Journal of Strength and Conditioning Research Publish Ahead of Print
DOI: 10.1519/JSC.0000000000000417

TITLE

Influence of Contrast Shower and Water Immersion on Recovery in Elite Netballers

AUTHORS

Laura E. Juliff[1,2,3], Shona L. Halson[1], Darrell L. Bonetti[3], Nathan G. Versey[1], Matthew W. Driller[1] and Jeremiah J. Peiffer[2]

1. Performance Recovery, Australian Institute of Sport, Belconnen, Australian Capital Territory, Australia
2. School of Psychology and Exercise Science, Murdoch University, Western Australia. Australia
3. Physiology, Australian Institute of Sport, Belconnen, Australian Capital Territory, Australia

CORRESPONDING AUTHOR

Dr. Jeremiah Peiffer

Senior Lecturer – Exercise Science

Murdoch University

90 South Street, Murdoch, Western Australia 6150

Email: j.peiffer@murdoch.edu.au

Phone: +61 089360 7603

RUNNING HEADER

Contrast showers and performance

DISCLOSURE OF FUNDING

None

ABSTRACT

Contrast water therapy is a popular recovery modality in sport; however, appropriate facilities can often be difficult to access. Therefore, the present study examined the use of contrast showers as an alternative to contrast water therapy for team sport recovery. In a randomized, cross-over design ten elite female netball athletes (mean ± SD; age: 20 ± 0.6 y, height: 1.82 ± 0.05 m, body mass: 77.0 ± 9.3 kg) completed three experimental trials of a netball specific circuit followed by one of the following 14 min recovery interventions; (1) contrast water therapy (alternating 1 min 38^{o}C and 1 min 15^{o}C water immersion), (2) contrast showers (alternating 1 min 38^{o}C and 1 min 18^{o}C showers) or (3) passive recovery (seated rest in 20^{o}C). Repeated agility, skin and core temperature and perception scales were measured pre, immediately post, 5 h and 24 h post-exercise. No significant differences in repeated agility were evident between conditions at any time point. No significant differences in core temperature were observed between conditions however, skin temperature was significantly lower immediately after contrast water therapy and contrast showers compared with the passive condition. Overall perceptions of recovery were superior following contrast water therapy and contrast showers compared with passive recovery. The findings indicate contrast water therapy and contrast showers did not accelerate physical recovery in elite netballers after a netball specific circuit; however, the psychological benefit from both interventions should be considered when determining the suitability of these recovery interventions in team sport.

Key words

Hydrotherapy, team sport, performance, core temperature, fatigue

INTRODUCTION

The professionalization of sport allows elite athletes to perform a greater volume of training and competition thus, resulting in the need for recovery strategies to enable athletes to cope with increased training load (27). In addition, sports which incorporate tournament style competitions provide a challenge for athletes to recover adequately before the next exercise bout (4). Hydrotherapy, specifically cold water immersion, can enhance recovery following both simulated and actual team-sport competition(9). Recently, Webb et al. (31) observed enhanced recovery in rugby union players following contrast water therapy (alternating hot and cold water immersion). The use of contrast water therapy has also been shown to benefit athletic recovery as evidenced by improved cycling sprint and time-trial performances (28), decreases in rating of perceived exertion and muscle soreness (13) and reductions in localized edema (26). Furthermore, Vaile et al. (26) observed the restoration of dynamic power and isometric force after contrast water therapy in individuals who completed a delayed onset muscle soreness inducing leg press protocol. These findings have increased the popularity of this recovery modality in sport (5); yet, access to facilities can be difficult, specifically when athletes are travelling. Most sporting venues allow athletes access to shower facilities, providing a possible alternative to contrast water therapy through the use of contrast showers (alternating hot and cold showers). To the authors' knowledge, no studies have examined the recovery benefits of contrast showers on athletic performance despite athletes anecdotally using showers as a form of recovery.

The sport of netball is played worldwide with an estimated 20 million participants and is characterized as a fast moving team-sport placing high physical demands on players through repeated jumps, lunges and rapid accelerations and decelerations (13,22).

