ABSTRACT

Introduction: cold-water immersion (CWI) is a popular recovery strategy; however, there is limited evidence of the effectiveness of this method in sport settings. Objective: to investigate the effect of CWI on muscle soreness and anaerobic performance after a Futsal match. Methods: ten players performed two simulated matches followed by two randomized recovery conditions (CWI or passive rest - C), separated for seven days. During the recovery interventions, the players remained seated in a comfortable position (C) or were immersed in a pool with cold water (CWI condition; 15±1°C) for 12 minutes. Muscle soreness assessment, counter movement jump (CMJ) test, repeated jump ability (RJA) test, and repeated sprint running test (rRST) were conducted prior to the match (Pre), immediately after the recovery intervention (P1) and 24h after the recovery intervention (P2). Results: a significant increase in muscle soreness after the Futsal match was observed for both interventions (C and CWI) during all time points (P1 and P2, p<0.05); however, no significant difference was detected between CWI and C interventions (p>0.05). There was a significant decrease in anaerobic performance (CMJ, RJA and rRST) immediately after the CWI intervention when compared to C (P1, p<0.05). No significant difference in anaerobic performance was detected between the two conditions at P2 (CWI and C; p>0.05). Conclusion: the CWI did not improve recovery related to muscle soreness and anaerobic performance of Futsal players.

Keywords: fatigue, muscle soreness, vertical jump, repeated sprint ability.

RESUMEN

Introducción: la inmersión en agua fría (IAF) es una estrategia popular de recuperación, pero, a pesar de ello, hay escasas evidencias sobre la eficacia de este método en el contexto deportivo. Objetivo: investigar el efecto de la IAF sobre la fatiga muscular y el rendimiento anaeróbico después de una prueba de Futsal. Métodos: diez jugadores realizaron dos pruebas simuladas seguidas de dos condiciones aleatorias de recuperación (IAF y reposo pasivo - C), separadas por siete días. Durante las intervenciones de recuperación, los jugadores permanecieron sentados en una posición cómoda (C) o fueron inmersos en una piscina con agua fría (condición IAF, 15±1°C) por 12 minutos. A la evaluación de la fatiga muscular, el salto vertical contra (SCM), la prueba de salto repetido (TPSR) se realizaron antes de la prueba (PRÉ), inmediatamente después de la intervención de recuperación (P1) y 24h después de la intervención de recuperación (P2). Resultados: se observó un aumento en la fatiga muscular después de la intervención de recuperación (P1 y P2, p<0.05); sin embargo, no se observaron diferencias significativas entre las intervenciones de IAF y C (p>0.05). Se observó una disminución en la capacidad anaeróbica (CMJ, RJA y rRST) inmediatamente después de la intervención de recuperación (P1) y 24h después de la intervención de recuperación (P2). Resultados: no se observó una disminución en la capacidad anaeróbica entre las dos condiciones (IAF y C; p>0.05). Conclusion: la IAF no mejoró la recuperación relacionada con la fatiga muscular y el rendimiento anaeróbico de los jugadores de Futsal.

Palabras clave: fatiga, dolor muscular, salto vertical, capacidad de sprints repetidos.
INTRODUCTION

There is a growing interest on interventions to accelerate the recovery process so athletes might perform successive training sessions or competitive matches without a significant decrement of performance. Recently, cold-water immersion (CWI) has emerged as one of the most popular interventions to accelerate recovery after exercise. However, there is limited data regarding the effectiveness of this intervention in sport-specific settings.

Research on CWI interventions to accelerate recovery show conflicting results since some studies suggest positive outcomes while others report non-significant effects. Despite this controversy, athletes have been using CWI to promote a faster recovery, to diminish muscle soreness, and to hasten a return to optimal performance. As a specific example, CWI has been largely utilized by Brazilian Futsal players between successive training sessions and competitive matches. However, there is insufficient evidence to support the use of this strategy following Futsal training sessions and competitive matches.

Futsal is a high intensity intermittent sport that relies on mixed contribution of anaerobic and aerobic energy systems. Barbero-Alvarez et al. and Castagna et al. have shown that the Futsal match demands are higher than soccer and other intermittent team sports. Futsal physical demands indicate that the competitive match might induce severe fatigue, and may require efficient recovery interventions.

