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Effectiveness of a 12-week Periodised Recovery Programme on Muscle Performance and Mood States in Youth Athletes

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ABSTRACT

Background: Youth athletes experience high-intensity physical and mental stress during a competitive season. In athlete populations, accumulated stress and strain have been associated with contributing to levels of fatigue that decrease athletic performance. While deliberate heat and cold exposure have been prevalent to aid recovery, there is a lack of conclusive literature regarding the specific implementation, periodisation, and monitoring for optimal recovery in youth athletes. **Objective:** This study aimed to investigate external physical (lower-body muscular power), internal physical (rating of perceived exertion) and psychological (profile of mood states) outcome measures during a 12-week competitive first XV rugby season to determine the effectiveness of a deliberate heat and cold exposure intervention. **Methods:** A single-group repeated measure within-subjects design was performed with 29 male first XV rugby athletes (mean age 17.6 ± 0.6 years; mean body weight 87.5 ± 9.7 kg; mean height 182.2 ± 6.2 cm) who volunteered for this study. Countermovement jump (CMJ), rating of perceived exertion (RPE) and profile of mood states (POMS) were recorded every fortnight over a 12-week competition. A total of two separate deliberate cold exposures (5°C for 5-minutes) and one deliberate heat exposure (100°C for 15-minutes) were administered weekly over the 12-week competitive season. **Results:** CMJ peak power ($p = 0.759$) and mean CMJ concentric power ($p = 0.712$) revealed no significant time effect. RPE presented a significant time effect ($p < 0.001$). Among the ten POMS domains examined, eight domains did not show a significant time effect ($p > 0.05$). However, the domains related to feeling sore or fatigued ($p = 0.032$) and excitement about competition ($p < 0.001$) displayed significant time effects. **Conclusion:** The recovery intervention of two cold and one heat exposures did not directly improve changes in CMJ power or psychological states; however physical and psychological performance was maintained. Further research is necessary to understand the duration and frequency of using recovery strategies to improve the long-term effectiveness of young athletes.

Key words: Physical Fitness, Athletic Performance, Exercise Therapy, Psychological Stress, Youth Sports

INTRODUCTION

In youth athletes, a distinct period emerges when the training age and competition demands reach a more advanced level. Consequently, the periodisation model employed must also evolve to provide a greater stimulus for adaptation (Kellmann, 2010). This period coincides with significant physical and psychological maturation, leading to heightened stress and strain. Inadequate recovery can result in a detrimental cycle of fatigue accumulation, hindering youth athletes' long-term development and career prospects (Brenner & Watson, 2024).

Within the specific context of youth rugby athletes, who experience high-intensity physical and mental stress during a competitive season, ineffective strain management can have significant adverse effects, both on and off the field. The accumulation of stress and strain from training, competition, and factors unique to youth has been associated with heightened levels of fatigue that impair overall athletic performance (Steinacker & Lehmann, 2022). Youth athletes face various activities unique to their age group, including academic workload, part-time work, participation in other sports, and social pressures. These activities can introduce additional stressors that can impact their performance (Mann et al., 2016). Moreover, internal dynamics specific to youth, such as psycho-social and maturation development, can potentially alter youth athletes' perceptions of training, competition, and external workloads. These dynamics can also impede recovery adaptation due to the imposed strain (Kiely, 2018). Given the complexity of youth athletes and the multifaceted challenges, implementing effective recovery methods becomes a significant challenge. However, the

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goal is to reduce stress and strain, which can otherwise lead to decreased performance and a higher risk of injury.

In recent years, deliberate cold and heat exposure has gained recognition as a valuable recovery strategy for athletes navigating demanding training and competition schedules (Bezuglov et al., 2021; Higgins et al., 2017). These interventions offer numerous proposed benefits of accelerating recovery through a decrease in muscle soreness, inflammation, and fatigue (Bleakley et al., 2012), improving mental well-being, and providing relaxation and psychological recovery benefits (Laukkanen et al., 2019). Therefore, in addition to fundamental recovery methods of nutrition, hydration, and sleep, the strategic implementation of deliberate heat and cold exposure has the potential to maximise recovery and psychological aspects in youth rugby athletes. However, the existing body of literature highlights a notable dearth of conclusive evidence elucidating the specific benefits of deliberate heat and cold exposure practices in enhancing recovery among young athletes. Moreover, despite the acknowledged significance of recovery, research has observed a recurrent failure among coaches to employ suitable monitoring tools for effectively assessing the efficacy of recovery methods (Simjanovic et al., 2009).

