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Running Title: Recovery interventions and intermittent-sprint performance.

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ABSTRACT

The purpose of this study was to compare four recovery interventions following simulated team sport, intermittent-sprint exercise on consecutive days. Ten female netball players performed four randomised sessions of a simulated netball exercise circuit on consecutive days. Each condition consisted of two identical sessions (Session 1 and 2), with the recovery intervention implemented at the completion of Session 1. Participants performed all interventions involving: passive recovery (PAS), active recovery (ACT), cold water immersion (CWI) and contrast water therapy (CTWT). No significant differences (p>0.05) were evident between conditions for exercise performance (vertical jump, 20-m sprint, 10-m sprint, total circuit time) during Session 2. Effect size data indicated trends for an ameliorated decline in 5 x 20-m sprints and vertical jump for CTWT and CWI respectively. CTWT demonstrated a significant reduction (p=0.04) in lactate post-intervention compared to ACT recovery. Further, ACT recovery resulted in a significantly elevated (p<0.01) heart rate compared to all other conditions post-intervention and demonstrated significantly higher (p<0.01) rating of perceived exertion post-intervention and muscle soreness pre-exercise Session 2. It is likely that while interventions may be applicable to team sport practices, the 24 h recovery period between exercise bouts was sufficient to allow performance to be maintained, regardless of recovery interventions.

Key Words: active recovery, cold water immersion, team sport, contrast water therapy.
INTRODUCTION

Athletes participating in competitive team sports are often exposed to demanding training and competition schedules which may include repeated, high-intensity exercise sessions performed on consecutive days, multiple times per week. Excessive volumes of intense training and competition, particularly with minimal recovery time, can place great physiological demands on the musculoskeletal, nervous, immune and metabolic systems, potentially causing a negative effect on subsequent exercise performance [24]. In order to restore physical function, a variety of post-exercise recovery interventions are often employed to improve recovery from training and competition bouts. It is proposed that the use of recovery strategies ensures performance in subsequent exercise sessions (training and/or competition) is not unduly compromised by lingering muscle soreness or decrements in power, flexibility, speed or agility [10]. Recently, the use of post-exercise recovery methods have gained popularity within sporting environments [7, 31] and include contrast water therapy (CTWT) [7], active recovery (ACT) [1, 9, 21] and cold water immersion (CWI) [14, 25]. In spite of their widespread use, limited scientific evidence is available to support the effectiveness of how these procedures are used in sporting settings to facilitate optimal post-exercise recovery. In particular the use of recovery interventions at the conclusion of a training day in preparation for training on the following day remains unknown.

A traditionally used recovery mode involves post-exercise ACT recovery in the form of continuous low-intensity movement. Accordingly, much of the available literature on post-exercise recovery has investigated the acute (0-60min) effects of ACT recovery on post-exercise removal of lactate (La⁻) and ensuing performance [1, 5, 23].
Many of these studies support the consensus that ACT recovery procedures reduce La\(^{-}\) accumulation by increasing blood flow to the exercised muscle to enhance the removal of metabolic by-products [23, 28, 29]. However, the relationship between La\(^{-}\) clearance and subsequent performance is tenuous [28] and while La\(^{-}\) is often measured as an indicator of metabolic acidosis, other measures including pH or HCO\(_3\) are likely to be more appropriate [12]. Moreover, for many team sports, including netball, acute (0–60min) recovery is of less importance as games or training sessions are often separated by at least 24 h. To date, few studies [10, 19] have investigated the effects of ACT recovery interventions on repeated bouts of intermittent-sprint exercise on consecutive days, separated by 24 h, as is often the case in many training scenarios.

