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Effects of contemporary cryo-compression on post-training performance in elite academy footballers

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ABSTRACT: Fatigue is a predisposing risk factor for injury commonly investigated in elite football populations. Little evidence advocates the most beneficial recovery strategies including contemporary cooling applications. The aim of the study was to examine immediate effects of the Game Ready® on physiological and biomechanical measures in a population of elite male academy footballers, following a fatiguing training session mid-competitive season. Twenty, elite male footballers took part (180.2 ± 8.7cm, 75.0 ± 11.4kg, 18 ± 0.5years). Following a normal fatiguing training session, players were randomly assigned to receive either cryotherapy (Game Ready®) (20-minutes at medium compression (5–55 mm Hg)) or passive recovery (PAS). Data was collected at match-day+1, immediately post-training and immediately post-intervention. Performance measures included countermovement jump (CMJ), isometric adductor strength (IAS), hamstring flexibility (HF), and skin surface temperature (T_{sk}). Significant main effects for group for CMJ data following exposure to cooling were displayed ($p = < 0.05$). Individual group analysis displayed a significant reduction in CMJ performance in the group exposed to cryotherapy ($p = < 0.05$) immediately post, but not for PAS. No main effects were identified for cryotherapy or PAS group for IAS or HF ($p = > 0.05$). T_{sk} reduced significantly ($p = < 0.05$) in the cryotherapy group, meeting therapeutic T_{sk} range. Reductions in performance immediately following exposure to pneumatic cryo-compressive devices may negate the justification of this recovery strategy if neuromuscular mechanisms are required in immediate short term. Application of such recovery strategies however are dependent on the type of recovery demand and should be adapted individually to suit the needs of the athlete to optimise readiness to train/play.

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INTRODUCTION

To optimise post-training recovery response to fatigue is desirable and several strategies are proposed within the literature to prepare athletes for in-season training demands [1, 2]. Perceptions and practices used in the practical setting however are not always supported by validated recommendations from research and vice versa [1]. Without appropriate recovery strategies optimal competition performance may be hindered or result in an increased risk of injury [3, 4]. Between bouts of fatiguing exercise through competitive season training cycles, the maintenance of muscular performance and function is required, and choice of recovery strategy or modality to achieve this is important [3, 5]. The effects of cryotherapy as an acute recovery strategy, measurable by performance parameters in sport, are debated in terms of periodisation and impact following training [2, 6]. Typically, the application of cooling is often utilised with the aim to reduce the symptoms of fatigue [7, 8], mitigating the consequence of reduced performance levels or perceptual indices of recovery in elite football/soccer. Equivocal evidence however fails to consolidate understanding around the effects of cryotherapy on muscular function in relation to optimal recovery through performance markers.

A large proportion of practitioners administer CWI post daily training and base the choice of modality on practicality and accessibility [2]. Inappropriate periodisation or choice of cryotherapy modality however has the potential to impact negatively the adaptations intended from training [9, 10], despite known physiological benefits. Dose-response in terms of duration of application presents further disparities thus failing to present agreement on optimal recovery protocols using cryotherapy. Many studies report on the use of CWI [2, 11] on pertinent football performance parameters however the same cannot be reported for many contemporary cryo-compressive devices, such as the Game Ready® (CoolSystems, Inc). A consensus on optimal protocols in terms of periodisation of cooling applications using cryo-compressive devices is also absent.

To further the understanding on current recovery practices in elite sport settings with the aim to develop cryotherapy protocols for within-season post training recovery, the effects of contemporary cryotherapeutic cooling devices on common performance parameters requires investigation. Conjecture in the current literature recommends the investigation of cooling recovery modalities with the target of informing evidenced-based prescription around professional team sport schedules [2]. The aim of the current study was to examine the immediate physiological and biomechanical performance effects of the Game Ready® as a recovery strategy in a population of male elite academy footballers, following a fatiguing training session during mid-competitive season.

MATERIALS AND METHODS

Subjects

Twenty, elite male academy footballers volunteered to take part in the study (height: 180.2 ± 8.7cm, weight: 75.0 ± 11.4kg, age: 18 ± 0.5years). The purpose of the study was presented to each participant with an information sheet outlining the protocol. All players provided written and verbal consent to take part. All players met the inclusion criteria (academy age group footballer, healthy, male, no current injury to the lower limbs). Players were excluded from the study if they presented with; current / history of lower limb injury/surgery in the last six months; female; outside academy age range, known neurological compromise to cold, such as Raynauds [12]. Ethical approval for the study was approved by the host university and adhered to the Declaration of Helsinki (2013), data collected was permitted for publication via the host football club. The same researchers collected each data from the physiological and biomechanical assessments throughout the study.