Furthermore, elite netballers can be required to train or compete multiple times per day in tournament style competitions resulting in large demands placed upon the cardiovascular, metabolic, immune and musculoskeletal systems (13). In order for athletes to cope with these demands, appropriate recovery is essential which has led many teams to adopt some form of recovery strategy. In a recent survey of New Zealand sporting teams, 100% of elite New Zealand netball teams reported using contrast water therapy as their recovery modality of choice (12). When coupled with the large travel commitments associated with many elite netball teams, it is likely that the development of alternative contrast water modalities is necessary. The purpose of the present study was to examine the influence of contrast showers and contrast water therapy on recovery following a netball specific exercise circuit. The findings could provide a viable alternative for coaches, athletes and strength and conditioning specialists who wish to use contrast water therapy as a recovery modality; yet, are limited by available facilities.

METHODS

Experimental Approach to the Problem

To determine the recovery benefits of contrast water therapy and contrast showers in elite level netballers, this study examined the influence of three recovery conditions (passive, contrast water therapy and contrast showers) on performance (repeated agility), physiological variables (core and skin temperature and heart rate) as well as perceptions of effectiveness at three time points (acute, delayed and 24 h) after a netball specific exercise circuit. Data collection was conducted in a pragmatic manner as participants were currently visiting our laboratory setting to complete a pre-season training camp. Consequently, repeated agility was

selected as the only performance variable due to its use within netball as a key performance test and its strong association with the physical demands of the sport. The study was conducted using a cross-over design in which all participants completed each of the three recovery conditions on different days. The order of conditions was randomized for each participant to avoid any order effects which could bias the data.

Subjects

Ten elite female netball athletes (mean ± SD; age: 20 ± 1 y (range: 18.5 y to 20.7 y), height: 1.82 ± 0.05 m and body mass: 77.0 ± 9.3 kg) volunteered to participate in this study. All participants were Australian representative netballers at either under 19 or under 21 age level and were in pre-season training. The sample size selected for this study was based on a sample of convenience as all participants were attending the laboratory settings as part of a pre-season training camp. Prior to data collection, participants were provided with written documentation of the risks and benefits of participation in the study and signed a document of informed consent. Ethical approval was obtained from the Murdoch University Human Ethics Committee (#2011/015) and the Australian Institute of Sports Human Ethics Committee (#20010206).

Procedures

This study required participants to complete five separate sessions: two familiarization sessions of the netball circuit to limit any learning or training effects, and three experimental testing sessions, during a four week period. All experimental and familiarization sessions were conducted in controlled conditions (indoor netball courts and recovery facilities),

separated by a minimum of two days and were completed at a similar time of day (± 1 h) to control for circadian variability (23). Training workloads prescribed by coaching staff were identical between sessions. Twenty-four hours prior to testing, participants were asked to refrain from caffeine and alcohol consumption and to ingest a similar diet. All participants were familiar with the performance test protocols and recovery techniques used in this study.

Six hours prior to the start of each experimental trial, participants ingested a core temperature pill (CorTemp® HT150002, HQ, Florida, USA). Upon arrival at the netball courts, participants were fitted with a heart rate monitor (Heart Rate Team Pack, Suunto, Vantaa, Finland) and skin temperature sensors (iButton®, Embedded Data Systems, California, USA) to four sites of the body; chest, arm, thigh and calf and completed baseline psychometric measures. Participants then commenced the exercise session (approximately 08:45) with a standardized 15 min warm-up, which consisted of running drills, dynamic stretches and a series of sprints and jumps. Immediately after warm-up, participants completed the baseline repeated agility test and commenced the 15 min simulated netball circuit. Immediately following the simulated netball circuit, agility and psychometric measures were repeated, followed 20 min later by one of three designated recovery intervention (passive recovery, contrast water therapy or contrast showers). Ten minutes after completion of the recovery intervention, participants returned to the netball courts for repeated agility and psychometric measures (acute) after which they completed these tests again at 16:00 (delayed) and 09:00 the next day (24 h) in order to replicate a typical training day for the athletes.