While ACT recovery is commonly used, other recovery modalities such as CWI and CTWT are becoming increasingly popular methods of recovery following exercise [7, 31]. CWI is commonly utilised following acute musculoskeletal injuries [22, 26, 32] and has recently been proposed to enhance both physiological [2, 13, 16, 30] and perceptual recovery [2, 6, 22]. The implementation of external cold application has been shown to produce physiological changes including a reduction in muscle oedema, swelling, muscle spasm and pain [17, 20]. To date, the majority of published literature has focused on the effects of CWI following muscle-damaging exercise, inducing delayed onset of muscle soreness (DOMS) [18, 31] and acute musculoskeletal injuries [17, 20]. However, research on the effects of CWI on intermittent-sprint or team-sport exercise performed on consecutive days, as is commonly used in the field, is lacking.
Additionally, the technique of alternating hot-cold water (C\textsubscript{T}WT) is proposed to create a “pumping” action through alternating vasodilation and vasoconstriction of the blood vessels to temperature change, thereby increasing blood flow and enhancing the removal of metabolic by-products, consequently speeding recovery [7, 27, 30]. It has been suggested that C\textsubscript{T}WT elicits benefits similar to that of ACT, although without the same energy demands [7, 27, 30]. Only recently has there been evidence to suggest that C\textsubscript{T}WT enhances subsequent athletic performance [31]. However, when consecutive bouts of high-intensity, intermittent-sprint exercise are performed with a 24 h rest interval between sessions, the effectiveness of C\textsubscript{T}WT remains unclear.

Therefore, despite the widespread use of ACT, CWI and C\textsubscript{T}WT as recovery strategies following team-sport exercise, there is minimal scientific evidence to substantiate the benefits of these recovery interventions on consecutive day bouts of exercise. As such, the aim of this investigation was to compare the effects of passive recovery (PAS), active recovery (ACT), cold water immersion (CWI) and contrast temperature water therapy (C\textsubscript{T}WT) on exercise performance during an intermittent-sprint exercise protocol (simulating a netball game) repeated on consecutive days, separated by a 24 h recovery.

METHODS

Experimental Approach to the Problem

Despite the popularity of the implementation of these aforementioned recovery strategies in team sports, there is limited evidence to suggest the effectiveness of these methods on subsequent athletic performance. Therefore, a repeated measures study was used to examine the effects of four different recovery interventions on exercise
performance following an intermittent-sprint exercise protocol, designed to simulate the demands of a netball game. Netball is a sport consisting of high-intensity, intermittent-sprint activity similar to that of basketball and is played over 60 min (4x15min). The activity patterns during a game of netball are similar in mode and relative intensities to many other team-sports. Participants completed an intermittent-sprint exercise protocol on consecutive days (Session 1 and Session 2), separated by a 24 h recovery interval. At the completion of Session 1, participants engaged in one of the four recovery conditions in a counter-balanced, semi-randomised order.

**Subjects**

Ten trained, female netball players with a mean ± sd age 19.5 ± 1.5y, height 171.1 ± 5.3cm and body mass 65.69 ± 7.73kg were recruited as participants for this study. These athletes competed in local and regional representative matches 1 - 2 times per week and trained ~3 times per week. Testing was completed during the mid-season of competition. All participants were informed of the requirements of the study and verbal and written consent was obtained prior to the commencement of testing. Human Ethics clearance was granted by the Institutional Ethics Committee prior to the completion of any testing procedures.

**Procedures**

Participants were required to undertake a familiarisation session and a test to predict maximal aerobic speed (v-VO$_{2\text{max}}$) followed by 8 testing sessions involving the four respective recovery interventions. v-VO$_{2\text{max}}$ was estimated via the 20-m multi-stage shuttle run test (Australian Sports Commission, Canberra, Australia), which is an incremental test with increases in speed delivered by audible prompts, requiring
participants to continue until the speed could no longer be maintained. The speed of the active recovery was accordingly set as 40% of the peak speed obtained in the shuttle-run test [8]. All testing sessions were conducted in an enclosed gymnasium (dry bulb temperature: 16.9 ± 2.1°C) with each session performed at the same time of day to account for any diurnal variation. Participants were required to present in a rested state and avoid any consumption of food or drink (including caffeine) 3h prior to testing and no alcohol 24h prior to testing. Participants recorded all food, drink and activity in the 24 h prior to the first testing session and replicated this for all testing sessions. Each experimental condition (recovery intervention) consisted of two testing sessions (Session 1 and Session 2) on consecutive days separated by 24 h. The intervention was performed at the completion of the first testing session, with each condition (both sessions) separated by a minimum of 5 days. The testing order was randomly assigned in a counter-balanced order, with the interventions consisting of: PAS: participants performed no physical activity and remained seated in a designated area of the gymnasium. ACT: subjects performed low intensity exercise at 40% v-V \( O_2 \text{max} \) [8]. CWI: participants were immersed in an ice bath (9.3±1.6°C) to the iliac crest for 5min followed by 2.5min seated at air temperature, which was performed twice [18, 25]. CTWT: participants alternated between immersion in cold (9.7±1.4°C) water (to the level of the iliac crest) for 1min and then a warm (39.1±2.0°C) shower for 2min. This procedure was repeated another 4 times until a total of 5 exposures were completed [8, 10, 16]. Each intervention was employed for a total duration of 15min.
**Exercise Protocol**

