Physiological and perceptual responses to a five-week pre-event taper in professional mixed martial arts athletes

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ABSTRACT

BACKGROUND: The purpose of this study was to evaluate changes in markers of endocrine, immune and mood status among Mixed Martial Arts (MMA) athletes during different stages of fight preparation camps.

METHODS: Six professional MMA athletes were observed across the final five weeks (W4 – W0); including the final seven days (D6 – D0) of fight camp, and were tested for salivary immunoglobin-A (sIgA), salivary cortisol (SC), creatine kinase (CK), urine osmolality (UO), body mass (BM), training load (TL), reported fluid intake and profile of mood state (POMS) scores.

RESULTS: Magnitude-based decisions revealed *large, very likely* decreases in sIgA concentrations in W1 relative to all previous weeks, and *large, very likely* reductions in CK concentrations within W0 in relation to W2 and W4. POMS scores were reduced in W0 and W1 compared to W4 (*moderate, very likely*), despite a reduction in training load in W0 relative to all previous weeks (*large, very likely*). In W0, reported fluid intake decreased as UO increased at D1 and D2, in comparison to all previous days (*large, very likely*). Elevated POMS and SC (*moderate to large, very likely*) were also observed at D1, in comparison to D2 to D6. While 8% of BM was lost over the 5-week period, 5% was lost within the final 4 days.

CONCLUSIONS: Across a 5-week fight camp, mood states are negatively affected, alongside increased markers of muscle damage and immune status, which can be partially offset with a pre-event taper. Owing to the weight cutting practices of these professional MMA athletes, ~ 5% of BM is lost in the final 4 days, which coincides with poorer mood states and increased stress-hormone responses in the final few days of the fight camp. Coaches should consider the implications of taper length and RWL strategies in the recovery process of MMA athletes.

Key words: dehydration, fatigue, overtraining, MMA, rapid weight loss

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Introduction

Mixed Martial Arts (MMA) is a combat sport, which combines various fighting techniques found in traditional martial arts, such as kickboxing, boxing, muay-thai, wrestling and Brazilian Jiu-Jitsu. Athletes within MMA are generally deemed to be in an 'off-camp' or 'fight-camp' phase, the latter of which is used to target specific adaptations in the final 4-10 weeks prior to a competitive event (UFCPI, 2018). As a result of training for multiple disciplines and in the event of agreeing a bout at short notice (< 4 weeks), training load can often be mismanaged within the fight camp, contributing to inadequate recovery and suboptimal performance (Amtmann, 2004). High training loads may lead to excessive muscle damage, kidney dysfunction (via rhabdomyolysis) and fluid or electrolyte imbalances (Mashiko et al., 2004), leading to chronic states of overreaching and subsequent development of over-training syndrome (Coutts et al 2007).

After repeated, strenuous bouts of prolonged training sessions, a window of 3-72 h of reduced immunity has been observed, referred to as the 'open window' (Walsh et al., 2011), leaving athletes at a greater risk to infections, particularly those of the upper respiratory tract (URTIs) (Budgett, 1998). Salivary proteins, such as IgA (sIgA) play an integral role in mucosal immunity and can serve as an indicator of URTI risk (Mackninnon, Ginn & Seymour, 1993). Indeed, reductions in sIgA secretion during prolonged training camps have been reported, and sIgA secretion is inversely related to URTI risk (Gleeson et al., 1995). In addition, higher cortisol, mood disturbances and muscle soreness are associated with decreased mucosal immunity, which can be elicited during a period of increased training loads (Papacosta, Nassis & Gleeson, 2016).

Progressive reductions in training load (tapers) are typically incorporated into pre-competition training programmes to minimise training-induced fatigue, maximize physiological

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53   adaptations and optimise performance (Mujika, 2010). Pre-competition tapering is more

54   complicated in combat sports (in comparison to non-weight classification sports), owing to the

55   potential use of rapid weight loss (RWL) strategies in the days leading up to a competitive

56   event. Such strategies aim to reduce body mass (primarily water mass) within the final days

57   preceding an event and are used in order to gain a competitive advantage (against a lighter

58   athlete). During intensive training, this may be detrimental to the athlete's health,

59   compromising immune function and reducing salivary flow rate (Ford et al., 1997; Tsai et al.,

60   2009). Therefore, it is suggested that the practices of MMA fighters towards the end of a fight

61   camp may compromise their health status, in turn, leading to suboptimal performance.

62   Athletes dehydrating for the purpose of RWL typically have inadequate time to rehydrate

63   before MMA events e.g. restoring 5% of body mass within 24 hours (Jetton et al., 2013). With

64   inadequate fluid intake and physical recovery, athletes are more susceptible to renal injury, due

65   to the high levels of plasma creatine kinase concentrations observed in MMA fighters and

66   reductions in myoglobin solubility (Weichmann et al., 2016). The resulting hypo-hydration and

67   severe energy restrictions from RWL have also been reported to lead to an increased perception

68   of fatigue, tension, anxiety and impaired short-term memory (Steen & Brownell, 1990; Choma,

69   Sforzo & Keller, 1998). Furthermore, hypo-hydration has been reported to impair muscle

70   excitability and reduce muscular endurance, irrespective of fluid replacement (Bigard et al,

71   2001; Bowtell et al., 2013). Therefore, hypo-hydration is likely to contribute to neuromuscular

72   fatigue before and during competition.