To date, no previous study has been conducted to verify the impact of CWI on muscle soreness and anaerobic performance of top-level Futsal players following a match. Therefore, the purpose of the present study was to investigate the effect of CWI on muscle soreness and anaerobic performance after a simulated match. The authors hypothesized that CWI would attenuate muscle soreness and minimize performance decrement thus accelerating recovery.

METHODS

The present study was conducted at the beginning of the competitive season (State Championship). The Futsal team involved in this study finished the season in the second position. All players were familiar with testing procedures used in the investigation. Players performed two highly competitive simulated matches (four quarters of 10 min with 5-min recovery period) separated by seven days in an ecological setting, using procedures previously described. It is important to highlight that verbal encouragement was provided by the coaches during both matches. Each match was followed by one of two recovery interventions, a passive recovery (Control - C) or a CWI intervention. The respective interventions were randomized and performed at the same time of day to avoid diurnal variation.

Thus, the order of recovery intervention (CWI and C) was individually counterbalanced. The recovery interval from the last bout of exercise was more than 48 h. To assess match intensity, a rating of perceived exertion (RPE) was recorded for all players after each match using Borg’s CR-10 scale. The players had 1 attempt on a continuous countermovement rebound jump for 15 seconds without any recovery between jumps on a jump mat. The average height of all jumps was considered for analysis. The players were instructed to jump as high as possible with their hands on their hips and to keep foot contact on the mat as short as possible. The RJA test consisted of five 30-m sprints, each separated by a 25-s period of active recovery (jogging). Infrared light sensors with a precision of 0.01 s recorded the sprint times. The mean sprint time was considered for analysis. The rRST showed an intraclass correlation coefficient (ICC) of 0.93.

Statistical Analyses

The distribution of the data was analyzed by the Shapiro-Wilk test. The Mauchly’s Test of Sphericity was performed to test the null hypothesis that the error covariance matrix of the orthonormalized-transformed dependent variables was proportional to an identity matrix. Two-way ANOVA with repeated measures was used to compare the two recovery procedures on three time points (Pre, P1, and P2). Tukey HSD post hoc test was utilized when necessary. In the case of violation of the assumption of sphericity, the significance was established by utilizing the Greenhouse-Geisser correction.

RESULTS

A similar session rating of perceived exertion (RPE) was observed for the two simulated matches (1st match: 6.8 ± 1.4, “hard” to “very hard”, 2nd match: 6.7 ± 1.2, “hard” to “very hard”). Figure 2 shows the muscle soreness of Futsal players. A significant increase in muscle soreness after the Futsal match was observed for both interventions during all time points (P1 and P2); however, no significant difference (p>0.05) was detected between CWI and C interventions. The results of the anaerobic performance tests (CMJ, RIA and rRST) are shown in figures 3, 4 and 5. There was a significant decrease in anaerobic performance (CMJ, RIA and rRST) immediately following
the CWI intervention when compared to C intervention (P1, p<0.05). No significant difference in anaerobic performance was detected between CWI and C at P2 (p>0.05).

Figure 2. Muscle soreness following the Futsal matches.

Figure 3. Counter movement jumping following the Futsal matches.

Figure 4. Repeated jumping ability following the Futsal matches.

DISCUSSION

The present study aimed to compare the effect of two recovery methods (passive and CWI) performed after a simulated Futsal match. This is the first study that analyzed the effect of CWI on muscle soreness and anaerobic performance after a Futsal match in top-level Brazilian professional players. The major findings of the present study were as follows: 1) CWI did not attenuate the magnitude of muscle soreness induced by a simulated Futsal match, 2) A significant decrease in the post-match anaerobic performance was observed immediately after the CWI intervention and 3) no difference in anaerobic performance was observed between both interventions after 24h.

The mean RPE score for both matches was similar (~7.0), indicating a perceived exertion between “hard” and “very hard”. Tessitore et al. showed that young Futsal players perceived the mean intensity from four friendly matches as “somewhat hard” using the Borg’s 6-20 Scale. These findings highlight that players attained a high-intensity effort during both matches. Previous studies confirm the high physiological demands of Futsal matches.

Nowadays many athletes and coaches habitually use CWI after intensive training sessions or competitive matches expecting that this intervention will accelerate recovery. To date, only one study has investigated recovery procedures in Futsal players, but the sample were composed by young players, members of college Futsal teams. Furthermore, Tessitore et al. did not evaluate the impact of CWI as a recovery strategy.