Elite youth athletes face a substantial workload throughout the first XV rugby season. Typically, a 22-week season includes weekly matches, with the potential for additional knockout games and extensive travel. These athletes face rigorous training sessions, intense matches, and the pressure to perform at peak levels. The demanding nature of this schedule can lead to physical and mental fatigue, potentially compromising physical and psychological performance. This is supported by findings from a study on adolescent South African rugby players, who reported having comparable workloads to elite-level players over an 11-week period (Barnard et al., 2020). Therefore, the current study aimed to determine the effectiveness of a 12-week periodised recovery programme in implementing and monitoring deliberate heat and cold exposure on muscle power performance and mood states during competition. It was hypothesised that rugby athletes who adhere to the prescribed recovery protocols would maintain or improve muscular power performance and psychological well-being.

METHODS

Participants

Using a repeated measure study design, with conservative effect size f=0.23, alpha=0.05, 1 group with an estimated total sample of 29 participants with 7 measures (time) and a correlation among repeated measures of 0.25, the achieved beta (power) is 0.805 (G*Power 3.1.9.6, Heinrich-Heine-University, Düsseldorf, Germany). Twenty-nine male first XV rugby athletes (mean age 17.6 ± 0.6 years; mean body weight 87.5 ± 9.7 kg; mean height 182.2 ± 6.2 cm) volunteered for this study. To be eligible for participation in this study, individuals had to meet specific inclusion criteria, including being a member of the first XV rugby team and providing written informed consent. Conversely, exclusion criteria included medical conditions impeding or jeopardising the participant's health and safety. Additionally, participants with a total protocol attendance percentage below 70%, as recorded in the attendance Google sheet, were excluded from the study. The selected group of athletes had varying levels of playing experience, ranging from 6 to 12 years, coupled with regular engagement in strength and conditioning training for 2 to 4 years. This study received ethical approval from the institution's human ethics MUHE committee. (4000027500). Written informed consent was obtained from all participants, and appropriate processes were carried out to protect all participants' confidentiality, privacy, and safety.

Outcome Measures

Countermovement jump

A linear position transducer (LPT, GymAware Kinetic Performance Technology, Canberra, Australia) recorded lower-body mechanical peak power and mean concentric power. GymAware is a commercially manufactured LPT that accurately measures the vertical-only displacement by correcting for horizontal movement through fundamental trigonometry. (Wadhi et al., 2018). Participants completed a 3-minute standardised warm-up consisting of skipping followed by a countermovement jump (CMJ). The participants performed a 3-repetition rebounding CMJ. Participants were instructed to keep their hands on their hips during the exercise to eliminate upper body power use. Additionally, participants wore a GymAware waist belt with the transducer tether attached. Starting in an upright position, participants performed a squat to a depth of their choice. They focused on completing the eccentric phase of the jump as rapidly as possible to maximise the height of the subsequent concentric jump.

Previous research, which establishes the rebounding counter movement as a valid and reliable measure for assessing neuromuscular fatigue in young male rugby athletes, informed the selection and protocol of the CMJ test (Lloyd et al., 2011; Roe et al., 2016). Considering the participants' natural maturation stage and limited pre-plyometric training, a 3-repetition rebounding CMJ test was prescribed. Athletes were allowed to practice with two warm-up sets before their recorded set to ensure familiarity with the test protocol.

Rating of perceived exertion

Athletes utilised a 10-point rating of perceived exertion (RPE) scale to assess the intensity of their most challenging training session in the previous two weeks, as outlined by Phibbs et al. (2018). The data about internal physical measures were collected through a Google Forms questionnaire and recorded in a Google spreadsheet.

Profile of mood states

Psychological data was gathered from participants using a Google form, with responses submitted every two weeks throughout the competition season. The applicability of the questionnaire was assessed on six athletes from the 2nd XV rugby team. Upon analysing the findings, necessary modifications were implemented to enhance the questionnaire's clarity, relevance, and overall suitability for the intended purpose. The questionnaire encompassed a comprehensive range of 10 domains, each capturing various aspects of psychological states. These domains covered a spectrum of experiences, including feelings of being rested and refreshed, levels of soreness or fatigue, motivation to train, presence of anxiety or stress, confidence in one's abilities, excitement about competition, management of academic workload, ability to focus and concentrate, sense of balance and control, and satisfaction with sleep quality. These domains were derived from the profile of mood states for youth (POMS) questionnaire that assessed participants' psychological states. The participants rated each domain using a four-point Likert scale with the following standards: 0 = Not at all; 1 = A little; 2 = Moderately; 3 = Quite a bit; 4 = Extremely.

