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MANUSCRIPT TITLE: The effects of a single whole body cryotherapy exposure on physiological, performance and perceptual responses of professional academy soccer players following repeated sprint exercise

1 **RUNNING TITLE:** Cryotherapy and recovery from soccer

2

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7 **ABSTRACT**

8 In professional youth soccer players, the physiological, performance and perceptual effects of a single
9 whole body cryotherapy (WBC) session performed shortly after repeated sprint exercise were
10 investigated. In a randomized, counter-balanced and crossover design, 14 habituated English Premier
11 League academy soccer players performed 15 x 30 m sprints (each followed by a 10 m forced
12 deceleration) on two occasions. Within 20 min of exercise cessation, players entered a WBC chamber
13 (Cryo: 30 s at -60°C, 120 s at -135°C) or remained seated (Con) indoors in temperate conditions
14 (~25°C). Blood and saliva samples, peak power output (countermovement jump) and perceptual
15 indices of recovery and soreness were assessed pre-exercise and immediately, 2 h and 24 h post-
16 exercise. When compared to Con, a greater testosterone response was observed at 2 h ($+32.5 \pm 32.3$
17 $\text{pg}\cdot\text{ml}^{-1}$, +21%) and 24 h ($+50.4 \pm 48.9 \text{ pg}\cdot\text{ml}^{-1}$, +28%) post-exercise (both $P=0.002$) in Cryo (trial x
18 treatment interaction: $P=0.001$). No between trial differences were observed for other salivary
19 (cortisol and testosterone/cortisol ratio), blood (lactate and Creatine Kinase), performance (peak
20 power output) or perceptual (recovery or soreness) markers (all trial x treatment interactions: $P>0.05$);
21 all of which were influenced by exercise (time effects: all $P<0.05$). A single session of WBC
22 performed within 20 min of repeated sprint exercise elevated testosterone concentrations for 24 h but
23 did not affect any other performance, physiological or perceptual measurements taken. While
24 unclear, WBC may be efficacious for professional soccer players during congested fixture periods.

25

26 **KEYWORDS:** Creatine Kinase, fatigue, football, muscle damage, recovery

27

28 **INTRODUCTION**

29

30 Up to 120 h are required to restore disturbances in metabolic and physical performance markers
31 following soccer match-play (19). We recently reported reduced countermovement jump (CMJ)
32 performance and elevated Creatine Kinase (CK) concentrations in the 48 h after professional soccer
33 matches of 90 min (21) and 120 min (23) durations. However, professional European soccer teams
34 may play in excess of 60 competitive matches per season (6, 10) and thus at specific times of the year,
35 multiple matches will be played within a single week (10). Although unclear (6) injury risk has been
36 observed to increase when less than 96 h separates games (10) and the reduced recovery time between
37 matches played in FIFA World Cup competitions is perceived by physicians to be a primary cause of
38 injury in professional soccer players (18). Therefore, the ability to facilitate post-match recovery is
39 desirable.

40

41 A number of interventions have been proposed to facilitate post-exercise recovery (19), including:
42 nutritional strategies, cold water immersion, active recovery, compression garments, massage and
43 electrical stimulation. An additional method is whole body cryotherapy (WBC), which typically
44 involves exposure to very cold and dry air (-110 to -195°C) for a period of two to three minutes in a
45 temperature-controlled chamber (2, 12, 14). As summarised in a narrative review (2), the therapeutic
46 effects of repeated WBC exposures have been proposed to relate to changes in haematology (i.e.,
47 reduced haemolysis), muscular enzyme activity (i.e., reductions in circulating CK and lactate
48 dehydrogenase concentrations) and modified hormonal responses (i.e., stimulated noradrenaline
49 release). The importance of anti-oxidant capacity, inflammation, immunity and cardiac markers (2)
50 and performance and perceptual indices of recovery have also been highlighted in WBC research (3).

51

52 The majority of studies employing WBC for recovery purposes have implemented multiple cold
53 exposures; either, within a single day or throughout the week(s) following muscle damaging exercise.
54 In elite Italian rugby players engaged in regular training, Banfi et al. (1) observed reductions relative
55 to baseline values in muscle enzyme concentrations following five once-daily sessions of WBC over
56 the course of a week. Similarly, numerous WBC exposures (3 min at -140 to -195°C) over a six day
57 period improved the recovery of peak torque, rate of torque development, squat jump start power, and
58 reduced muscle soreness at various time-points following damaging hamstring exercise (12). While
59 multiple WBC sessions administered over the course of a 6 or 7 day period appears advantageous, the
60 feasibility of such practices (i.e., repeated cold exposures) may be limited in soccer players who are
61 competing in congested fixture schedules and thus likely have limited time (i.e., <96 h) between
62 consecutive matches, and may also have travel commitments associated with away games.