Testing Protocol

Data collection took place in a rehabilitation testing suite at the football club, mid-competitive academy season. Players were randomly allocated to receive either passive recovery (PAS) (Group 1) or cryotherapy intervention (CRYO) (Group 2) post fatiguing exercise coinciding with normal weekly training schedules (Table 1). Familiarisation of the biomechanical and psychological assessments were not required as these tests are regularly performed by the squad and participants therefore conversant of each outcome measure. Baseline measures were collected at match day+1 consisting of hamstring flexibility (HF) via sit and reach test (SRT) (Apollo Sit & Reach Box), neuromuscular function (NMF) through a countermovement-jump (CMJ) (OptoJump System, Microgate, Bolzano, Italy) and isometric adductor strength (IAS) quantified by a Sphygmomanometer (Disytest; Welch Allyn, Skaneateles, NY). Intervention of either PAS or CRYO commenced on match day+3 following a fatiguing training session (Table 1). PAS group consisted of 20-minutes laying still in a semi-recumbent position on a plinth. The cryotherapy intervention utilised in the CRYO group consisted of the Game Ready® pneumatic-cooling device applied to both lower limbs (circumferentially wrapped around the thigh) for a 20-minute dose with medium intermittent compression (5–55 mm Hg). One Game Ready® base unit was used and two lower limb cuffs connected with a splitter device allowing for the crushed ice and water contents to circulate both limb cuffs. Individuals remained in a supine semi-recumbent position on a plinth during application.

Physiological Measure

Thermal images were taken of the hamstring and quadriceps of both limbs before and after either intervention. Skin surface temperature (T_{sk}) collected using Infrared Thermal Imaging (ThermoVision A40M, Flir Systems, Danderyd, Sweden) followed standard protocol set up of the TISEM guidelines [13] capturing three images per region of interest (ROI) with analysis taking the mean average T_{sk}. Emissivity settings were 0.97–0.98 following normal clinical approaches with the thermal imaging camera situated at 134cm from the ground perpendicular to the lower limb [14]. Images of the anterior thigh were taken initially, followed by the posterior thigh turning from a supine to prone position on the plinth. Over the anterior thigh a ROI was determined by placing thermally inert markers providing a framework to quantify T_{sk} [15]. Location of markers included superiorly (one-third way between anterior superior iliac spine (ASIS) and base of the patella) and inferiorly (two thirds way between ASIS and base of the patella) with central anterior thigh determined by measure of thigh circumference, 50% between ASIS and base of patella [14]. Posterior markers were applied in a similar fashion, applied superiorly one-third from the ischial tuberosity to the lateral epicondyle of the femur and inferiorly two-thirds from the lateral epicondyle of the femur to ischial tuberosity. Centre of the posterior thigh determined by thigh circumference in the same approach as the anterior thigh marker placement. Markers were then placed at 10% medially and laterally from these marker locations to complete a ROI for the posterior thigh. To complete the ROI, markers were applied at 10% of the distance in lateral and medial directions from the centre of the thigh for both anterior and posterior regions.

Ambient room temperature monitored at the point of testing for each participant was measured to ensure consistency throughout testing and to monitor any fluctuations (21.8 ± 0.7°C).

Performance measures protocols

CMJ height as a form of quantifying neuromuscular function was performed. Excellent test-retest reliability (ICC 0.982–0.989) has been demonstrated for the Optojump system [16] for field-based assessment of CMJ with acknowledgement in contemporary literature as being the most accurate when comparing to other portable devices used to measure neuromuscular parameters [17]. To perform the CMJ participants positioned themselves in-between the infrared platform (OptoJump System, Microgate, Bolzano, Italy) with both feet (wearing trainers) on the ground, shoulder width apart with their hands on their hips throughout the full CMJ [18]. To execute the jump players flexed their knees to their preferred starting push-off position [19]. The decision to keep hands-on-hips was based upon the approach that suggests hands-on-hips isolates lower extremity force production and eliminating potential arm-swing and postural variations [18, 20]. Taking off from this position the participant was instructed to jump as high as they possibly could and landed back on both feet. Trials were validated by the researcher through visual inspection to ensure satisfactory landing and participants performed three trials, separated by 45 seconds of passive recovery [21]. Jump height of each player was calculated by flight time (cm) and best jump used for analysis [21].