73   It is likely that the cumulative demands of pre-competition preparation for combat sports

74   athletes induce physical and mental fatigue, which can lead to chronic overreaching and

75   subsequently over-training syndrome, unless adequate recovery is provided (Urhausen &

76   Kindermann, 2002). Those with OTS report disrupted mood, sleep and behaviour (Meeusen et

77   alk 2013), as well as neuroendocrine dysregulation (Cadegiani & Kater, 2017). Indeed, some

78 hormones secreted from the hypothalamic pituitary adrenal axis have been related to

79 immunosuppression (Ford et al., 1997) and could be used to monitor the health status of combat

80 sports athletes. Presently, there has been no investigation of combat athletes' well-being and

81 endocrine response to an MMA fight camp. It is therefore necessary to evaluate the fight

82 preparation period of professional MMA athletes, as this information could be used to inform

83 future preparations.

84 The purpose of the study was to evaluate the change in physiological (hydration, endocrine and

85 immune) and perceptual markers (mood state) of professional MMA athletes within the final

86 5-weeks (minimum fight camp time frame + period of RWL) of an uninterrupted fight camp.

87

88 **Materials and methods**

89 Participants provided written informed consent to participate in a prospective observational

90 study across five weeks. Institutional ethical approval was given for this study, which was

91 conducted in accordance with the 1964 Helsinki declaration. Prior to initial testing, participants

92 arrived at the laboratory, completed a physical activity readiness questionnaire (PAR-Q) and

93 were familiarised with methods for obtaining and storing urine and saliva samples. In addition,

94 they were familiarised to the Profile of Mood State (POMS) questionnaire.

95

96 On each testing day, participants were instructed to obtain urine and saliva samples at home

97 within 30-min of waking up. Upon arrival at the laboratory in the morning (~0900 h) in a fasted

98 state before training, they were requested to empty their bladders, followed by measurements

99 of body mass, POMS and capillary blood samples (from the ear) to assess plasma creatine

100 kinase (Figure 1). Each testing day was identical except for the final week (excluding fight

101 day), wherein daily measurements of POMS, urine, saliva and body mass were taken. Weeks

102 and days are expressed as n where n = number of weeks/days from fight day (Figure 1).

103

104

105   ***Insert Figure 1 here***

106

107   *Participants*

108

109   Six male (age: 27 ± 7 years, stature: 1.71 ± 0.08 m, body mass: 78.1 ± 10.3 kg, training age: 6

110   ± 4 years, counter-movement jump height: 0.39 ± 0.10 m) professional MMA athletes with no

111   underlying health conditions, consented to take part in this study. Inclusion criterion

112   necessitated that the athletes were injury free and competing within a regulated MMA

113   organization.

114

115   *Methods*

116

117   *Body mass*

118   Following, urination and prior to any fluid and energy intake the mean of three nude body mass

119   measurements were taken using a portable scale (MPMS-230, Marsden Weighing Group,

120   Oxfordshire, UK).

121

122   *Urine Osmolality*
123

124   Participants were instructed to collect midstream samples of first urine (within 30-min of

125   waking up) (50 ml collection pots)) and return them to the laboratory on each testing day. Pre-

126   fight (weigh-in) day urine was assessed in the final 30-min prior to stepping on the scale at the

127 event. Fight day urine was assessed ~ 6-h prior to the bout, before consumption of a lunch meal

128 and a minimum of 1-h post water consumption. Urine osmolality ($mOsml·kg^{-1}H_2O$) was

129 measured using a thermally compensated refractometer (Osmocheck refractometer, Vitech

130 Scientific Ltd, West Sussex, UK) with a manufacturer's reported testing accuracy of $\pm$ 20

131 $mOsml·kg^{-1}H_2O$ and a between run coefficient of variation (CV) of 0.3%. Participants were

132 asked to report fluid intake (L) on a daily basis in the final week.

133

134 *Whole-blood Creatine Kinase concentration*
135

136 Approximately 300 μl of capillary whole-blood (from the ear) was collected

137 (Microcuvette®CB300, Sarstedt, Numbrecht, Germany), placed in a refrigerated centrifuge

138 (Mikro 220R D-78532, Tuttlingen, Germany) and spun at 3500 rev/min for 6-min at 4 ∘C. All

139 samples were then stored and analysed using an automated analyser (Clinical Analyser Rx

140 Daytona – Randox Teoranta, Co. Donegal, Republic of Ireland) with a between run CV of 2.0

141 %.