63

64 Despite the use of WBC in athletic populations, limited studies have profiled the responses to an
65 isolated bout of WBC performed after muscle damaging exercise. Of those that have, authors have
66 typically examined the short term (i.e., ≤ 30 minutes) effects of cold exposure (25, 28). Furthermore,
67 as training status (via habituation to eccentric contractions) has been proposed to modulate the
68 efficacy of WBC (14), there is a need to determine the effects of a single WBC session in professional
69 athletes. In a study examining the optimal duration of cryotherapy exposure, Selfe et al. (25) recently
70 observed no differences in inflammatory markers between trials of one, two or three minutes
71 performed on the day after a competitive Rugby League match. However, in the absence of a non-
72 cryotherapy trial to determine the efficacy of the intervention *per se*, the effects of an isolated bout of
73 WBC in professional athletes recovering from intermittent exercise remains to be determined.
74 Therefore, the aim of this study was to examine the physiological, performance and perceptual effects
75 (over 24 h) of a single bout of WBC performed shortly after repeated sprint exercise in professional
76 soccer players.

77 METHODS

78

79 Experimental Approach to the Problem

80

81 To investigate the effects of a single WBC exposure performed after repeated sprint exercise on
82 physiological, performance and perceptual responses, 14 professional academy soccer players were
83 required to attend the testing venue on six occasions throughout a 14 day period. The first two of these
84 sessions were preliminary visits that included procedural habituation whereas both main trials each
85 required a further two separate visits.

86

87 Subjects

88

89 Following ethical approval from the Swansea University Ethics Committee, 14 male academy soccer
90 players recruited from an English Premier League club (age: 18 ± 2 years, mass: 74.5 ± 5.5 kg,
91 stature: 1.78 ± 0.05 m) provided written informed consent (and parental consent where players <18
92 years) before study involvement.

93

94 Procedures

95

96 Two main trials (Cryo: Whole body cryotherapy, Con: Control), separated by seven days, were
97 completed in a randomized, counter-balanced and cross-over design. Main trials were performed in
98 an enclosed sports hall that housed a 3G surface and was maintained at a temperature of $\sim 25^{\circ}\text{C}$. To
99 minimize the effects of circadian variation, the timing of measurements were consistent between
100 trials. A light tactical training session, abstention from caffeine and replication of dietary intake was
101 required in the 24 h before the first visit of each trial.

102

103 Upon arrival, resting capillary blood and saliva samples were taken before perceived muscle soreness
104 and recovery was assessed. Following a short warm-up (~5 min), players performed two CMJ
105 attempts (separated by 30 s) on a portable force platform (Type 92866AA, Kistler, Germany). A
106 standardized 10 min warm-up (consisting of channel drills, dynamic stretches and progressive
107 intensity sprinting) and 5 min passive rest then preceded 15 x 30 m timed (Brower timing system, Salt
108 Lake City, Utah, USA) sprints that were each separated by 60 s rest (16). Each sprint required
109 deceleration to a standstill within a 10 m zone, which contributes to the muscle damaging properties
110 of the protocol (16). The protocol elicits similar distances covered at high intensity to those observed
111 in a similar age group of professional players during match-play (22). Blood and saliva samples,
112 perceived muscle soreness and recovery and CMJ performance were assessed immediately, 2 h and 24
113 h following the repeated sprint protocol and these measurements took ~10 min to complete on each
114 occasion.