All recovery conditions were 14 min in duration as this is consistent with previous contrast water therapy research (2,30). During the passive recovery condition, participants

remained seated with minimal movement in a temperature controlled room (20.0°C ± 0.7°C). The contrast water therapy condition consisted of participants alternating between hot (38.0°C ± 0.4°C) and cold water (15.0°C ± 0.3°C) full body immersion (excluding head and neck; starting with hot immersion) every minute with a five second transfer time between water baths. Water temperatures were controlled using a water tank and heater/chiller pump system custom built as part of the Australian Institute of Sport Recovery Center. Within the current contrast water therapy literature, a multitude of temperatures and durations have been employed (2,30). The choice of temperature and duration selected for this recovery intervention is consistent with previous contrast water therapy research within our laboratory (26,28,29). During the contrast showers, participants started with exposure to the hot shower (38.0°C ± 1.2°C) and alternated between hot and cold showers (18.0°C ± 0.4°C) every minute. Participants immersed their entire body including head under the shower. Participants were required to alternate between two showers (one hot and one cold) in order to eliminate the need to adjust water temperatures. The temperature of the cold shower represented the coldest water available from a standard tap within the recovery center. During all water based recovery interventions, water temperature was continuously monitored (1Hz) using an iButton temperature sensor.

The netball specific circuit used in this study was modified from Higgins et al.(10) and comprised of five stations spanning the length of the netball court separated by 3.5 m. A 'lap' was characterized by running through each station over the length of the court and jogging back in 30 s. The stations were comprised of movements such as short explosive sprints, agility, jumps and backward and sideways movements. The completion of one circuit involved five laps of the stations in 150 s (30 s per lap) followed by 30 s to complete five maximal counter movement jumps with any remaining time provided as rest. Two up and

back sprints from baseline to baseline were then completed in 24 s, followed immediately by 10 netball chest passes at a wall. Five minutes were allocated to complete one circuit. This circuit was completed three times, totaling 15 min.

The repeated agility test was used as the measure of physical performance and was selected as it represents a measure consistent with the primary physical demands of the sport. Participants were required to start from a stationary position and maneuver in and out of a series of five poles 2.5 m apart (21). The test was performed four times with participants starting every 20 s. The total time of each run was measured by dual beam electronic timing gates (Speedlight TT, Swift Performance Equipment, Wacol, Australia). The laboratory coefficient of variation for the repeated agility test is 1.2%.

Throughout the netball circuit mean and maximum heart rates were recorded. Core and skin temperature were recorded at baseline, post warm-up, post-exercise, prior to recovery as well as immediately and 20 min post-recovery. Mean skin temperature (T_{skin}) was calculated using the following equation derived by Ramanathan(19):

$$T_{skin} = 0.3 \times (T_{chest} + T_{arm}) + 0.2 \times (T_{thigh} + T_{leg})$$

Rating of perceived exertion was measured immediately following the netball specific exercise using the Borg scale (3). In addition, perceptions of fatigue were assessed at baseline, post-exercise, immediately post-recovery, and at both the delayed and 24 h time-point using a 10 point Likert scale (1 = no fatigue and 10 = extreme fatigue) (3). To determine participants' perception of the efficacy of each recovery modality, a pre- and post-intervention questionnaire was employed. Prior to recovery, participants were asked "Do you believe the

post-exercise recovery modality will accelerate your recovery in this trial?". Immediately post-recovery participants were asked "Do you believe the post-exercise recovery modality has accelerated your recovery in this trial?". Participants answered on a visual analogue scale (100 mm in length) with strongly agree (0 mm) and disagree (100 mm) at each end.