142

143 *Saliva Variables (sIgA & Cortisol)*
144

145 An IPRO Lateral Flow Device reader (IPRO Interactive Ltd, Wallingford, UK) was used to

146 analyse salivary cortisol and sIgA. Saliva swab testing kits with instructions were administered

147 for participants to obtain morning saliva within the first 30 min of waking up, prior to arrival

148 at the laboratory. Approximately 0.5 ml of saliva was collected via an oral swab and placed

149 into a buffer solution. Two drops of the buffer/saliva mixture were then placed on to a lateral

150 flow indicator test strip, allowing the mixture to flow laterally across the conjugated pad and

151 the nitrocellulose membrane. Test strips were left for a 15-min incubation period before

152 analysis. Between run mean CV were 8.5 % and 6.8 % for sIgA and cortisol respectively.

153

Training Load

Participants were asked to provide a rate of perceived exertion (RPE) using a 10-point rating scale. The intensity of all training sessions (technique drilling, grading, sparring, strength and conditioning) were recorded within 30-min of completion. A typical weekly training schedule is shown in Table 1.

*** Insert Table 1 here ***

The RPE value was multiplied by training time to calculate session RPE (sRPE) as a measure of training load (Lambert & Borresen, 2010). Intended taper length was also requested to indicate when and how training load reduction was expected. Athletes within this study underwent a taper length between six and ten days, which was preceded by a final 'maximal' sparring session and utilizing the days within the taper to reduce load via mobility, conditioning and 'drilling' sessions.

Profile of Mood States Questionnaire (POMS)

POMS was administered to assess transient disturbances in 6 different moods: anger, confusion, tension, fatigue, depression and vigour. The questionnaire consisted of 65 questions assessed through a 5-point likert scale ranging between 'not at all' and 'extremely' and resulted in an overall mood disturbance score. Participants were asked to complete an online version of the POMS questionnaire while isolated in a quiet area of the laboratory at the start of each testing day (~ 9 am) (Morgan et al., 1987).

179   *Statistical analysis*

180   Magnitude-based decisions (MBD) were used to determine whether observed effects were

181   unlikely or likely, allowing practical inferences to be drawn from the approach described by

182   Batterham & Hopkins (Batterham & Hopkins, 2006). Effect sizes (ES) and MBD identified

183   likelihood of effects of time on each dependent variable (BM, UO, sIgA, CK, SC, TL, POMS

184   overall score and sub-scores) across the final five weeks. ES were defined as; *trivial* = 0.2;

185   *small* = 0.21 – 0.6; *moderate* = 0.61 – 1.2; *large* = 1.21 – 1.99; *very large* > 2.0. Raw data were

186   log-transformed to account for uniformity of effects. Threshold probabilities for a substantial

187   effect based on the 90% confidence limits were: <0.5% *most unlikely*, 0.5 – 5% *very unlikely*,

188   5.1 – 25% *unlikely*, 25.1 – 75% *possibly*, 75.1 – 95% *likely*, 95.1 – 99.5% *very likely, > 99.5%*

189   *most likely*. Thresholds for the magnitude of the observed change in the dependant variables

190   were determined as the within-participant standard deviation x 0.2 (*small*), 0.6 (*moderate*) and

191   1.2 (*large*). Effects with confidence limits across a *likely, small* positive or negative change

192   were classified as unclear. The uncertainty of effects were based on 90% confidence limits for

193   all variables. A custom spreadsheet designed for cross-over trials was used to perform all of

194   the calculations (http://www.sportsci.org/).

195

196   **Results**

197

198   *Changes across final five weeks*

199   *Large,* very likely reductions in TL were observed between week 0 and all other weeks. There

200   were *large, very likely* reductions in sIgA between week 1 and weeks 2, 3 & 4.

201   CK reductions were *large, very* or *most likely* between week 0 and weeks 1, 2 & 4, and also

202   between weeks 1 & 3.

203 POMS depression score reductions were *large, very likely* between week 4 and weeks 3 & 2

204 while POMS confusion score reductions were *large, very* or *most likely* between week 4 and

205 weeks 2 & 1. (Table 2)

206

207

208 *** Insert Table 2 here ***

209

210 *Changes across final seven days*

211 There were *large, very* or *most likely* reductions in UO and increases in fluid intake between

212 all days (Table 3).

213 There were *large, very likely* increases in POMS scores between day 1 and days 4, 5 & 6, and

214 reductions between day 4 and days 0 & 2. *Large, very likely* increases in POMS depression

215 scores were found between day 1 and days 2, 3 & 4. *Large, very* or *most likely* increases in

216 POMS confusion scores were found between day 1 and days 3, 4, 5 & 6. *Large, very likely*

217 reductions in POMS fatigue scores were found between day 1 and days 4, 5 & 6. There were

218 also *large, very likely* reductions in POMS vigour scores between day 1 and days 4, 5 & 6.