115

116 After providing blood and saliva samples and having completed the perceived recovery and soreness
117 scales and CMJ testing, players commenced the WBC treatment in a purpose built temperature-
118 controlled portable cryotherapy unit (BOC Cryotherapy Chamber, Linde, Surrey, UK) within 20 min
119 of completing the repeated sprint protocol. Before entering the liquid nitrogen cooled chamber,
120 players towel-dried themselves (to remove sweat) and wore minimal clothing (wearing shorts, socks,
121 clogs, mask, gloves and a hat covering the auricles to avoid frostbite; 28); processes which were
122 completed within 10 min. Players entered the first pre-cooling chamber (-60°C) for 30 s before
123 moving into the second chamber (-135°C) for a further 120 s; a duration considered optimal when
124 using a chamber of -135°C (25). Minimal deviations from the target temperature were observed when
125 players moved between the pre-cooling and main chambers. Players were instructed to gently move
126 fingers and legs to avoid tension, and to take slow, shallow breaths while in the chamber (28, 30).
127 Upon leaving the chamber, players dressed in enough training attire to attenuate subjective feelings of
128 cold and remained seated for ~95 min in the same room as used in the Con trial. In Con, players
129 remained seated in a temperate environment (~25°C) for ~110 min. All players remained seated until

130 the 2 h post-exercise assessments before being provided with a meal from a standardized menu and
131 then leaving the laboratory. Players were requested to replicate their post-visit dietary intake between
132 trials and no structured training was scheduled in the time between the 2 h and 24 h measurements.
133 Verbal questioning of players on arrival for the 24 h post-exercise assessment supported adherence to
134 these requests.

135

136 Peak power output was determined according to previously described methods (20, 29). Briefly, the
137 instantaneous velocity and displacement of the player's center of gravity was derived from the vertical
138 component of the ground reaction force (GRF) elicited during the CMJ and the participants' body
139 mass. Instantaneous power output was determined using Equation 1 and the highest value produced
140 from the two attempts performed at each time-point was deemed the peak power output.

141

142 Eq'n 1: Power (W) = vertical GRF (N) x Vertical velocity of centre of gravity ($\text{m}\cdot\text{s}^{-1}$)

143

144 Whole blood (5 μL), sampled from the fingertip (after immersion in warm water necessary for one
145 participant during the Con trial), was analysed for lactate concentrations (Lactate Pro, Akray, Japan).
146 A further 120 μL of blood (Microvette CB300 EDTA, Sarstedt AG & Co, Germany) was centrifuged
147 at 3000 $\text{revolutions}\cdot\text{min}^{-1}$ for 10 min (Labofuge 400R, Kendro Laboratories, Germany) and plasma
148 samples were stored at -70°C before subsequently being analysed for CK (Cobas Mira; ABX
149 Diagnostics, Northampton, UK) concentrations. Samples were measured in duplicate (3% coefficient
150 of variation) and recorded as a mean. Saliva samples were collected into sterile vials (LabServe, New
151 Zealand) via passive drool (~2 ml over 2 min) which were then stored at -80°C . To minimize sample
152 dilution, players were instructed to avoid eating, drinking warm fluids, and brushing of teeth in the
153 two hours preceding sampling. Samples were analysed in duplicate using commercially available
154 enzyme immunoassay kits (Salimetrics LLC, State College, PA, USA). The lowest detection limits for
155 testosterone and cortisol were $0.001 \text{ nmol}\cdot\text{L}^{-1}$ and $0.08 \text{ nmol}\cdot\text{L}^{-1}$, respectively and inter-assay CV

156 values were <10% in both cases. To eliminate inter-assay variance, samples for each player were
157 analysed within the same assay kit (8). The perception of recovery was assessed using a 10-point
158 likert scale (17) whereas a 7-point likert scale evaluated lower limb muscle soreness (27).

159

160 **Statistical Analyses**

161

162 Statistical analyses were carried out using SPSS Statistics software (IBM Inc., USA) with significance
163 set at $P \leq 0.05$. Data are reported as mean \pm standard deviation (SD). Paired samples t-tests were
164 performed for between-trial comparisons of data expressed over a single time-point within a trial (i.e.,
165 mean and total sprint times). For data expressed over multiple time-points within a trial (i.e.,
166 individual sprint times, power output, blood lactate and Creatine Kinase concentrations, salivary
167 testosterone and cortisol concentrations; including testosterone/cortisol ratio, and perceived soreness
168 and recovery), between trial comparisons were investigated using two-way repeated measures
169 analysis of variance (ANOVA; within-participant factors: trial x time). Where significant interaction
170 effects were observed, trial was deemed to have influenced responses and simple main effect analyses
171 were performed. Timing effects represent the main effect of time from the two-way repeated measures
172 ANOVA analysis performed. Partial eta-squared (η^2) values were calculated and Bonferroni corrected
173 *post-hoc* tests (with 95% Confidence Intervals; CI) were performed to isolate significant differences.