Statistical Analyses

Differences in performance, psychometric and physiological measures between conditions over time were determined using a linear mixed model analysis. Significant main effects or interactions were analyzed using an adjusted Fisher LSD post-hoc analysis. The results of the efficacy questions were analyzed using a one-way ANOVA to test for differences within the three recovery conditions. A pre-post t-test was conducted to analyze differences within each recovery intervention. All statistical analysis was conducted using a SPSS statistical software package (SPSS Statistics v.21, IBM) with the level of significance set to $p<0.05$. All data are presented as means ± standard deviations.

RESULTS

No significant differences were observed for mean heart rate during the netball specific exercise circuit between the contrast water therapy (180 ± 8 bpm), contrast showers (181 ± 7 bpm) or passive (182 ± 8 bpm) recovery conditions. Similarly, no significant differences were observed for rating of perceived exertion during the netball specific exercise in the contrast water therapy (18 ± 2 units), contrast showers (18 ± 1 units) and passive (19 ± 1 units) recovery conditions.

A main effect for time was observed for the repeated agility test. In all conditions, immediately after the netball specific exercise, repeated agility times were slower when compared with all other time points (Figure 1).

Figure 1 about here

There was a significant interaction between conditions for skin temperature at the immediately post and 20 min post-recovery time-points with a greater mean skin temperature in the passive condition (31.2 ± 1.1^{o}C and 30.6 ± 0.8^{o}C; respectively) when compared with contrast showers (27.4 ± 1.5^{o}C and 25.4 ± 1.7^{o}C; respectively) and contrast water therapy (24.6 ± 2.3^{o}C and 24.9 ± 1.4^{o}C; respectively) (Figure 2). No significant differences between recovery interventions were observed for core temperature. Regardless, the absolute magnitude of change in core temperature measured from immediately to 20 min post-recovery was greater after contrast water therapy (-0.3 ± 0.2^{o}C) and contrast showers (-0.4 ± 0.2^{o}C) compared with the passive (-0.1 ± 0.1^{o}C) condition.

Figure 2 about here

Participants' perceptions of fatigue are displayed in Table 1. A main effect for condition and time was observed for the fatigue measures with greater fatigue reported in the passive compared with the contrast water therapy conditions. Furthermore, in all conditions perceived fatigue was lower at baseline and 24 h compared with all other time-points; however, no differences were noted between conditions at any time-points. Perceived effectiveness before the recovery intervention was greater for contrast water therapy (20 ± 15) compared with contrast showers (47 ± 15) and passive (69 ± 11) conditions. After recovery,

participants perceived contrast water therapy (19 ± 14) and contrast showers (18 ± 13) to provide superior recovery benefits compared with the passive (73 ± 14) condition. A change in positive perception pre- to post-recovery intervention was observed for contrast showers only.

Table 1 about here

DISCUSSION

This study examined the influence of contrast water therapy and contrast showers on recovery following a netball specific exercise circuit in elite netballers. The main findings were; 1) despite inducing fatigue following the netball specific exercise circuit in all conditions, no performance differences were noted between recovery conditions at any time-point, 2) core temperature was not different between conditions at any time-point, although greater heat removal was observed in both water recovery conditions compared with control from immediately to 20 min post-recovery, 3) overall positive perceptions of recovery were observed following contrast water therapy and contrast showers compared with passive recovery, and 4) participants' perceptions of contrast showers changed positively pre- to post-intervention.

The use of either contrast water therapy or contrast showers after the netball specific exercise did not enhance the recovery of performance in comparison with the control condition (Figure 1). Our findings are similar to previous contrast water therapy research (6,13) during which an inability to induce adequate fatigue was suggested as the rational for the null findings. We do not believe this to be the reason for our findings as post-exercise

increases in agility times indicate fatigue. Furthermore, this netball specific circuit has previously shown to induce a high level of fatigue (10). Contrast water therapy is associated with a reduction of delayed onset muscle soreness following some team sports (e.g. rugby) which has been suggested to indicate recovery (31). It is possible in this study, although not measured; that muscle damage may have been minimal which would have limited the efficacy of our recovery interventions. Furthermore, current literature indicates contrast water therapy can enhance recovery following team sport activity; however, this was only observed greater than 24 h after the intervention (31). As the present study ceased measures at 24 h in order to determine the suitability of each recovery intervention in relation to normal netball competition demands, it is possible any recovery benefit may have been missed. In the absence of performance changes following either recovery intervention, we suggest future research is warranted to examine the use of contrast water therapy and contrast showers in netballers after actual competition as well as repeated performance assessments more than 24 h following exercise (11,28).