Table 1. A typical weekly microcycle during the competition phase

	Morning	Afternoon
Monday	Team Gym (Power/Strength)	Backs (Speed Technique) Forwards (Scrums)
Tuesday	Rest	Team Training - conditioning game warm-up
Wednesday	Metabolic Conditioning	*Conditioning may be scheduled in the afternoon during some weeks
Thursday	Individual Gym AM or PM (Power/Strength)	Team Training - Speed warm-up
Friday	Rest	Captains Run/Travel Day
Saturday	Gym Activation and Ice Bath	Match (12/1pm)
Sunday	REST DAY (Active Recovery)	

Intervention

The intervention included deliberate heat and cold exposures over the 12 weeks of competition. As part of the weekly microcycle (Table 1), two separate cold exposures and one deliberate heat exposure were administered each week during home and away games. The outcome measures were assessed every two weeks, specifically focusing on CMJ perceived exertion rating, and mood state profile. These measurements were taken six days after each game.

Heat and cold exposure protocols

The heat exposure protocol consisted of the athletes sitting in a flat-pack dry six-person barrel cedar sauna (191 [width] x 196 [height] x 224 [depth]). For 15 minutes, the athletes were exposed to a sauna temperature of 100°C with a relative humidity of 10%. The use of a single 15-minute sauna session at 100°C for athlete recovery is supported by earlier research that reported beneficial effects on the cardiovascular system, autonomic nervous system, and endocrine system (Hannuksela & Ellahham, 2001). Moreover, this protocol is well-suited to the time constraints imposed by the athlete's school setting.

The cold exposure involved the athletes immersing their bodies in a four single-person, 1420 mm (length) x 450 mm (width) x 300 mm (height) polyethene ice baths. The water temperature was maintained at 5°C and monitored using a digital thermometer. Athletes showered before exposure to remove any dirt, sweat or other matter that may impact athlete hygiene. Athletes with open cuts or blood were required to have a waterproof covering and participate last before the bath was cleaned, emptied, and cleaned directly afterwards. All baths were drained and cleaned with disinfectant every 48 hours.

The findings from a meta-analysis (Poppendieck et al., 2013) revealed that shorter durations of cold-water immersion (less than 5 minutes) are more effective in enhancing performance recovery than longer durations. Moreover, the analysis showed that lower water temperatures (below 10°C) are associated with greater improvements in performance recovery than higher temperatures. These findings suggest that implementing exposures at 5°C for 5 minutes or less could be a highly effective strategy for promoting post-game recovery within the context of the current study.

The primary researcher closely supervised all sessions to ensure strict adherence to the protocol, as well as to monitor any potential adverse effects that may arise. The findings from previous research support the recommendation of immediate post-game cold exposure, which has been demonstrated to alleviate muscle soreness and enhance recovery between matches (Rowsell et al., 2009). Additionally, research has demonstrated the benefits of incorporating a second cold exposure five days after the match, taking into account the cumulative workload experienced by athletes within the microcycle (Versey et al., 2012). These findings strongly indicate that intentional cold exposure offers the greatest advantages when implemented within the 24 to 96-hour following exercise. Consequently, the implication is that a secondary cold exposure later in the microcycle could potentially enhance recovery from strength, metabolic, and field sessions, effectively equipping athletes for the imminent competition within the subsequent two days. Furthermore, deliberate heat exposure 48 hours after a match has been shown to have positive effects on the endocrine system, including increased plasma growth hormone and prolactin levels for up to 72 hours after its use (Scoon et al., 2007).

Training & playing week

During the competitive phase, a common microcycle strategy frequently employed a peaking and unloading approach. On Monday, athletes participated in low-volume, high-intensity workouts to promote ongoing recovery. Tuesday and Wednesday sessions consisted of high-intensity, high-volume exercises, with a subsequent reduction in volume and intensity leading up to Saturday. This approach aimed to promote super compensation and improve the athlete's preparedness for peak performance on match day (Cross et al., 2019) (Table 1).

