenuates endurance and resistance training effects on muscle performance and on circulatory adaptation. **European Journal of Applied Physiology.** 96: 572-80. 2006.
95. Yanagisawa, O., Kudo, H., Takahashi, N. & Yoshioka, H. Magnetic resonance imaging evaluation of cooling on blood flow and oedema in skeletal muscles after exercise. **European Journal of Applied Physiology**. 91: 737-40. 2004.
96. Yanagisawa, O., Homma, T., Okuwaki, T., Shimao, D. & Takahashi, H. Effects of cooling on human skin and skeletal muscle. **European Journal of Applied Physiology**. 100: 737-45. 2007.
97. Yeargin, S.W., Casa, D.J., McClung, J.M., Knight, J.C., Healey, J.C., Goss, P.J., Harvard, W.R. & Hipp, G.R. Body cooling between two bouts of exercise in the heat enhances subsequent performance. **Journal of Strength and Conditioning Research.** 20: 383-9. 2006.



ASCA PROFESSIONAL COACH'S ASSOCIATION

The aim of the ASCA Professional Coaching Structure is to provide a professional accreditation and recognition structure for strength and conditioning coaches within the ASCA.
There are five levels of competency within this structure as follows:

ASCA PSI (Professional Structure Intern)
ASCA PSG (Professional Structure Graduate)
ASCA PSP (Professional Structure Professional)
ASCA PSE (Professional Structure elite)
ASCA PSM (Professional Structure Master)

You can receive recognition through the ASCA Professional Coaching Structure by:
Completing the application form available from the ASCA website. www.strengthandconditioning.org
Then gather all relevant supporting documentation and send it along with the application and fee payment to the ASCA National office. The ASCA Assessment Panel will review the applications, and a judgment will be made as to whether the applicant wholly or partially meets the requirements. The applicant will then be notified of their success or in the case of a partial completion of the competencies; the panel will outline these and advise how to successfully complete them to receive recognition.