To the authors' knowledge, this is the first study to examine differences in core and skin temperature responses to both contrast water therapy and contrast showers. Regardless of the difference in the temperature of the cold water used during the contrast water therapy ($15.0^{o}C \pm 0.3^{o}C$) and contrast showers ($18.0^{o}C \pm 0.4^{o}C$); no differences were observed in core temperature between modalities (Figure 2b). This finding is not surprising as Proulx et al. (18) have reported similar core temperatures during post-exercise cold water immersion in water ranging 8 - $20^{o}C$. Consistent with previous research (15,16,25) this study's findings are likely a product of peripheral blood vessel vasoconstriction (16,28) upon cold water exposure limiting blood contact with the cooler periphery. While not observed during the recovery interventions, we did observe a delayed cooling response in contrast showers and contrast

water therapy from post-recovery to 20 min post-recovery compared with the passive condition. Versey et al. (28) observed a delayed cooling response in eleven trained male cyclists who completed a contrast water therapy intervention (alternating 1 min hot; 38°C, 1 min cold; 15°C for 6, 12 and 18 min) following a 75 min cycling protocol (28). This delayed cooling can be explained by the 'afterdrop' phenomena(1), the removal of core body heat after exposure to cold conditions due to sustained peripheral muscle cooling after rewarming.

It should be acknowledged that fatigue is a multi-dimensional phenomena (1,14) consistent with both physiological and psychological changes which can influence athletic performance (1). In this respect, the efficacy of recovery techniques should be evaluated at both a physiological and psychological level. It is possible for athletes who feel less pain and muscle soreness to have a heightened sense of well-being following recovery and perform better (20). For this reason, the placebo effect can have significant influence on the success of a recovery intervention (7,17). Our participants perceived both the contrast water therapy (19 ± 14) and contrast showers (18 ± 13) to accelerate recovery when compared to the passive condition (73 ± 14). These findings are likely due to the change in skin temperature associated with both water interventions (Figure 2a) as skin temperature is an integral component of a human's perception of fatigue and comfort (8,24). An individual's comfort level is shown to improve when the environment allows the return of body temperature toward homeostasis (8). Compared with the contrast water therapy conditions, a perceptual change was observed pre- to post-intervention for contrast showers. The noted change in perception further indicates the influence of skin temperature on perception, while the difference between conditions is likely due to prior exposure. The current group of participants had routinely been exposed to contrast water therapy, thus influencing the perceived benefit; however, contrast showers

were not as customary, therefore perceptions of this modality changed only after the initial exposure.

In conclusion, the current study provides novel information regarding contrast showers as a recovery modality and its comparison to contrast water therapy in a simulated team-sport setting. While no improvements in performance were observed, contrast water therapy and contrast showers resulted in accelerated skin cooling and greater perceptions of recovery. With the continued use of contrast water therapy and possible use of contrast showers in netball, future research is needed to determine the efficacy of these modalities using extended monitoring periods and competition scenarios.

PRACTICAL APPLICATIONS

The large physical demands placed on athletes during both training and competitions compel coaches and strength and conditioning specialists to provide the most appropriate recovery strategies to increase the chance of their athletes' success. Past research indicates contrast water therapy can be an effective recovery modality in a range of sports; yet, practitioners may be limited in the ability to provide this modality due to facilities and logistics. Findings from this study showed 14 min of contrast showers (alternating hot and cold each minute) used immediately after netball training provided a similar perception of enhanced recovery when compared with contrast water therapy. While neither modality resulted in enhanced physical recovery compared with the control condition, we would suggest the psychological benefits observed could lead to greater athletic success in some circumstances. With the increasing use of contrast water therapy as a recovery modality in

team and individual sport, we propose contrast showers could provide a more practical alternative due to the availability of shower facilities at most sporting events.