174 **RESULTS**

175 A two-way repeated measures ANOVA analysis revealed that individual sprint times were similar
176 between trials (time x trial interaction: $F_{(6,78)}=0.354$, $P=0.905$, $\eta^2=0.026$) and did not differ throughout
177 the duration of the 15 x 30 m timed sprints (time effect: $F_{(3,44)}=0.574$, $P=0.658$, $\eta^2=0.042$). Paired
178 samples t-tests highlighted that mean (Con: 4.34 ± 0.17 s, Cryo: 4.37 ± 0.23 s, $P=0.572$) and total
179 (Con: 65.08 ± 2.56 s, Cryo: 65.56 ± 3.38 s, $P=0.572$) sprint times were comparable between trials.

180

181 Peak power output was not influenced by trial (time x trial interaction: $F_{(3,39)}=0.762$, $P=0.522$,
182 $\eta^2=0.055$) but did differ according to timing (time effect: $F_{(3,39)}=10.091$, $P<0.001$, $\eta^2=0.437$). Peak
183 power output reduced immediately post-exercise ($P<0.001$) by 134 ± 100 W ($-3.2 \pm 2.3\%$) but
184 subsequently returned to pre-exercise values at 2 h ($P=0.052$) and 24 h ($P>0.99$) post-exercise (Table
185 1).

186

187 ***** INSERT TABLE 1 NEAR HERE *****

188

189 Blood lactate concentrations were similar between trials (time x trial interaction: $F_{(2,21)}=1.023$,
190 $P=0.361$, $\eta^2=0.073$, Table 1) but were influenced by timing (time effect: $F_{(1,16)}=50.609$, $P<0.001$,
191 $\eta^2=0.796$). A 2.18 ± 1.01 mmol·L⁻¹ increase from baseline values occurred immediately post-exercise
192 ($P<0.001$) but blood lactate concentrations returned to pre-exercise values thereafter ($P>0.05$).

193

194 Concentrations of CK did not differ according to trial (time x trial interaction: $F_{(2,26)}=0.733$, $P=0.491$,
195 $\eta^2=0.053$) but did vary due to timing of sample (time effect: $F_{(1,14)}=243.872$, $P<0.001$, $\eta^2=0.949$).
196 Compared to pre-exercise values, CK was elevated by $14 \pm 13\%$, $28 \pm 10\%$ and $253 \pm 89\%$
197 immediately ($P=0.006$), 2 h ($P<0.001$) and 24 h ($P<0.001$) post-exercise, respectively (Table 1).

198 Salivary testosterone concentrations were influenced by trial (trial x treatment interaction:
199 $F_{(3,39)}=6.231$, $P=0.001$, $\eta^2=0.326$) and time of sample (time effect: $F_{(3,39)}=6.275$, $P=0.001$, $\eta^2=0.326$).
200 Despite salivary testosterone being similar between trials at pre-exercise and immediately post-
201 exercise (both $P>0.05$), Cryo elicited a greater salivary testosterone response at 2 h ($+32.5 \pm 32.3$
202 $\text{pg}\cdot\text{ml}^{-1}$, $+21 \pm 21\%$) and 24 h ($+50.4 \pm 48.9 \text{pg}\cdot\text{ml}^{-1}$, $+28 \pm 34\%$) post-exercise (both $P=0.002$)
203 compared to Con (Figure 1).

204

205 ***** INSERT FIGURE 1 NEAR HERE *****

206

207 Salivary cortisol concentrations did not differ according to trial (time x trial interaction: $F_{(3,39)}=0.253$,
208 $P=0.859$, $\eta^2=0.019$) but did vary due to sampling time (time effect: $F_{(3,39)}=13.998$, $P<0.001$,
209 $\eta^2=0.518$). Immediately post-exercise, salivary cortisol was similar to pre-exercise values ($P=0.052$)
210 whereas significant reductions were observed at 2 h post-exercise ($p=0.003$). These reductions had
211 dissipated at 24 h post-exercise (Figure 1). Salivary testosterone/cortisol ratios did not differ due to
212 trial (time x trial interaction: $F_{(3,39)}=0.696$, $P=0.560$, $\eta^2=0.051$) but timing did influence the response
213 (time effect: $F_{(2,28)}=8.66$, $P=0.001$, $\eta^2=0.518$). Post hoc analyses were unable to isolate these
214 differences relative to pre-exercise values.