Isometric Adductor Strength (IAS)

For IAS measures, participants lay in a semi-supine position, hips flexed at 45°, with the sphygmomanometer placed in-between both legs at the medial aspect of the knees [22]. The sphygmomanometer was set to 10 mm Hg tension prior to each session [22]. When relaxed participants then squeezed the cuff in between their legs as forcefully as they could for 3 seconds and a score was recorded.

Hamstring Flexibility (HF)

HF was quantified via the SRT (Apollo Sit & Reach Box). Participants removed their trainers to perform the SRT, in a half-sitting position with knees in full extension, and both feet flat against the SRT box. The bar was slowly pushed as far as possible with palms facing down and tips of fingers moving forwards [23]. To the nearest cm the range was calculated. Participants repeated the test once for analysis per each timepoint.

Statistical Analysis

Statistical analysis was performed using SPSS (Version 26.0) (SPSS Inc, Chicago, IL). The statistical significance was set at $p = \leq 0.05$ with all data presented as mean ± (SD) with 95% confidence limits. A univariate repeated-measures general linear model quantified the main effects across all timepoints and interventions for biomechanical and physiological measures. Post-hoc analysis with a Bonferonni correction for performance parameters explored any significant main effects. To assess residual normality for each dependant variable, q-q plots were generated using stacked standardised residuals. Scatterplots of the stacked unstandardized and standardised residuals were utilised to assess error of variance associated with the residuals. The assumptions associated with the statistical model were assessed to ensure model adequacy. Mauchly's test of sphericity were completed for all dependent variables, with a Greenhouse Geisser correction applied if the test was significant. Partial eta squared (η^2) values were calculated to estimate effect sizes for all significant main effects and interactions. Partial eta squared was classified as small (0.01–0.059), moderate (0.06–0.137), and large (> 0.138).

RESULTS

Physiological Measures (T_{sk})

Overall analysis identified a significant main effect of group and timepoint for quadriceps (Group: $F = 93.38, p = < 0.00, \eta^2 = 0.940$; Timepoint: $F = 84.69, p = < 0.00, \eta^2 = 0.966$); and hamstrings T_{sk} (Group: $F = 2136.41, p = < 0.00, \eta^2 = 0.997$; Timepoint: $F = 2060.27, p = < 0.00, \eta^2 = 0.999$). Significant interaction was displayed for group *x* timepoint for quadriceps ($F = 91.08, p = < 0.00, \eta^2 = 0.968$) and hamstrings T_{sk} ($F = 1993.0, p = < 0.00, \eta^2 = 0.998$). Statistically significant decreases in T_{sk} over the quadriceps and hamstrings ROI's immediately post-intervention, compared to immediately post-training and baseline temperatures for the Cryo group were displayed ($p = < 0.05$). No significant differences in T_{sk} were reported for the PAS group across any timepoint (Table 2).

Biomechanical Measures (CMJ, IAS, HF)

Overall analysis for the biomechanical data set displayed significant main effects group ($F = 5.005, p = 0.029, \eta^2 = 0.85$), but not timepoint ($F = 1.028, p = 0.365, \eta^2 = 0.037$) for CMJ. No

TABLE 1. Data collection protocol.

		Weekly Post Match Day Training Schedule		
		Match Day +1	**Match Day +2**	**Match Day +3 Scheduled Training**
Time Point (1–3)		1. Baseline Data Collected *	No data collected	2. Post Training 3. Immediately Post Intervention
GROUP	**Group 1 (PAS)**	Baseline Data Collected *	No data collected	Post training data collected * Immediately post (PAS) data collected *
	Group 2 (Cryo)	Baseline Data Collected *	No data collected	Post training data collected * Immediately post (Cryo) data collected *

*Data collection at all timepoints consisted of; Performance measures = Countermovement Jump (CMJ); Isometric Adductor Strength (IAS), Hamstring Flexibility (HF); Skin Surface Temperature (T_{sk}) of hamstring and adductors.

TABLE 2. Descriptive (mean ± SD) for hamstring and quadriceps ROI, for both PAS and Cryo groups across all time points.