219 (Table 4)

220

221 *** Insert Table 3 here ***

222

223 *** Insert Table 4 here ***

224

225 **Discussion**

226   The aim of this study was to evaluate changes in physiological and mood state across the final

227   five weeks of a fight camp amongst professional MMA fighters. The main observations within

228   this study include a reduction in BM of ~ 8% within the final five weeks, with ~ 5% occurring

229   within the final four days of the weight cut. Mood state worsened across the five weeks,

230   particularly due to the increase in POMS sub-scores of confusion, depression and tension. *Very*

231   *large* plasma CK reductions were observed in the final week relative to all weeks, however a

232   *large* reduction in sIgA secretion was observed within the penultimate week. Though sIgA also

233   improved with TL reduction (taper), it did not return to baseline concentrations. Finally, a *large*

234   increase in SC was observed within the final two days (weigh-in and fight day), yet overall

235   change was *trivial* across the five weeks. Collectively, the results provide novel evidence of

236   the undesirable changes in immunoendocrine and mood status in professional MMA athletes

237   across the final five weeks of a fight preparation camp.

238

239   Participants within the present study achieved a total BM loss of ~10.0% across the final four

240   weeks, with 4.7-5.7% of BM reduction occurring within the final week. A similar magnitude

241   of change across time has been observed in MMA (Jetton et al., 2013; Kasper et al., 2018), judo

242   (Pallares et al., 2016), wrestling (Roemmich & Sinning, 1997) and boxing (Reljic, Hassler &

243   Jost, 2013). However, athletes within the current study decreased BM by 1.8 kg within the final

244   24-h, which is lower than previously reported losses of 3.4 and 9.8 kg within 24-h and 27 days

245   respectively (Barley, Chapman & Abbiss, 2017). Five of the six athletes were hyper-hydrated

246   before gradually dehydrating to a hypo-hydrated state during weigh-in day. With reported fluid

247   intake as high as 8.5 L at D6 but as low as 0.2 L at D1, patterns follow a typical weight-cutting

248   method reported amongst MMA athletes, known as 'water-loading' (Reale et al., 2018). It is

249   possible that methods of water loading within this study differed from others, as most did not

250   reach a state of severe hypo-hydration (> 1200 mOsml$\cdot$kg^{-1}H$_2$O) that has been reported (Kasper

251 et al., 2018). Though final UO was not measured immediately prior to the fight (~ 6-h), the

252 current findings confirm that fluid balance is manipulated by MMA athletes to control body

253 mass losses but suggest that magnitude/method of water loading may vary between individuals.

254 It is also possible that the changes in BM were influenced by calorie restriction; however, this

255 was not monitored and is a limitation of the study.

256

257 TL was *largely* reduced in W0 to facilitate at least a one week taper, in order to minimise

258 training induced fatigue and maximise physiological adaptations prior to the fight. However,

259 irrespective of TL periodisation strategies, a reduction in sIgA secretion and increase in mood

260 scores remained evident in the final two weeks of the preparation camp. Acute reductions in

261 TL have been strongly associated with improved mood state (Saw, Main & Gastin, 2016), yet

262 peak disturbances in overall mood scores were observed in the penultimate day (weigh-in) and

263 penultimate week within this study, indicating that the athletes' psychological state was not

264 solely dependent on load reduction and may have been attributed to fluid restriction levels.

265 This has been observed in participants regardless of whether fluid restriction was involuntary

266 (Ely et al., 2013) or voluntary and when sleep, diet and caffeine were controlled (Mundel, Hill

267 & Legg, 2015). With increased POMS sub-scores of confusion, depression, anger alongside

268 decreased plasma CK and sIgA concentration, it is possible that mood disturbances were also

269 reflective of pre-fight stressors, along with the recovery process from training-induced fatigue.

270 This suggests that POMS provides a useful global indicator of mood state but may not

271 consistently coincide with adjustments in TL, due to a multitude of factors involved in

272 subjective scoring.

273

274 Plasma CK concentrations increased across the pre-competition fight camp, with peak values

275 occurring within W1. However, this was reduced in W0, in accordance with a programmed

276 decrease in TL. CK concentrations were larger than anticipated in the current sample, with

277 fight day concentrations almost resembling CK values 24-h post-fight and 3 times the observed

278 values pre-event (Weichmann et al., 2016). The reasons for this are unclear but could be related

279 to muscle damage induced by MMA bouts, which include repetitive eccentric contractions (e.g.

280 kicking decelerations) and blunt trauma associated with strikes (Baird et al., 2012; Weichmann

281 et al., 2016), which were not specifically monitored during the fight camp. Nevertheless, these

282 data indicate a progression in indirect muscle damage markers during fight camp, which

283 suggests that the participants in this study may have entered their fights with a higher level of

284 muscle damage than previously reported (Weichmann et al., 2016), further highlighting the

285 importance of TL management to optimise recovery within the correct time frame.