215

216 Perceived soreness (time x trial interaction: $F_{(3,39)}=0.700$, $P=0.558$, $\eta^2=0.051$) and recovery (time x
217 trial interaction: $F_{(2,22)}=0.245$, $P=0.752$, $\eta^2=0.019$) were not influenced by trial but timing effects were
218 significant ($F_{(3,39)}=13.010$, $P<0.001$, $\eta^2=0.500$, $F_{(3,39)}=27.094$, $P<0.001$, $\eta^2=0.676$, respectively).
219 Significant changes were only observed immediately post-exercise (both $P<0.001$).

220 **DISCUSSION**

221

222 This study aimed to examine the physiological, performance, and perceptual effects of a single bout of
223 WBC administered shortly after repeated sprint exercise in professional soccer players. Based on
224 circulating CK concentrations yielded from capillary blood samples, our findings indicate that
225 perturbations in selected physiological responses were not restored back to baseline values within a 24
226 h period. Moreover, a single WBC session increased testosterone concentrations at 2 h and 24 h post-
227 exercise when compared to a Con trial despite no differences in CMJ performance, blood lactate and
228 CK concentrations, and markers of perceived recovery. Although further investigation is warranted,
229 these findings highlight a potential role for a single WBC exposure in the early stages of recovery
230 from muscle damaging exercise in professional soccer players.

231

232 Contrary to previous authors (1, 31) Cryo did not influence blood CK concentrations when compared
233 to Con (Table 1). Conversely, and despite torque loss being limited in the 48 h following trail running
234 (14), Hausswirth et al. observed similar CK concentrations to that observed during a passive recovery
235 trial after a single WBC exposure (14). Therefore, it has been proposed that repeated WBC sessions (a
236 minimum of 5 to 10) are required before muscle membrane breakdown or exercise-induced cell
237 permeability is modified to such an extent that the significant reductions in CK concentrations seen by
238 previous authors (1, 31) become evident (14). Moreover, the elevated baseline CK concentrations of
239 soccer players observed in this study and previously (21, 23, 26) may afford another explanation as to
240 the lack of differences observed between trials in this variable and is likely attributable to residual
241 levels of muscle damage still present from previous regular training (26).

242

243 Testosterone has been suggested to be a primary anabolic hormone involved in protein synthesis and
244 protection against skeletal muscle degradation (15). Notwithstanding the debated role of endogenous

245 hormones in the muscle hypertrophic and strength response (24), the 21% and 28% increases in
246 testosterone at 2 h and 24 h post-exercise in Cryo versus Con, respectively, indicates a potentially
247 favourable hormonal profile following a single exposure to WBC after soccer-specific exercise. Such
248 findings corroborate observations of elevated testosterone concentrations following multiple WBC
249 sessions (13) but are the first to be reported following a single bout of WBC that followed muscle
250 damaging exercise in professional athletes. As testosterone concentrations influence training
251 motivation (7), this finding may have important implications for practitioners during congested
252 periods of competition.

253

254 The anti-inflammatory effects of WBC are a key factor purported to explain its efficacy (1, 2). As
255 opposed to changes in lysosomal membrane stabilization which are apparent following multiple
256 cryotherapy exposures (31), reductions in serum soluble intercellular adhesion molecule-1 (sICAM-1;
257 mediator of the leukocyte response at the damaged tissue, resulting in a lower pro-inflammatory
258 response, less reactive oxygen species and an increase in anti-inflammatory markers), have been
259 proposed to explain the anti-inflammatory response to a single WBC session (11). Notably, low serum
260 testosterone concentrations are significantly associated with elevated levels of inflammation (4).
261 Speculatively, and given its role as a potential mediator of the inflammatory response in both healthy
262 and clinical populations, the increases in testosterone observed at 2 h and 24 h post-exercise versus
263 Con in this study may reflect reduced levels of inflammation following WBC. However, in the
264 absence of inflammation data these proposed mechanisms should be interpreted with caution.