Group	ROI**	Limb	Time Point Baseline (T_{sk}) (°C)	 Immediately Post Training (T_{sk}) (°C)	 Immediately post intervention (T_{sk}) (°C)
PAS	Quadriceps*	LEFT	30.7 ± 1.5	30.2 ± 0.2	31.1 ± 0.8
		RIGHT	30.1 ± 1.2	29.9 ± 0.5	30.0 ± 0.5
	Hamstrings*	LEFT	30.9 ± 1.2	30.1 ± 0.9	30.2 ± 0.5
		RIGHT	30.5 ± 0.8	29.8 ± 0.8	30.1 ± 0.4
	Average T_{sk} (quadriceps and hamstrings both limbs) (°**C**)		30.5 ± 1.2	30.0 ± 0.6	30.2 ± 0.6
Cryo	Quadriceps*	LEFT	30.1 ± 1.2	29.9 ± 1.1	10.8 ± 1.1
		RIGHT	30.5 ± 1.3	30.1 ± 1.2	14.3 ± 1.2
	Hamstrings*	LEFT	29.8 ± 1.3	30.6 ± 1.1	11.3 ± 1.3
		RIGHT	29.5 ± 0.9	30.5 ± 1.2	12.8 ± 1.4
	Average T_{sk} (quadriceps and hamstrings both limbs) (°**C**)		29.8 ± 1.2	30.3 ± 1.2	12.3 ± 1.3

*Bilateral limb T_{sk} measures (mean ± SD). **ROI = Region of Interest. ***Significance at *p = < 0.001*

Table 3. Descriptive (mean ± SD) for biomechanical measures of CMJ, IAS and HF for both PAS and Cryo groups across all time points.

GROUP	PERFORMANCE PARAMETER	TIMEPOINT Baseline (match day+1)	 Immediately Post Training (IPT) (match day +3)	 Immediately Post Intervention (IPI) (match day +3)	Percentage change (%) from IPT to IPI time point
PAS	*CMJ (Jump Height – cm)*	35.1 ± 5.1	34.7 ± 5.5	35.2 ± 5.1	+1.43%
	HF (cm)	24.0 ± 5.5	22.4 ± 5.3	22.6 ± 4.7	+0.88%
	IAS (mm Hg)	224.0 ± 41.9	231.9 ± 51.9	235.0 ± 55.8	+1.33%
Cryo	*CMJ (Jump Height – cm)*	33.2 ± 4.7	33.8 ± 5.1	29.3 ± 4.2*	-13.3%
	HF (cm)	24.5 ± 5.6	24.1 ± 5.9	24.2 ± 5.9	+0.41%
	IAS (mm Hg)	215.0 ± 41.9	215.0 ± 51.9	220.0 ± 71.3	+2.2%

CMJ = Countermovement Jump; IAS = Isometric Adductor Strength; HF = Hamstring Flexibility; *Significance at *p = < 0.05 data compared to baseline.*

significant main effects were displayed for group or timepoint for IAS (Group: $F = 0.977, p = 0.327, \eta^2 = 0.018$; Timepoint: $F = 0.112, p = 0.894, \eta^2 = 0.004$) or HF (Group: $F = 0.918, p = 0.342, \eta^2 = 0.017$; Timepoint: $F = 0.68, p = 0.935, \eta^2 = 0.003$). No significant interactions were displayed between group *x* timepoint for CMJ, IAS or HF (CMJ: $F = 1.345, p = 0.269, \eta^2 = 0.047$; IAS: $F = 0.030, p = 0.971, \eta^2 = 0.001$, HF: $F = 0.199, p = 0.820, \eta^2 = 0.007$).

Collapse of the data into physiological and biomechanical data for Cryo group displayed no significant effects for HF ($F = 0.016, p = 0.984, \eta^2 = 0.001$), CMJ ($F = 2.674, p = 0.87, \eta^2 = 0.165$), or IAS ($F = 0.026, p = 0.944, \eta^2 = 0.002$). For the PAS group no significant effects for HF ($F = 0.281, p = 0.758, \eta^2 = 0.020$), CMJ ($F = 0.018, p = 0.982, \eta^2 = 0.001$), or IAS ($F = 0.127, p = 0.881, \eta^2 = 0.009$). A significant difference is displayed between Cryo and PAS groups for CMJ ($p = 0.02$) regardless of timepoint. Significant reductions in CMJ were reported between immediately-post training and immediately-post cooling timepoints ($p = 0.04$) for the Cryo group (Table 3). No other significant differences at any other timepoint for Cryo group for CMJ data were reported ($p = > 0.05$). For the PAS group no significant differences were displayed for CMJ, HF or IAS data when comparing between each timepoint ($p = > 0.05$). The Cryo group displayed no significant differences between timepoint for IAS or HF ($p = > 0.05$).