In the present study, CWI intervention did not decrease the magnitude of muscle soreness after the match (24h post-intervention) when compared to the passive recovery (C). In agreement with the findings of the present study, Jakeman et al. also showed that a single bout of CWI (10 min at 10°C) following a damaging exercise (10 sets of 10 counter-movement jumps) has no beneficial effect on perceived muscle soreness during recovery (1, 24, 48, 72, and 96h after the exercise). Yanagisawa et al. also did not observe a positive effect of CWI (15 min at 5°C) on muscle soreness attenuation after a damaging exercise (ankle plantar flexion; five sets of 12 repetitions) up to 168h post-protocol. In addition, Goodall & Howatson investigated the effect of multiple CWI (12 min at 15°C - applied immediately post-exercise, 24, 48, 72, and 96 h) after the exercise bout (five sets of 20 drop jumps) on perceived muscle soreness assessed at these same time points. These authors did not observe a positive effect of this strategy on the muscle soreness when compared to the control group at any time analyzed.

However, other investigations showed that CWI attenuates muscle soreness. The recent meta-analyses conducted by Leeder et al. and Bleakley et al. showed that CWI is effective to alleviating muscle soreness.
ness after damaging exercise between 24h up to 96h of its application. One mechanism that has been proposed to explain the attenuation of muscle soreness is that CWI causes reduction in muscle blood flow and tissue temperature, lowering the inflammation induced by high-intensity damaging exercise. This intentional reduction of inflammation might be related to attenuation of DOMS.

Regarding to the effect of CWI on physical performance the results are also diverse and inconsistent. The results of the present study indicated that CWI may impact negatively in anaerobic performance assessed immediately after the intervention. A significant decrease in CMJ, RJA and rST performance was observed immediately after the CWI. In line with these results, Crowe et al. observed a decrease in anaerobic performance (30-s “all out” maximal cycling test) after CWI (15 min at 13-14°C). In this study, peak power, total work and post-exercise blood lactate were significantly reduced following CWI compared to the first exercise test and the control condition. Buchheit et al. did not show a significant difference in mean power output and completion time during 1-km cycling time trials between the CWI (5 min at 14°C) and passive recovery in male cyclists, despite the improvement of perceived rating of recovery after the CWI. Likewise, Jakeman et al. showed that after a damaging exercise, the CWI did not show a positive effect from recovery of maximal voluntary contraction of the quadriceps up to 96h after its application when compared to the passive recovery.

In the present study, the decrease in anaerobic performance immediately after the CWI could be explained by the lower muscle temperature. The possible mechanisms involved in the performance deterioration include decreased stiffness of muscles and joints, increased transmission rate of nerve impulses, altered force-velocity relationship and increased glycogenolysis, glycolysis, and high-energy phosphate degradation. Therefore, a lower muscle temperature immediately after the CWI might have impaired muscle contractile ability and exercise performance. García-Manso et al. showed that CWI may modify skeletal muscle physiology of professional soccer players, increasing stiffness and decreasing muscle contraction velocity. On the other hand, the benefits of warm-up on the short-term neuro-muscular performance appear to be largely, although not entirely, attributable to the increase in muscle temperature.

More recently, Stanley et al. investigated the effects of CWI on both central (i.e., cardiac output) and peripheral (i.e., muscle oxygenation) facilitators of O₂ delivery to exercising muscle. In addition, these researchers also assessed the influence of CWI on the anaerobic contribution during subsequent high-intensity interval training (HIIT). Interestingly, they showed that using CWI prior to a subsequent HIIT led to increased cardiac parasympathetic activity, slowed VO₂ on-kinetics and reduced muscle O₂ utilization, probably due to the reduced muscle blood flow. In addition, CWI increased anaerobic contribution during HIIT. These central and peripheral responses seem to persist up to 45 min. From the practical point of view, the authors suggest that athletes should be advised not to use CWI if high-intensity events are separated by 45 min or less.

**CONCLUSION**

In summary, the results of the current study indicate that a single bout of CWI after a simulated Futsal match had no beneficial effect on perceived muscle soreness and anaerobic performance during a short-term recovery period. However, additional studies are necessary to analyze the effect of different CWI protocols on recovery of Futsal players during tournaments with subsequent matches in a short period of time.

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