Individual testing sessions commenced with a warm-up involving 3 min at 60 W on a cycle ergometer (Monark 818E, Varberg, Sweden), 3 laps of the exercise circuit at increasing speeds and 3 maximal 20-m run-throughs. Participants then performed pre-exercise performance measures before completing a 4 x 15min intermittent-sprint exercise circuit with rest intervals of 3 min at quarter-time and 5 min at half-time, simulating the game demands of netball. At the conclusion of the exercise circuit participants completed post-exercise performance tests, followed by one of the four recovery interventions. Participants were then allowed 24 h before the completion of identical procedures the following day.

The exercise circuit, designed to mimic the duration and performance demands of a netball game, was a modified version of that utilised by Bishop et al. [3] (Figure 1). Typical activity patterns associated with a game of netball were incorporated and included short sprints, agility movements, jumping, jogging, side-stepping, walking and striding. Participants performed a lap of the exercise circuit in ~40–45-s and this was repeated every minute for a total duration of 4 x 15min (60min). The remainder of each minute (~15–20-s) was used as passive recovery time. A standardised total amount of 750mL of water was available for the subjects to consume throughout the rest intervals.

*Insert Figure 1 here*
Measures

Performance

Participants completed pre- and post-exercise performance measures each session consisting of 5 counter-movement vertical jumps (VJ) in 20-s (jump=~1-s, rest=~3-s) (Vertitech, Swift Performance, Sydney, Australia). This was followed by 5 x 20-m sprints departing every 20-s with 10-m and 20-m sprint time recorded (Speed Light, Swift, Sydney, Australia). Performance measures were recorded to determine decrements in power and speed [15] resulting from the intermittent-sprint exercise circuit and the ensuing effect of the recovery interventions. Further, throughout the exercise circuit, 10-m sprint time (occurring at the start of each individual circuit) and time to complete each individual lap of the circuit were also recorded.

Physiological

On arrival and post-exercise, nude mass was measured via a set of calibrated scales (HW 100k, A & D, Tokyo, Japan) for which participants were required to towel down and remove any surface sweat in order to estimate changes in body mass due to sweat loss. Following the measurement of nude mass, resting physiological measures were recorded consisting of a 100µL sample of capillary blood collected from a hyperemic ear for the measurement of lactate (La'), pH and bicarbonate (HCO₃⁻) (ABL825 Radiometer, Denmark, Copenhagen). Heart rate (HR) was measured with a heart rate chest monitor and wrist watch receiver (F1, Polar, Finland), while skin temperature (Tsk) was measured with skin thermistors (Montherm, 4070, Mallinkrodt, USA) placed on the mid-point of the calf, forearm and top of the sternum. All blood, heart rate and skin temperature measures were obtained at rest, post warm-up, post-performance tests, during each rest interval in the exercise circuit, post-exercise and
following the recovery interventions. In addition, HR was recorded at the 5\textsuperscript{th} and 10\textsuperscript{th} minute during each quarter.

\textit{Perceptual}

Self-reported perceptual measures consisted of subjective ratings of perceived exertion (RPE) (Borg CR-10 scale) and ratings of muscle soreness (MS) (10-point Likert scale; 0=normal, 10=extreme soreness). Ratings were recorded at rest, post warm-up, post-performance tests, during each rest interval in the exercise circuit, post-exercise and following the recovery interventions.

\textbf{Statistical Analyses}

Data were analysed using the Statistical Package for the Social Sciences (Version 14; SPSS, Inc., Chicago, IL). All statistics were expressed as mean ± SD. Data were analysed via a repeated measures analysis of variance to determine whether any significant differences were present between each recovery intervention. Significance was set apriori at $p<0.05$ and where appropriate, Tukey’s post hoc comparisons were employed. Effect size (ES) data analysis was conducted to analyse the magnitude of effect of the respective recovery interventions compared to the control (Passive rest) condition. Effect sizes $<0.4$ were considered small, 0.4–0.7 moderate and $>0.7$ large. Technical error of measurement for the exercise circuit was $<5\%$.