Statistical Analyses

Physical data was analysed using descriptive statistics of mean and standard deviation. The rebounding CMJ peak power and mean power over time were analysed using a one-way repeated measures analysis of variance. Psychological data from the POMS questionnaire and RPE data were analysed using a non-parametric Friedman test using descriptive statistics of mean, standard deviation, and interquartile ranges. When the main effect of time revealed a significant difference, post-hoc comparisons were performed using the Bonferroni correction. The significance level was set at $p < 0.05$, and all data was analysed by Statistical Package for Social Sciences (SPSS, Statistics version 28, IBM New York, USA). The normality of the data was analysed using the Shapiro-Wilk test, which showed that normal distribution and sphericity were not breached.

RESULTS

The participants demonstrated an overall protocol adherence rate of 80.3%. Mean and standard deviation (SD) data for CMJ peak power F (6,168) = 0.439, p = 0.759 and mean CMJ concentric power F (6,168) = 0.474, p = 0.712 are shown in Figures 1 and 2. There was no significant time effect (Figures. 2 & 3). For RPE, there was a significant time effect F (6,168) = 6.082, $p < 0.001$, such that a post hoc comparison identified a significant time effect between week 0 (baseline) compared to week 2 through week 12 (Table 2).

Eight of the ten POMS domains reported no significant time effect ($p > 0.05$) (Table 2). The presence of soreness or fatigue demonstrated a significant time effect χ^2 = 27.976, df = 6, p = 0.032, as did the level of excitement regarding the competition χ^2 = 27.976, df = 6, p < 0.001. Post hoc comparisons identified the significant time effect for sore or fatigued occurred from week 2 to week 4 (p = 0.040). The significant time effect for excitement about competition occurred between week 0 (baseline) and week 10 (p = 0.040).

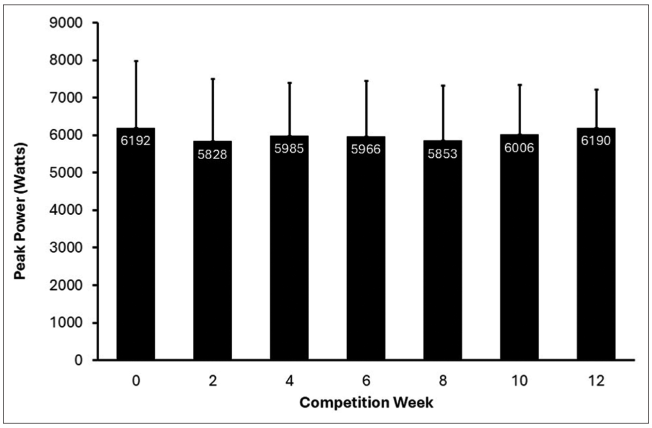

Figure 1. Mean ± SD of CMJ peak power over the 12-week competition

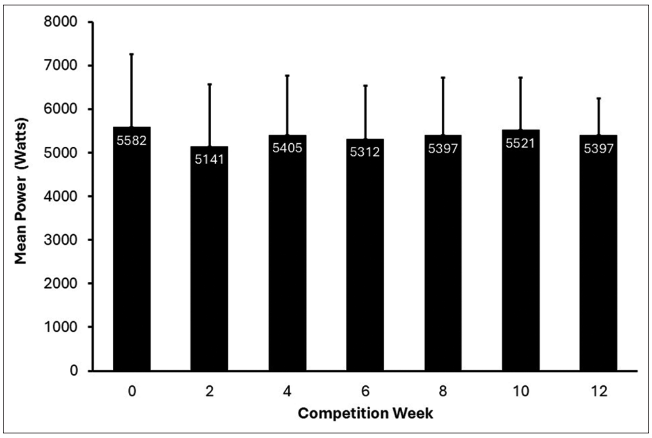

Figure 2. Mean ± SD of CMJ peak power over the 12-week competition

DISCUSSION

This study aimed to determine the efficacy of a 12-week periodised recovery programme of deliberate heat and cold exposure on muscle power performance, RPE, and mood states during a competition season for youth first XV rugby athletes. The findings support the hypothesis that participants maintained their lower body power performance and psychological mood states, as there were no significant changes in CMJ performance over the 12 weeks. Additionally, the reduction in RPE observed from week two was sustained through week 12.

The present study found no statistically significant changes in CMJ peak power and CMJ mean concentric power, which is consistent with previous research. For example, a survey of youth elite football athletes found no significant changes in CMJ height (p = 0.74) when alternating 1-minute 10°C cold exposure with 1-minute no exposure for 10 minutes. (Rowsell et al., 2009). Another study, which involved deliberate heat exposure, reported no significant differences (p = 0.35 in CMJ performance between the deliberate heat and placebo groups (Skorski et al., 2020). It's worth noting that the intervention in the latter study was significantly different from the present study, as it involved three 8-minute intervals at temperatures ranging from 80-85°C. (Skorski et al., 2020). Although the present study utilised a unique combination of individual deliberate heat and cold exposure interventions, it is reasonable to conclude that neither method provides a discernible advantage in terms of recovery.