265

266 The increased testosterone concentrations observed against Con at 24 h post-exercise in Cryo may
267 also reflect an increased sleep quality that has been reported previously (5). When compared to a
268 previous night's sleep that did not follow a cryotherapy intervention, sleep quality was improved the
269 night after WBC exposure (5). As sleep deprivation/restriction reduces testosterone concentrations (9),
270 WBC may be beneficial for players experiencing disrupted sleeping patterns; perhaps resulting from

271 travel and/or factors associated with evening kick-offs. Unfortunately, records of sleep quality were
272 unavailable to support this supposition and warrants further investigation.

273 In contrast to previous studies that have implemented muscle damaging exercises that demonstrate
274 low levels of ecological validity to soccer, such as; drop jumps combined with eccentric lower body
275 exercise (12) and isokinetic unilateral knee extensor exercises (28), we used a repeated sprint protocol
276 (16) that represents the high intensity distance covered in soccer match-play (22) and is also typical of
277 some soccer training sessions. Although physiological measurements were not collected during
278 exercise, players reported increased perceptions of soreness and a reduced recovery state immediately
279 post-exercise (Table 1) while blood lactate concentrations reflected those observed following a soccer
280 match and peak power output demonstrated a soccer-specific fatigue-related profile (21, 23).
281 Furthermore, we observed increases in CK concentrations that were similar in magnitude to those
282 reported following soccer match-play (21, 23). The reductions in cortisol concentrations observed 2 h
283 post-exercise are likely explained by circadian rhythmicity given the non-significant effects of
284 exercise on salivary cortisol when assessed immediately post-exercise and the subsequent restoration
285 at 24 h. Therefore, our data highlights a potential role for WBC as a method of maintaining salivary
286 testosterone concentrations in professional soccer players for up to 24 h following intense exercise.

287

288

289 **PRACTICAL APPLICATIONS**

290

291 A single session of WBC elicited greater testosterone concentrations for 24 h after repeated sprint
292 exercise when compared to a passive recovery protocol despite selected physiological, performance
293 and perceptual markers being unaffected. Although unclear, such findings may link to an attenuated
294 inflammatory response to exercise, an enhanced sleep quality in the 24 h following cold exposure, and
295 possibly have implications for subsequent training motivation. Consequently, WBC administered
296 shortly after intermittent exercise may offer an ergogenic strategy for soccer players involved in a
297 congested fixture or training period. A secondary finding of this study was that professional soccer
298 players performing 15 x 30 m sprints (each followed by a forced deceleration within a 10 m zone)
299 experienced a short term (up to 2 h) transient reduction in post-exercise muscle function (i.e., CMJ
300 performance) and perturbations in circulating CK concentrations that required more than 24 h to
301 return to baseline.