\textbf{RESULTS}

No significant differences in performance were evident between the conditions in Session 1 or 2 for 20-m sprint time or VJ ($p=0.6–0.9, 0.8–0.9$ for 20-m sprint and VJ respectively). No significant differences were observed between the conditions in
Session 1 or 2 for mean (sec) and total time (sec) of 5 x 20-m sprints (p=0.6-0.8). There was however, a large effect (ES=0.74) observed in 20-m sprint % decrement following CTWT post-exercise Session 2 compared to the PAS condition (Table 1). In addition, a large effect size (ES=0.75) was present for a reduction in the % decrement in VJ pre-exercise Session 2 for CWI compared to the PAS condition (Table 1). No significant differences were evident between the conditions in Session 2 in the performance of 10-m sprint within the exercise circuit (2.37±0.16, 2.37±0.20, 2.34±0.20 and 2.29±0.16 s for PAS, ACT, CWI and CTWT respectively) or total circuit time (sec) (p>0.05) (34.74±2.00, 35.57±3.31, 34.45±2.94 and 33.98±1.87 for PAS, ACT, CWI and CTWT respectively).

Table 1 here

HR was significantly elevated (p=0.01) at the completion of the ACT recovery (145±12) compared to all other conditions (PAS: 108±20, CWI: 108±20, CTWT: 111±9). There were no significant differences between conditions (p>0.05) in HR at any other time point in Session 1 and 2. Following CWI in Session 1, Tsk was significantly decreased (p<0.01) compared to all other conditions, whilst La was significantly reduced post-intervention (p=0.04) following CTWT compared to ACT (2.6±1.0mmol l⁻¹ and 3.9±1.3 mmol l⁻¹ respectively) (Figure 2). In addition, a large effect (ES=0.71) was observed post-intervention with a lowered La following the PAS recovery compared to ACT. Measures of HCO₃ were significantly decreased (p=0.04) post-intervention Session 1 in the ACT condition compared to PAS (19.9±1.7 and 21.7±1.02 respectively), with a further large effect (ES=0.75) observed
post-exercise Session 2 with a lower HCO$_3^-$ following CWI compared to PAS (17.5±0.8 and 18.5±1.5 respectively). No significant differences (p>0.05) were present between the conditions in Session 1 and 2 for pH; however, a lowered pH, which tended toward significance (p=0.06) was observed immediately following the ACT recovery. In addition, a large effect (ES=1.17) was evident post-intervention Session 1 with a reduced pH following the ACT recovery compared to PAS (7.38±0.03 and 7.42±0.01 respectively).

**Insert Figure 2 here**

Self-reported ratings of MS pre- and post-exercise in Session 1 and 2 indicated that following CWI and CTWT, perceived MS was significantly reduced (p<0.01) compared to the ACT recovery (Figure 3). In addition, a large effect was observed 24h later in Session 2 with participants reporting a lower MS in both the CWI and CTWT conditions (ES=0.84 and 0.88 respectively) compared to PAS. Following ACT recovery, RPE were significantly elevated (p<0.01) compared to the other conditions, increasing to a mean of 4.5±2.0 compared to 0.2±0.3, 0.1±0.3, 0.1±0.2 for PAS, CWI and CTWT respectively.

**Insert Figure 3 here**
DISCUSSION

The present study investigated the effects of CWI, C7WT, ACT and PAS recovery on bouts of intermittent-sprint exercise, simulating the demands of a netball match, performed on consecutive days and separated by a 24h recovery interval. Results indicated that limited and minor benefits were present between conditions based on the recovery interventions used. Despite no significant differences between the conditions in any performance variable measured during Session 2, large effect sizes were evident for a reduced % decrement in VJ and 20-m sprint time in the CWI condition pre-exercise Session 2 and C7WT post-exercise respectively. In addition, physiological measures indicated significant differences between the conditions in regard to HR, Tsk, La−, pH and HCO3, whilst psychological measures of RPE and MS were significantly higher post-intervention (Session 1) following ACT recovery and lower pre-exercise Session 2 following CWI and C7WT respectively.