In contrast, previous research reported a significant improvement in weighted squat jump performance using an intervention that alternated 1-minute exposures to cold water at 15°C and hot water at 38°C for 14 minutes (Vaile et al., 2008). It is important to note that this study employed distinctive interventions and included participants from a demographic different from the current study. Factors such as the unique combination of heat and cold exposures, variations in measurement timing, and the inclusion of youth athletes in our study may have influenced the outcomes observed. Although there were no changes in CMJ peak and concentric power, there was a consistent pattern of fluctuations that could suggest subtle effects of the recovery protocol on physical performance. Although not statistically significant, these fluctuations might indicate a tendency for performance to stabilise despite the competition, which is relevant for ath-

Table 2. Mean±SD of POMS domains and RPE of the most challenging session of the fortnight and the time effect across 12 weeks of competition

POMS Domains	Fortnightly Measures							Time effect p-value
	Week 0	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12	
Rested and refreshed	2.36±0.66	2.59±0.66	2.27±0.77	2.68±0.57	2.64±0.73	2.41±0.80	2.60±0.85	0.204
Sore or fatigued	1.59±0.85	1.32±0.84	2.18±0.80 ⊗	1.59±0.96	1.50±1.01	1.59±0.96	1.86±1.04	0.032
Motivated to train	3.05±0.58	3.05±0.95	2.95±0.65	2.77±0.53	2.95±0.79	2.64±0.85	2.73±0.83	0.141
Anxious or stressed	1.50±1.01	1.36±1.00	1.55±0.91	1.32±0.89	1.50±0.86	1.45±0.86	1.55±1.01	0.937
Confident in your abilities	2.59±0.73	2.45±0.86	2.59±0.67	2.68±0.57	2.59±0.80	2.59±0.50	2.50±0.60	0.812
Excited about competition	3.50±0.67	3.36±0.58	3.23±0.61	3.23±0.69	2.95±0.79	2.68±0.89 ⊕	2.77±0.92	<0.001
Managing academic workload	2.23±0.81	2.23±0.81	2.23±0.81	2.14±0.77	2.18±0.66	2.09±1.02	2.32±0.95	0.909
Able to focus and concentrate	2.32±0.89	2.27±0.77	2.64±0.85	2.32±0.72	2.41±0.67	2.23±1.02	2.27±0.70	0.466
Balanced and in control	2.36±0.79	2.36±0.79	2.50±0.51	2.41±0.50	2.45±0.60	2.32±0.99	2.41±0.73	0.998
Satisfied with sleep quality	2.00±0.87	2.41±1.10	2.36±0.85	2.27±0.88	2.00±0.93	2.23±0.92	2.23±0.75	0.276
RPE	8.28±1.20	6.18±1.56*	6.32±2.44*	6.10±1.54*	6.00±1.66*	5.73±1.64*	6.23±1.82*	<0.001

KEY: * significantly different to week 0 (baseline)
⊗ significantly different to week 2
⊕significantly different to week 0 (baseline)

lete management and has practical importance in programme design and athlete preparation.

The analysis of RPE demonstrated a significant time effect throughout the 12-week competition season when comparing the baseline scores with those of the subsequent weeks. The mean baseline RPE of 8.28 showed a noticeable decrease by week two (6.18), but in successive weeks, it did not exhibit any statistically significant changes in RPE. This observation may be attributed to the introduction of the intervention, which could have influenced perceptions of in-season workloads differently compared to preseason loads without the intervention. A previous study reported a significant reduction in RPE when implementing a 10-minute cold exposure at temperatures ranging from 0.5°C to 4.4°C (Galder & Gann, 2015). This suggests that a single 10-minute cold exposure intervention at temperatures below 5°C, as opposed to the current study's two separate 5-minute exposures, may be more effective in improving RPE.