ACKNOWLEDGMENTS

We express our thanks to the all the participants for their participation in the study and coaching staff for their cooperation during the study.

None of the authors of this manuscript have any professional relationships with companies or manufacturers who would benefit from the results of the present study.

REFERENCES

1 Abbiss, CR, Laursen, PB. Models to explain fatigue during prolonged endurance cycling. Sports Med 35: 461-465, 2005.

2 Bieuzen, F, Bleakley, CM, Costello, JT. Contrast water therapy and exercise induced muscle damage: a systematic review and meta-analysis. PLoS One 8: e62356, 2013.

3 Borg, G. Borg's perceived exertion and pain scales: Human Kinetics; 1998

4 Buchheit, M, Horobeanu, C, Mendez-Villanueva, A, Simpson, B, Bourdon, P. Effects of age and spa treatment on match running performance over two consecutive games in highly trained young soccer players. J Sports Sci 29: 591-598, 2011.

5 Cochrane, DJ. Alternating hot and cold water immersion for athlete recovery: a review. Phys Ther Sport 5: 26-32, 2004.

6 Coffey, V, Leveritt, M, Gill, N. Effect of recovery modality on 4-hour repeated treadmill running performance and changes in physiological variables. J Sci Med Sport 7: 1-10, 2004.

7 Finberg, M, Braham, R, Goodman, C, Gregory, P, Peeling, P. Effects of electrostimulation therapy on recovery from acute team-sport activity. Int J Sports Physiol Perform 8: 293-299, 2013.

8 Flouris, AD. Functional architecture of behavioural thermoregulation. Eur J Appl Physiol 111: 1-8, 2011.

9 Higgins, T, Cameron, ML, Climstein, M. Acute response to hydrotherapy after a simulated game of rugby. J Strength Cond Res 27: 2851-2860, 2013.

10 Higgins, T, Naughton, GA, Burgess, D. Effects of wearing compression garments on physiological and performance measures in a simulated game-specific circuit for netball. J Sci Med Sport 12: 223-226, 2009.

11 Higgins, TR, Heazlewood, I, Climstein, M. A random control trial of contrast baths and ice baths for recovery during competition in U/20 rugby union. J Strength Cond Res 25: 1046-1051, 2011.

12 Hing, W, White, SG, Lee, P, Boouaphone, A. The use of contrast therapy recovery within the New Zealand elite sports setting. NZJSM 37: 8-11, 2010.

13 King, M, Duffield, R. The effects of recovery interventions on consecutive days of intermittent sprint exercise. J Strength Cond Res 23: 1795-1802, 2009.

14 Knicker, AJ, Renshaw, I, Oldham, AR, Cairns, SP. Interactive processes link the multiple symptoms of fatigue in sport competition. Sports Med 41: 307-328, 2011.

15 Peiffer, JJ, Abbiss, CR, Nosaka, K, Peake, JM, Laursen, PB. Effect of cold water immersion after exercise in the heat on muscle function, body temperatures, and vessel diameter. J Sci Med Sport 12: 91-96, 2009.

16 Peiffer, JJ, Abbiss, CR, Watson, G, Nosaka, K, Laursen, P. Effect of a 5-min cold-water immersion recovery on exercise performance in the heat. Br J Sports Med 44: 461-465, 2010.

17 Pollo, A, Carlino, E, Benedetti, F. The top-down influence of ergogenic placebos on muscle work and fatigue. Eur J Neurosci 28: 379-388, 2008.

18 Proulx, CI, Ducharme, MB, Kenny, GP. Effect of water temperature on cooling efficiency during hyperthermia in humans. J Appl Physiol 94: 1317-1323, 2003.

19 Ramanathan, N. A new weighting system for mean surface temperature of the human body. J Appl Physiol 19: 531-533, 1964.