The use of ACT, CWI or C7WT to aid recovery from high-intensity exercise did not result in any significant improvements in 20-m sprint time, VJ, circuit time or 10-m circuit sprint time during Session 2 of consecutive days of exercise performance. There was a large effect observed with a reduced % decrement in 20-m sprint time following C7WT (4.4±1.7%) compared to PAS recovery (5.8±1.4%) in Session 2. This trend was also evident with a reduced % decrement in VJ performance in Session 2 following CWI (4.4±2.7%) compared to a PAS recovery (8.1±4.8%). While no statistical improvements in 20-m sprint or VJ performance were evident with any recovery condition during Session 2, the observed trend for a reduced % decline in performance with C7WT and CWI may suggest that the respective recovery interventions might contribute to reducing the decline over repeated maximal efforts.
The demands of the current protocol simulated the common demands of training or competition and feedback from the participants indicated it represented the physical level of a game. Despite this, no evidence of a major day-to-day decrement in performance was evident from the protocol.

While Netball lacks heavy direct body contact, previously, Dawson et al. [10] have examined the effects of post-exercise interventions on the recovery of explosive power (VJ and 6-s cycle ergometer) following Australian Football games. Recovery periods of 15 and 48 h following Western Australian State League matches (WAFL) were examined. Results indicated at 15 h post-game, measures of VJ and 6-s work and power were significantly lower than pre-game measures in the control condition, which were no longer evident 48 h post-WAFL match. Similar to the present findings, despite the inclusion of various recovery procedures, no significant differences were evident between the conditions in VJ, even though subjects still reported significantly higher ratings of MS. Dawson et al. [10] suggested that despite increased ratings of MS 48 h post-exercise, players may be able to produce “one-off” efforts which are equal to or close to their maximum. Accordingly, the observed effects for a reduction in the % decrement may confirm this hypothesis, in that recovery strategies may assist the maintenance of performance rather than improve outright performance. Further, the time frame between immediately post- and 15 h following high-intensity work appears to indicate performance is still suppressed; however, with no significant differences between performance due to recovery procedures at 24 h (current study) and 48 h [10], the time frame of 24 – 48 h, regardless of a recovery strategy, seems to be adequate to allow athletes return to baseline speed and power values.
Supporting the results of previous studies [4, 11, 23], the present investigation found that following an ACT recovery, HR was significantly increased compared to the other conditions. As suggested by Draper et al. [11], it is evident that an increase in HR during ACT recovery is due to the continuation of low-intensity exercise increasing blood flow to the working muscles. An increase in blood flow is subsequently thought to enhance the removal of metabolic by-products from the exercising muscle [1, 4]. However, although HR was significantly increased following ACT recovery in the present study, results did not indicate a subsequent reduction in La⁻. Despite the lack of this proposed association between HR and La⁻, a significant difference in post-intervention La⁻ was observed following CTWT compared to ACT. Following 15 min alternating between immersion in warm and cold water, La⁻ was significantly reduced compared to the ACT condition. It has been proposed, that due to the alternating vasoconstriction and vasodilation resulting from CTWT, muscle blood flow ‘pumping’ occurs, increasing blood flow and metabolic by-product removal [7, 27] including La⁻; however, an alternative interpretation is that the inactive process of these recovery interventions may have resulted in a reduced La⁻ value compared to ACT. Accordingly, while previous research suggests recovery intensities of 40% VO₂max, it is likely that the intensity of the ACT recovery (40% v-V O₂max) could possibly have been too high, and consequently had a detrimental effect on acute metabolic and cardiovascular recovery. This should be noted by practitioners as recovery strategies that are too intense may hinder ensuing recovery of metabolites and performance (although this was not noted in the present study).

Despite no significant differences, a large effect was observed for a reduced pH immediately following the ACT recovery compared to the PAS condition (p=0.06;
ES=-1.17). In addition, a significantly reduced post-intervention HCO$_3$ value following ACT was also evident, suggesting that following exercise, the continuation of an active recovery period continued to utilise HCO$_3$ as a metabolic buffer to counter the continued reduction of pH. Although, despite a decreased pH and HCO$_3$ following ACT, the small extent of these physiological changes and long recovery interval meant subsequent exercise performance 24 h later was not inhibited. However, given the higher likelihood of pH and HCO$_3$ describing the metabolic condition of the exercised muscle groups, it should be noted that a suppressed metabolic recovery was observed in the ACT condition. Again, the intensity associated with the recovery may have been too high for the fit, but not elite standard of athlete used here, and accordingly highlights the importance of tailoring recovery interventions to the individual athletes.