In the present study, the analysis of the POMS domains revealed a significant time effect in two out of the ten domains examined. Notably, there was a discernible temporal shift in perceptions of soreness or fatigue, as indicated by the mean scores of week two (1.32) and week four (2.18). During weeks two to four, which coincided with the period of lowest adherence to the interventions, a notable increase in soreness or fatigue was observed. These findings align with prior research. (Rowsell et al., 2009), who reported reduced perceptions of general fatigue (p = 0.007) and soreness (p = 0.004) following a 10-minute intervention involving alternating 1-minute exposures to 10°C cold and no exposure. Additionally, Ahokas et al. (2023) have documented a decrease in subjective soreness after a 20-minute deliberate heat intervention at 43°C. These findings (Rowsell et al. 2009; Ahokas et al. 2023) support the current study's observation that the intervention effectively improved perceptions of soreness and fatigue following a statistically significant increase in week 4.

The participant's perception of excitement about competition, as captured by the POMS domain, exhibited a significant time effect between the mean score at baseline (3.50) and the mean score at week 10 (2.68). The consistent accumulation of game losses throughout the season may have influenced the observed outcome of decreased excitement about competition. Further, previous work has identified the potential benefits of regular, deliberate heat interventions involving temperatures ranging from 80-100°C and durations based on individual subjective discomfort (Kukkonen-Harjula et al., 1989). The authors revealed that norepinephrine, epinephrine, and beta-endorphin levels increased two to four times, resulting in improved stress mitigation, increased energy availability, and enhanced well-being. Based on these findings, the current study may not have been sufficient to improve excitement levels if it had included only one deliberate heat exposure per week. Incorporating multiple interventions could have potentially yielded more favourable outcomes. Therefore, to realise significant effects, the frequency and duration of the recovery interventions might need adjusting to capture changes in these psychological states.

The present study did not find any statistically significant changes in physical or psychological measures. In contrast, without any recovery intervention, Oliver et al. (2015) observed neuromuscular and perceptual fatigue in youth rugby athletes over a 7-week competition period. They reported a significant decline in CMJ performance, with reductions of -6.8% at week four and -14.6% at week seven and significant decreases in perceptual well-being measures, indicating the impact of long-term accumulated fatigue. Therefore, as the current findings show, implementing a recovery programme during the competition will likely maintain neuromuscular (power), internal load (i.e., RPE), and mood state measures. Although CMJ performance metrics did not show significant changes, a consistent adherence rate of 80.3% indicates strong engagement with the intervention, which may positively influence long-term athletic development in laying the foundation for future improvements.

With any field-based study, some limitations need to be considered. The individual responses to the intervention may have varied due to factors beyond the study's control. These factors include participants engaging in other sports, using alternative recovery methods, encountering diverse microcycle workloads, and contending with external factors influencing recovery, such as sleep, nutrition, and hydration. While it would have been ideal for the study to include both an experimental and control group, such an approach would have been impractical and inequitable. It would have required providing the intervention to some team members while withholding it from others. Consequently, the ability to make direct comparisons between participants was limited. The frequency and duration of the recovery intervention and measurement timing may not have fully captured the short-term fluctuations in physical performance and mood state. Additionally, it is currently unclear how body composition affects the response to intentional exposure to heat and cold. In rugby, the diverse range of body compositions resulting from varying positional needs may have required individualised protocols to ensure consistent outcomes for different players.

The programme's practical benefit provides a method for managing in-season recovery without introducing additional performance decrements. This could be an important strategy for coaches who aim to keep athletes performing consistently throughout a competition season while minimising stress and strain. Practitioners should consider modifying the frequency, duration, or intensity of heat and cold exposures based on the specific needs of athletes. For instance, increasing the number of sessions per week or adjusting exposure times may yield more significant benefits. The high adherence rate (80.3%) shows that youth athletes can successfully integrate these recovery methods into their routines, which may support their long-term development. Regular engagement with structured recovery strategies may lay the foundation for better habits in future athletic careers.

CONCLUSION

To the best of our knowledge, this is the first study to have examined the efficacy of a 12-week periodised recovery programme involving one deliberate heat and two deliberate cold exposures a week in youth rugby athletes. Physical and psychological measures did not present statistically significant changes, indicating that the recovery programme enabled the maintenance of CMJ peak power, CMJ mean concentric power, RPE and POMS. Therefore, the recovery intervention appeared to maintain physical and psychological aspects over a 12-week competition. However, more comprehensive and controlled research is needed to confirm and extend these findings.

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AUTHOR CONTRIBUTION

DC and LY conceptualised the study. LY collected the data. DC and LY analysed the data, with LY drafting the manuscript and DC provided additional writing, reviewing and editing. Both authors read and agreed to the published version of the manuscript.

ETHICAL APPROVAL

The study was approved by Massey University Human Ethics Committee (4000027500) and carried out under the guidelines of the Declaration of Helsinki for human research.

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