286

287 SC and sIgA concentrations were monitored across the 5-week tapering period, as an indication

288 of the hypothalamic pituitary axis stress response and mucosal immunity, respectively. Peak

289 reduction of sIgA concentrations were observed in W1, indicating potential increased URTI

290 risk due to a reduced mucosal immunity[5]. It was speculated that this steep decline in sIgA

291 concentration is representative of the 'open window' phenomenon, whereby athletes have been

292 reported to have lower salivary immunoglobins and peripheral blood immune cells following

293 prolonged and intensified training (Walsh et al., 2011). Similarly, the athletes examined here

294 were recovering from training-induced fatigue, following a period of high TL. Interestingly,

295 there was a *moderate* reduction in sIgA concentration in W0 (compared to W3 & W2), which

296 occurred alongside reductions in TL and plasma CK concentration, indicating a partially

297 successful tapering strategy. sIgA concentrations observed in the initial weeks were not

298 restored in the final stages of the taper, suggesting higher risk of illness and infection near to

299 the day of the fight. In addition to physical exertion, cortisol secretion can be induced by non-

300 physical stimuli, such as anxiety and psychological stress (Kunz-Ebrecht et al., 2003). This is

301 supported by similar trends observed in overall mood and sub-scores of confusion and
302 depression reported in the current study. These findings indicate that some professional MMA
303 athletes might experience higher levels of anticipatory psychological stress or arousal
304 particularly at weigh-in and fight days. Further research is required to understand the way in
305 which this can be managed to facilitate optimal performance.

306

307 Changes in sub sections of mood state may have also been associated with factors other than
308 SC. For example, in the final week of the taper, scores of confusion, depression and anger
309 increased as BM reduced, but decreased again as BM increased within the final day. Such a
310 trend suggests that the mood state of an MMA athlete may be influenced by the magnitude or
311 method of BM reduction within the final week of fight preparation. Hypo-hydration has been
312 reported to impair visuomotor performance (Wittbrodt et al., 2018), short-term memory
313 (Choma, Sforzo & Keller, 1998) and brain metabolism (Kempton et al., 2011), suggesting acute
314 altered brain function. As cortisol is a glucocorticoid, which can be elevated due to
315 euphorigenic or neuro-stimulatory causes (Kunz-Ebrecht et al, 2003), it is hypothesised that
316 rises in cortisol, tension and fatigue may also be attributed to neuroendocrine and corticospinal
317 responses to hypo-hydration. It is also important to note that though participants returned to
318 baseline BM, UO did not, suggesting blood volume may have not increased and reached
319 baseline values. The reduction in blood volume and increase in UO results in a shift of sodium
320 uptake, leading to altered excitation-contraction capabilities (Hackney et al., 2012; Bowtell et
321 al., 2013). As a result, though athletes may have achieved initial BM, this may not be reflective
322 of restored performance, tolerance to fatigue and sarcolemmal breakdown (within bouts), as
323 has been reported previously (Bigard et al., 2001) and could have major implications upon brain
324 morphology (e.g. ventricular enlargement) (Wittbrodt et al., 2018), increased oxygen

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325   metabolism (Kempton et al., 2011) and neuromuscular function (e.g. time to fatigue in skeletal

326   muscle) (Bigard et al., 2001; Hackney et al., 2012; Bowtell et al., 2013)..

327

328   Data presented here suggest MMA athletes may enter competitive events with significant

329   muscle damage due to sub-optimal tapering strategies, which should be monitored in

330   accordance to individual load and type of session. Rehydration strategies should be considered

331   (i.e. bolus vs metered drinking, % of BM lost vs total litres of fluid ingested, electrolyte and

332   glucose content) for effective recovery of blood volume and BM. Furthermore, it is

333   recommended that coaches look towards alternative and additional methods of subjective

334   mood/stress scoring, specific to overreaching and/or discriminating between psychosocial

335   stressors and TL.

336

337   The authors acknowledge that a larger sample size with a wider weight-class range are needed

338   to further examine the immunoendocrine and mood status of MMA athletes undergoing a fight

339   preparation camp. It is possible that heavyweight athletes may not engage in RWL strategies

340   and therefore present a different physiological and mood profile during a fight preparation

341   camp.

342

343   **Conclusions**

344   The mood state of professional fighters appears to deteriorate across the five-week fight camp,

345   leading to increased feelings of confusion, depression and tension. Indirect markers of muscle

346   damage and mucosal immunity are also negatively affected during the five-weeks, but can

347   partially recover with a de-loading taper strategy in the pre-fight period. Professional MMA

348   athletes practice pre-fight fluid restriction as a method of RWL, which appears to coincide with

349   negative mood states. Increased cortisol in the final few days of the fight camp may also be

350 related to increased pre-fight stress/anxiety, while salivary IgA decreased >70% 1 week out

351 from fight day, potentially increasing risk of MMA athletes to URTIs towards or after

352 competition date. Practitioners and coaches within MMA should consider refining methods

353 related to the monitoring of load management and mood states while looking to optimise the

354 rehydration process for their athletes during fight preparation camps.