DISCUSSION

The study aimed to investigate the effects of a contemporary cryo-compressive cooling device compared to passive recovery on physiological and biomechanical measures following a fatiguing training session within an elite male academy football population. With physical performance known to decline following competitive match play in football [24, 25], optimal recovery strategies are therefore paramount for readiness to train / play performance. Furthermore, the effects of congested schedules on performance and injury risk may be heighted due to accumulative fatigue and literature encourages the need for optimal recovery strategies [24]. Cryotherapy in many forms is used for recovery and is common practice within elite performance settings despite limited evidence for its efficacy or use [26]. The current study observed several parameters, both physiological and biomechanical in nature, representing typical monitoring techniques used during a competitive football season with results demonstrating significant main effects for group, for CMJ data following exposure to cooling (Game Ready®). Further analysis displayed significant reductions in CMJ performance (jump height) in the group exposed to cryotherapy (CRYO) ($p = < 0.05$) immediately post exposure following a fatiguing training session, the same was not demonstrated in the PAS group. No main effects were identified for the CRYO or PAS group for IAS or HF ($p = > 0.05$). Results have implications of decision-making for the use of the Game Ready® device to optimise its application as a recovery strategy compared to passive recovery in an elite football setting. Findings support the multifaceted approach of athlete monitoring in practice; replicated in research this helps determine response to common strategies applied in elite performance settings through relevant applied markers.

T_{sk} reduced significantly ($p = < 0.05$) in the CRYO group across both ROI's (hamstring and quadriceps), compared to IPT timepoint, meeting therapeutic T_{sk} range for physiological changes to ensue, according to previous literature [27]. Similar T_{sk} responses after Game Ready® applications are reported in recent literature [28] albeit varying slightly thought to be due to levels of compression adjunct between the available protocols offered by the device and differences in methodological approaches between studies. The Game Ready® protocol chosen in the current study represented a typical application of contemporary cryo-compression method used in the club where data was collected. Although T_{sk} was not consistent bilaterally (Table 2), results support this protocol if the target aim is to successfully reduce T_{sk} to within therapeutic range circumferentially over the bilateral thigh region in this population. We can only presume intra-muscular response as this was not quantified in this study however, we consider the significant reduction in CMJ in the CRYO group occurred due to physiological changes in deeper structures required for feedback, altering neuromuscular biomechanical output, resulting in a reduced jump height. The effectiveness of recovery protocols is often quantified by neuromuscular function through various assessment of contractile properties. Definitive conclusions as to the effects of cryotherapy on neuromuscular performance however are problematic to draw based on available literature [26]. Previous studies typically quantify the effects of CWI for recovery, using CMJ as a means of measuring neuromuscular performance [29, 30], this is the first study to our knowledge that explores the Game Ready® quantified in a comparable fashion. Results from the current study appear to represent similar findings by Hohenauer et al, (2016) [30], in terms of time-course recovery at immediately post cold exposure, although direct comparisons are limited due to differences in cold modality applied. Perceptual indices were not determined in the current study, which may, as [30] Hohenauer et al (2016) suggests, influence objective performance measures. Quantification of wellbeing parameters should be considered in future study designs of a similar nature to fully elucidate the impact and effects of recovery parameters.