20 Stacey, DL, Gibala, MJ, Martin Ginis, KA, Timmons, BW. Effects of recovery method after exercise on performance, immune changes, and psychological outcomes. J Orthop Sports Phys Ther 40: 656-665, 2010.

21 Taylor, KL, Bonetti, DL, Tanner, KT. Netball players. In: Tanner RK, Gore CJ eds, Physiological tests for elite athletes. 2nd edition ed. South Australia: Human Kinetics 2013

22 Terblanche, E, Venter, RE. The effect of backward training on the speed, agility and power of netball players. S Afr J Res Sport Phys Educ Recreation 31: 135-145, 2009.

23 Trine, MR, Morgan, WP. Influence of time of day on psychological responses to exercise. A review. Sports Med 20: 328-337, 1995.

24 Tucker, R, Marle, T, Lambert, EV, Noakes, TD. The rate of heat storage mediates an anticipatory reduction in exercise intensity during cycling at a fixed rating of perceived exertion. J Physiol 574: 905-915, 2006.

25 Vaile, J, Halson, S, Gill, N, Dawson, B. Effect of hydrotherapy on recovery from fatigue. Int J Sports Med 29: 539-544, 2008.

26 Vaile, J, Halson, S, Gill, N, Dawson, B. Effect of hydrotherapy on the signs and symptoms of delayed onset muscle soreness. Eur J Appl Physiol 102: 447-455, 2008.

27 Vaile, J, Halson, S, Graham, S. Recovery review- Science vs practice. JASC Supp 2: 5-21, 2010.

28 Versey, N, Halson, S, Dawson, B. Effect of contrast water therapy duration on recovery of cycling performance: a dose–response study. Eur J Appl Physiol 111: 37-46, 2011.

29 Versey, NG, Halson, SL, Dawson, BT. Effect of contrast water therapy duration on recovery of running performance. Int J Sports Physiol Perform 7: 130-140, 2012.

30 Versey, NG, Halson, SL, Dawson, BT. Water immersion recovery for athletes: effect on exercise performance and practical recommendations. Sports Med 43: 1101-1130, 2013.

31 Webb, N, Harris, N, Cronin, JB, Walker, C. The relative efficacy of three recovery modalities following professional rugby league matches. J Strength Cond Res 27: 2449-2455, 2013.

Tables

Table 1. Mean (±SD) fatigue scores (units) measured at baseline, immediately post-exercise, immediately post-recovery, 5 h (delayed recovery) and 24 h after recovery in the contrast water therapy, contrast showers and passive recovery conditions.

	Baseline**	Post-exercise#	Post-recovery	Delayed-recovery	24 h recovery
Contrast water therapy*	3.1±0.8	7.6±1.8	3.9±1.5	3.8±1.1	3.7±1.1
Contrast showers	3.7±1.2	7.8±1.4	4.0±1.0	4.7±1.3	4.1±1.4
Passive	3.6±0.7	7.9±1.3	4.3±1.0	4.7±1.1	4.0±1.1

* Main condition effect; contrast water therapy significantly less than passive condition. ** Baseline values significantly less than all other time points. # Post-exercise values greater than all other time points.

Figure Legends

Figure 1: Mean (± SD) repeated agility measured at baseline, immediately post-exercise (PostEx), immediately post-recovery (Acute), 5 h post-recovery (Delayed) and 24 h post-recovery (24h) in the contrast showers (●), contrast water therapy (■) and passive (▲) recovery intervention groups. * PostEx significantly greater than all other time-points.

Figure 2: Mean (± SD) **(a)** skin temperature and **(b)** core temperature following contrast showers (●), contrast water therapy (■) and passive recovery (▲) measured at baseline, post-exercise (PostEx), start of recovery (StartRec), end of recovery (EndRec) and 20 min post-recovery (20minPost). * Contrast water therapy and contrast showers significantly less than passive condition. # Contrast showers significantly greater than contrast water therapy. ** Selected time-points significantly greater than baseline. + Selected time-points significantly less than PostEx. ¥ Significantly less than StartRec.