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477 **TABLES**

478 Table 1.— Typical weekly training schedule of a single MMA fighter. MA – martial arts, MMA – mixed martial arts, S&C – strength &
479 condition, D&S – drills and sparring, S – sparring.

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	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
AM	MA specific – D&S (120 min)	Rest	MMA – S (90 min)	MA specific – D&S (120 min)	Rest	MMA – S (90 min)	MA specific – D&S (150 min)
PM	S&C (90 min)	MA specific – D&S (120 min)	S&C (90 min)	MA specific – D&S (120 min)	Rest	S&C (60 min)	Rest

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486   Table 2.— Magnitude-based decisions for dependant variables across week 4 to 0.

Variable	Week from fight					Direction and qualitative inference [ES] (log transformed ± 90 % CL)
	4	**3**	**2**	**1**	**0**	
BM (kg)	77.12 ± 7.61	76.42 ± 7.44	76.2 ± 8.55	75.48 ± 8.21	75.6 ± 8.19	**P + :** 4 v 1 [0.19] (± 0.13), 4 v 0 [0.18] (± 0.15)
TL (AI)	3852 ± 738	4028 ± 817	4635 ± 1067	3969 ± 1097	2871 ± 433	**L + :** 4 v 3 [0.86] (± 0.97), 4 v 1 [1.05] (± 1.22) **VL + :** 3 v 0 [1.83] (± 0.94), 1 v 0 [1.63] (± 1.28) **ML + :** 4 v 0 [2.68] (± 0.70), 2 v 0 [2.6] (± 1.03)
CK (u/L)	1473 ± 453	1171 ± 487	1285 ± 738	1489 ± 1288	713 ± 667	**L + :** 4 v 3 [0.56] (± 0.40) **VL + :** 4 v 0 [3.24] (± 1.95), 3 v 0 [2.69] (± 1.92), 2 v 0 [2.69] (± 1.28) **ML + :** 1 v 0 [2.44] (± 0.53)
SC (ug/ml)	14.61 ± 4.49	15.7 ± 4.91	18.97 ± 9.11	16.76 ± 9.16	20.76 ± 13.48	**P - :** 4 v 3 [0.13] (± 0.24)
sIgA (ug/ml)	474 ± 202	532 ± 180	499 ± 110	240 ± 164	364 ± 157	**L + :** 2 v 0 [0.64] (± 0.63) **VL + :** 4 v 1 [1.39] (± 1.08), 3 v 1 [1.66] (± 1.21), 3 v 0 [0.71] (± 0.48), 2 v 1 [1.59] (± 0.89)
POMS (Overall)	16.2 ± 10.6	31.3 ± 15.5	33.8 ± 18.1	45.5 ± 22.0	35.3 ± 17.2	**P - :** 2 v 1 [0.32] (± 0.45) **L - :** 4 v 2 [0.85] (± 0.76), 3 v 1 [0.53] (± 0.68) **VL - :** 4 v 1 [1.17] (± 0.88), 4 v 0 [0.93] (± 0.71)
Depression	2.0 ± 1.0	3.1 ± 2.6	2.0 ± 1.8	8.0 ± 11.2	7.7 ± 6.3	**VL - :** 4 v 3 [1.57] (± 1.11), 4 v 1 [2.87] (± 2.51) **L + :** 3 v 2 [0.85] (± 0.70) **VL + :** 1 v 0 [0.7] (± 0.37)
Confusion	3.3 ± 1.0	5 ± 2.4	7.7 ± 1.9	7.6 ± 1.9	6.2 ± 4.8	**VL - :** 4 v 3 [0.86] (± 0.60), 4 v 2 [2.02] (± 1.13), 3 v 1 [1.16] (± 0.56) **ML - :** 4 v 1 [2.02] (± 0.74) **L - :** 3 v 2 [1.16] (± 1.16)
Tension	6.3 ± 5.4	8.3 ± 3.2	8.8 ± 4.9	13 ± 6.8	13.5 ± 5.5	**L - :** 4 v 2 [0.47] (± 0.39), 4 v 1 [0.82] (± 0.92), 3 v 1 [0.36] (± 0.41) **P + :** 1 v 0 [0.35] (± 0.47)
Fatigue	11 ± 7.9	13 ± 2.4	14.2 ± 5.1	10.7 ± 2.0	8.5 ± 5.5	**P + :** 3 v 0 [0.27] (± 0.32), 2 v 1 [0.22] (± 0.41)
Anger	8.3 ± 4.5	13.7 ± 8.5	10.8 ± 7.1	13.8 ± 5.7	10.7 ± 2.7	**L - :** 4 v 1 [0.7] (± 0.58), 4 v 0 [0.49] (± 0.53), 2 v 1 [0.63] (± 0.74)
Vigour	15.2 ± 5.4	12 ± 6.9	9.7 ± 6.3	9.7 ± 4.6	11.7 ± 7.5	**L + :** 4 v 2 [0.77] (± 0.67), 4 v 1 [1.01] (± 0.91)

Qualtitative inferences: L = Likely; VL = Very likely; ML = Most likely; P = Possibly; + = Increase; - = Decrease.