Despite the lack of a change in peak performance measures on consecutive days, immediately following exposure to C$_7$WT and CWI, subjects reported a significantly lower RPE and MS compared to the ACT recovery, highlighting potential perceptual benefits of immersion recoveries. In support of this finding, Coffey et al. [8] reported that following C$_7$WT, participants reported a lower perception of fatigue, discomfort and stress compared to the ACT recovery, whilst appearing to provide similar effects for the removal of La$^+$ (although not significant). This finding may possibly have implications for team sports when implementing recovery interventions to alleviate potential perturbations resulting from intense exercise with minimal player discomfort. Despite only minor differences in performance, subjects reported lower ratings of MS 24 h following C$_7$WT and CWI interventions. In support of this finding, Kuliogowski et al. [18] reported a reduction in delayed onset of muscle
soreness (DOMS) following C_{T}WT and CWI, concluding that the application of cold through the use of cold whirlpools or C_{T}WT is best for the treatment of DOMS. Although the exercise protocol in the current investigation did not aim to, or result in inducing DOMS, similar findings to Kuliogowski et al. [18] were evident, suggesting a reduced perception of MS following CWI and C_{T}WT interventions respectively. Based on these results, it may be suggested that following intermittent-sprint exercise, athletes may prefer to utilise C_{T}WT or CWI as methods of recovery compared to an ACT intervention as these strategies are performed with minimal physical exertion, achieve similar physiological responses, and result in lowered ratings of perceived MS compared to an ACT recovery.

In conclusion, the results of the current study indicated that performing an immediate post-exercise recovery intervention, consisting of either ACT, CWI or C_{T}WT, did not significantly enhance peak performance during an ensuing bout of exercise, however may assist the maintenance of performance in intermittent-sprint exercise performance compared to PAS recovery. It may be suggested from these results that a recovery period of 24 h between successive exercise bouts simulating non-contact team-sports, is adequate to allow recovery to the pre-exercised state and maintenance of exercise performance. However, the use of recovery interventions when the duration between bouts is 24 h or more may assist in the reduction of self-reported recovery as evidenced by lower perceived ratings of MS following CWI and C_{T}WT compared to an ACT recovery. As such, it may be preferential to utilise CWI or C_{T}WT interventions following intermittent-sprint exercise, due to the reduced perceptions of MS and physical exertion.
PRACTICAL APPLICATIONS

With team sport athletes often engaging in consecutive day exercise bouts during training and competition, recovery strategies are commonly performed at the completion of such sessions. Despite the implementation of recovery methods such as CWI and C\textsubscript{T}WT, there is minimal evidence to support the effectiveness of these strategies in aiding performance bouts separated by 24 h of recovery. Although the results of the present study found that subsequent peak performance was not significantly improved by CWI or C\textsubscript{T}WT, the decline in exercise performance was less in the second session following these recovery strategies. Further, the use of these strategies resulted in an improved self-reported perceptual recovery. As it is important to overcome both physical and mental fatigue during sport, this finding may have significant implications when exercise is performed over a prolonged period of time as athlete’s perception of recovery was improved by both CWI and C\textsubscript{T}WT. While 24 h is sufficient time to recover from such non-damaging exercise, these recovery strategies may assist the maintenance of performance and self-reported recovery for ensuing sessions, and therefore, may be of use at the conclusion of a training day. Also, this study highlights the importance of tailoring recovery sessions to the individual needs of athlete’s. Finally, further research should explore the acute effects of recovery on performance and the effects from more intense exercise and environmental conditions.

ACKNOWLEDGEMENTS

No acknowledgements.
FIGURE LEGENDS

• Figure 1: Schematic diagram of the simulated Netball exercise circuit.

• Figure 2: Mean ± sd blood lactate concentration at the end of each quarter (Q) and post-intervention in Session 1 (S1) and 2 (S2) for passive, active, cold water immersion (CWI) and contrast temperature water therapy (C\textsubscript{T}WT) conditions (\(n=10\)).

* Significant difference between C\textsubscript{T}WT and ACT conditions (p < 0.05).
# Large effect size between PAS and ACT conditions (ES > 0.7).

• Figure 3: Mean ± sd ratings of muscle soreness pre- and post-exercise and post-intervention in Session 1 (S1) and 2 (S2) for passive, active, cold water immersion (CWI) and contrast temperature water therapy (C\textsubscript{T}WT) conditions (\(n=10\)).

* Significant difference in CWI and C\textsubscript{T}WT compared to PAS and ACT conditions (p < 0.05)
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