302

303

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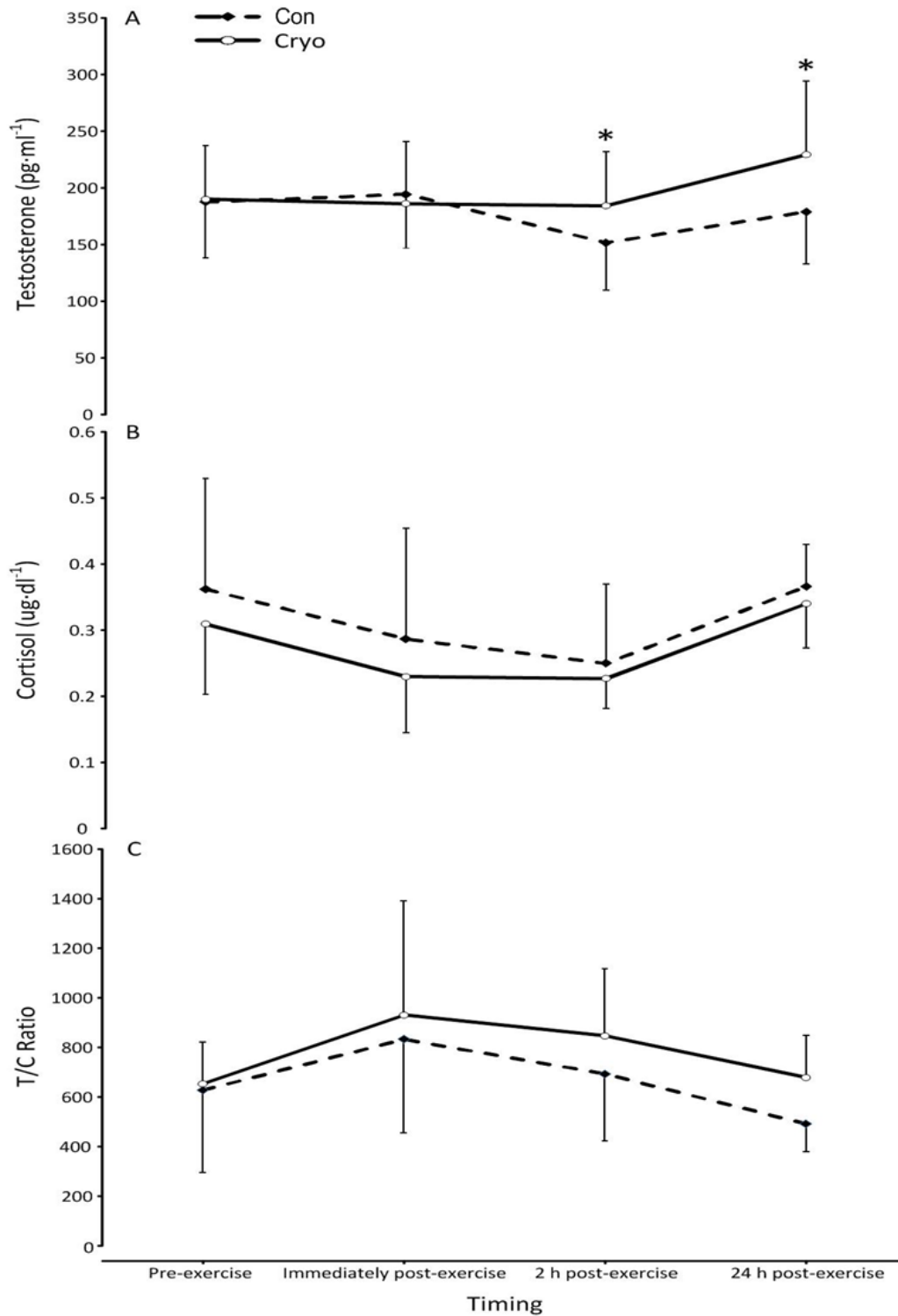
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399 **FIGURE LEGEND**



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401 Figure 1: Mean ± SD testosterone (panel A), cortisol (panel B) and testosterone/cortisol ratio (panel
 402 C) responses throughout each trial. Con represents control trial, Cryo represents cryotherapy trial. *
 403 represents significant difference (P<0.05) between conditions at the corresponding time-point.

404

405 **TABLES**

406

407 Table 1: Mean \pm SD blood lactate, peak power output, Creatine Kinase, perceived soreness and perceived recovery responses throughout each trial.

Variable	Trial	Timing				Significant differences relative to pre-exercise (A)	95% confidence interval for <i>post hoc</i> difference
		Pre-exercise (A)	Immediately post-exercise (B)	2 h post-exercise (C)	24 h post-exercise (D)		
Blood lactate (mmol·L ⁻¹)	Con	1.21 \pm 0.40	3.49 \pm 1.29	1.06 \pm 0.31	1.29 \pm 0.46	A vs. B	1.35 – 3.02
	Cryo	1.06 \pm 0.39	3.15 \pm 1.14	1.22 \pm 0.38	1.33 \pm 0.36		
Peak power output (W)	Con	4151 \pm 494	4004 \pm 443	4055 \pm 489	4089 \pm 459	A vs. B	-216 – -51
	Cryo	4092 \pm 466	3971 \pm 482	4009 \pm 406	4127 \pm 468		
Creatine Kinase (μ ·L ⁻¹)	Con	232 \pm 44	261 \pm 53	291 \pm 59	785 \pm 129	A vs. B	8 – 57
	Cryo	232 \pm 49	269 \pm 63	303 \pm 65	799 \pm 141	A vs. C A vs. D	46 – 83 452 – 668
Perceived soreness (units)	Con	1 \pm 1	3 \pm 2	2 \pm 1	2 \pm 2	A vs. B	1 – 3
	Cryo	1 \pm 1	3 \pm 2	1 \pm 1	2 \pm 2		
Perceived recovery (units)	Con	6 \pm 2	3 \pm 2	6 \pm 2	6 \pm 2	A vs. B	-4 – -1
	Cryo	7 \pm 2	4 \pm 2	7 \pm 2	6 \pm 3		

408 Con represents control trial, Cryo represents cryotherapy trial.