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487   Table 3.— Magnitude-based decisions for dependant variables across final seven days.

	Day from fight							Direction and qualitative inference [ES] (log transformed ± 90 % CL)
Variable	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
BM (kg)	75.6 ± 9	75.8 ± 8	75.6 ± 8	74.9 ± 8	73.4 ± 7	71.8 ± 6	75.6 ± 8	**VL + :** 5 v 1 [0.38] (± 0.17), 4 v 1 [0.36] (± 0.16) **P -** : 2 v 0 [0.21] (± 0.13) **P +** : 5 v 2 [0.22] (± 0.13) **L +** : 6 v 1 [0.36] (± 0.17) **VL -** : 1 v 0 [0.37] (± 0.16)
UO (mOsml·kg-1H2O)	252 ± 133	153 ± 147	215 ± 148	524 ± 129	733 ± 158	1024 ± 176	506 ± 388	**VL -** : 6 v 3 [1.01] (± 0.52), 6 v 2 [1.4] (± 0.66), 5 v 0 [1.19] (± 0.81), 2 v 1 [0.39] (± 0.12) **ML** - : 6 v 1 [1.78] (± 0.70), 5 v 3 [1.65] (± 0.50), 5 v 2 [2.03] (± 0.65), 5 v 1 [2.42] (± 0.58), 4 v 3 [1.21] (± 0.45), 4 v 2 [1.6] (± 0.54), 4 v 1 [1.99] (± 0.82), 3 v 1 [0.77] (± 0.21) **L +** : 6 v 5 [0.64] (± 0.68), 2 v 0 [0.84] (± 1.01), 1 v 0 [1.23] (± 1.03) **L -** : 6 v 0 [0.56] (± 0.42), 5 v 4 [0.43] (± 0.52), 4 v 0 [0.76] (± 0.82), 3 v 2 [0.39] (± 0.24)
Fluid intake (L)	5.2 ± 2.4	5.8 ± 1.7	5.2 ± 1.4	2.5 ± 0.5	1.8 ± 0.7	0.6 ± 0.3	3.4 ± 1.3	**VL + :** 6 v 0 [0.78] (± 0.43), 4 v 0 [0.87] (± 0.39) **VL - :** 2 v 0 [1.15] (± 0.72) **ML - :** 1 v 0 [3.4] (± 1.03) **ML + :** 6 v 3 [1.26] (± 0.48), 6 v 2 [1.92] (± 0.61), 6 v 1 [4.18] (± 0.97), 5 v 3 [1.55] (± 0.39), 5 v 2 [2.21] (± 0.78), 5 v 1 [4.46] (± 0.87), 5 v 0 [1.06] (± 0.41), 4 v 3 [1.35] (± 0.39), 4 v 2 [2.01] (± 0.59), 4 v 1 [4.27] (± 0.72), 3 v 1 [2.92] (± 0.92), 2 v 1 [2.25] (± 0.76) **L + :** 3 v 2 [0.66] (± 0.6) **L - :** 3 v 0 [0.48] (± 0.53)
SC (ug/ml)	15 ± 7	11 ± 5	11 ± 4	10 ± 3	12 ± 5	23 ± 12	21 ± 13	**VL + :** 6 v 5 [0.47] (± 0.15) **VL -** : 4 v 1 [0.93] (± 0.38), 2 v 1 [0.91] (± 0.50) **ML -** : 5 v 1 [0.99] (± 0.38), 3 v 1 [1.1] (± 0.34) **L +** : 6 v 4 [0.41] (± 0.29), 6 v 3 [0.57] (± 0.38), 6 v 2 [0.39] (± 0.22) **L -** : 6 v 1 [0.52] (± 0.22)
sIgA (ug/ml)	555 ± 221	476 ± 298	507 ± 162	400 ± 142	324 ± 192	400 ± 294	364 ± 157	**L + :** 6 v 3 [0.46] (± 0.37), 6 v 2 [0.87] (± 0.71), 6 v 1 [0.87] (± 0.98), 4 v 3 [0.37] (± 0.25), 4 v 1 [0.78] (± 0.95), 3 v 2 [0.41] (± 0.41) **VL +** : 4 v 2 [0.78] (± 0.52)

Qualitative inferences: L = Likely; VL = Very likely; ML = Most likely; P = Possibly; + = Increase; - = Decrease..