Non-significant changes were displayed for IAS / HF for both groups, and only marginal trends suggesting better increases in IAS measures following cooling compared to PAS depicted by small percentage change from IPT to IPI (Table 3). It was considered, compared to CMJ response however, that players felt more able to better perform isometric contraction following cooling due to analgesic influence on muscle soreness levels, although perceptual responses were not quantified in this study. The choice of performance measure, such as IAS is identified as a useful outcome measure that sports medicine or performance practitioners may implement during a congested season for the assessment of players readiness to compete [31]. That said, eccentric contraction as a damaging exercise and functional assessment of strength may provide better representation of fatigue related to injury risk factors in football and should be considered in future investigations of this nature as a relevant performance measure. Hohenauer et al, (2015) [7] concluded that evidence suggests after muscle damaging exercise, compared to passive strategies, cooling is a superior for recovery, although this conclusion was based on subjective responses alone. Assessment of wellbeing through perceptual responses to fatigue and recovery interventions may be beneficial in future studies to consider alongside physiological and biomechanical indices. In agreement with Ihsan et al (2020) [32] the suggestion of CWI is contextual, and so should the application of cryo-compressive devices in the same setting. A multifaceted approach to research design and parameters of measures is key to fully elucidate the influences on performance both positive and negative that cryotherapy modalities have. The trend of a small incremental increase in HF depicted by percentage change from IPT to IPI in the PAS group, although non-significant, may be explained by the impact cooling has on muscle mechanical properties through reduced stretch in muscle tissue [33]. The combination of objective and psychological measures for overall athlete response to cryotherapy recovery strategies may provide further explanation of biomechanical performances after exposure to such modalities. In addition to this, and a potential limitation in the current study is the period of observation. It would be beneficial to consider further assessment of performance measures again at 24-hours post training/intervention for example given the known temporal patterns of fatigue reported in football [25]. Future study design is recommended over a longer period of investigation, considering multiple micro-cycles to determine cumulative effects of multiple bouts of cryotherapy on several performance measures. Comparison of this protocol using methods such as CWI may be beneficial in future investigations through the additional exploration of individual athlete response.

Beneficial physiological responses to cooling following fatigue are generally focused around the symptom reduction of delayed onset muscle soreness (DOMS) [34] or perceived fatigue [7]. Several mechanisms explain the benefits of across many modes of cryotherapeutic exposures, including minimising muscle damage, inflammation [32] and soreness [35]. Optimal recovery may be determined by complex training load, fatigue and adaptation interactions [10]. Modulated recovery therefore is complex and the effect on performance is contradictory in supporting the benefits for recovery [36]. The outcomes of the current study suggest cryo-compression may negate the potential to perform optimal neuromuscular function immediately post exposure. Despite the physiological benefits highlighted in literature, findings suggest biomechanical function is reduced through the effect on neuromuscular response to cold. Consequently, this may be detrimental to the athlete, emphasising the need for correct periodisation of cryo-compression for maximum benefits of this modality. Although the current study supplements current debate, it only observes the acute effects and a temporal pattern of response is required to examine the effects of cryo-compressive recovery strategies over time (during a typical weekly micro-cycle) or multiple dosages. Safer periods of rewarming prior to functional movements requiring optimal neuromuscular performance following cryo-compression requires further investigation to optimise understanding and periodisation.

Although not demonstrated in this exploratory study, individual analysis of response is important to establish. Average group analysis as portrayed in the current study provides an approach too broad to provide crucial understanding within an applied sports performance setting for individualisation of recovery protocols. In accumulation these considerations in future research would benefit decision making around not only periodisation of cooling modalities within normal training and playing schedules but the individual responses within elite populations. Baseline measures were taken at match day+1, not pre-training, additional data at this timepoint may be more beneficial as a comparison due to the expected reductions in objective performance parameters so soon following a competitive fixture. Table 3 therefore depicts percentage differences from IPT-IPI timepoints as an indication of the meaningful effects of the recovery strategies employed in the current study. These observations have implications on future study design considering at what point data is collected to optimally reflect key markers of athlete recovery within mid-season micro-cycles.

CONCLUSIONS

Variable responses following exposure to the Game Ready® (20-minutes, medium compression (5–55 mm Hg) bilateral (thigh)) compared to passive recovery across several performance measures suggest individualisation of recovery strategies is important. Significant reductions in neuromuscular performance immediately following exposure to pneumatic cryo-compressive devices may negate the justification of this recovery strategy if neuromuscular mechanisms are required in the short term. Application of such recovery strategies however are dependent on the type of recovery demand and should be adapted to suit the needs of the athlete to optimise readiness to train/play. Future investigation into periodisation of contemporary cryo-compressive modalities within training micro-cycles for recovery is required over longer periods to fully elucidate temporal patterns. Multifactorial measures generate better understanding to support or refute the application of such methods currently practiced widely in elite football performance settings. Future studies should consider individual data analysis to establish optimal cry-compressive applications which may be advantageous for the athlete in terms of individualisation of recovery programmes.

Conflict of Interest

There are no conflicts of interest to declare.

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