488   Table 4.— Magnitude-based decisions for POMS and sub-scores across final seven days.

	Day from fight							Direction and qualitative inference [ES] (log transformed ± 90 % CL)
Variable	6	5	4	3	2	1	0	
POMS (Overall)	22.8 ± 7.5	23.3 ± 7.1	20.2 ± 11.6	32.5 ± 21.5	40.8 ± 18.1	51.8 ± 12.4	35 ± 16.7	**L +** : 1 v 0 [0.87] (± 0.72) **VL -** : 6 v 1 [1.63] (± 0.75), 5 v 1 [1.55] (± 0.60), 4 v 2 [1.61] (± 1.26), 4 v 1 [2.21] (± 1.34), 4 v 0 [1.35] (± 1.04) **L -** : 6 v 2 [1.02] (± 0.88), 6 v 0 [0.77] (± 0.65), 5 v 2 [0.94] (± 0.89), 5 v 0 [0.68] (± 0.63), 3 v 2 [0.8] (± 0.79), 3 v 1 [1.41] (± 1.27), 2 v 1 [0.61] (± 0.57)
Depression	5.5 ± 3.2	5.5 ± 2.8	5 ± 3.4	6.3 ± 5.9	8.5 ± 7.3	12.3 ± 7.5	8.2 ± 6.3	**L -** : 6 v 1 [1.63] (± 1.81), 5 v 1 [1.56] (± 1.67) , 3 v 2 [0.45] (± 0.43) , 5 v 1 [1.56] (± 1.67) **VL -** : 4 v 1 [2.06] (± 1.35), 3 v 1 [1.97] (± 1.09), 2 v 1 [1.65] (± 1.16) **VL +** : 1 v 0 [1.53] (± 1.16)
Confusion	3.5 ± 0.8	4.2 ± 1.7	4.7 ± 1.9	7 ± 2.7	8.5 ± 4.6	10.2 ± 3.8	6.2 ± 4.8	**L -** : 6 v 4 [0.75] (± 0.69), 3 v 2 [0.4] (± 0.40), 2 v 1 [0.73] (± 0.63) **VL -** : 6 v 3 [1.94] (± 1.29), 6 v 2 [2.34] (± 1.52), 5 v 3 [1.72] (± 1.47), 5 v 2 [2.12] (± 1.63), 5 v 1 [2.86] (± 1.62), 4 v 3 [1.19] (± 0.93), 4 v 2 [1.59] (± 1.05) **ML -** : 6 v 1 [3.08] (± 1.09), 4 v 1 [2.32] (± 0.88), 3 v 1 [1.13] (± 0.44) **VL +** : 1 v 0 [2.23] (± 1.55) **L +** : 2 v 0 [1.49] (± 1.29)
Tension	9.2 ± 3.3	10.3 ± 2.1	11.2 ± 3.1	10.8 ± 3.1	11.5 ± 3.0	12.5 ± 4.2	13.5 ± 5.5	**L -** : 6 v 5 [0.37] (± 0.36), 6 v 3 [0.41] (± 0.57), 6 v 2 [0.6] (± 0.53), 6 v 0 [0.84] (± 0.81), 3 v 0 [0.43] (± 0.58) **VL -** : 6 v 4 [0.53] (± 0.32)
Fatigue	7.5 ± 2.0	6.8 ± 1.9	5.2 ± 2.9	10.7 ± 5.3	9.8 ± 3.7	11.5 ± 2.7	8.5 ± 5.5	**VL -** : 6 v 1 [1.25] (± 0.91), 6 v 0 [0.93] (± 0.62), 5 v 1 [1.54] (± 0.86), 5 v 0 [1.2] (± 0.71), 4 v 1 [2.81] (± 1.79), 4 v 0 [2.57] (± 1.65) **P +** : 6 v 5 [0.28] (± 0.28) **L +** : 5 v 4 [1.28] (± 1.39) **VL +** : 6 v 4 [1.56] (± 1.35)
Anger	9.5 ± 5.1	9 ± 4.5	9 ± 4.8	8.5 ± 6.3	10.8 ± 6.0	12.5 ± 6.8	10.7 ± 2.7	**P -** : 3 v 2 [0.3] (± 0.37)
Vigour	12.3 ± 3.1	12.5 ± 3.0	7.5 ± 1.9	7.9 ± 2.7	8.1 ± 4.5	8.8 ± 3.8	7.7 ± 4.8	**L -** : **6** v 4 [0.47] (± 0.63), 5 v 4 [0.42] (± 0.57) **VL -** : 1 v 0 [1.66] (± 1.34) **L +** : 5 v 3 [0.64] (± 0.73) **VL +** : 6 v 2 [1.57] (± 1.21), 6 v 1 [2.41] (± 2.01), 5 v 2 [1.61] (± 1.28), 5 v 1 [2.45] (± 2.03), 4 v 3 [1.06] (± 0.6), 4 v 2 [2.04] (± 1.38), 4 v 1 [2.88] (± 1.61)

Qualitative inferences: L = Likely; VL = Very likely; ML = Most likely; P = Possibly; + = Increase; - = Decrease.

490   **FIGURES**

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Week	W4	W3	W2	W1				W0			
Day from fight day	D28	D21	D14	D7	D6	D5	D4	D3	D2	D1	D0
Variables	BM sIgA SC CK TL POMS	BM sIgA SC CK TL POMS	BM sIgA SC CK TL POMS	BM sIgA SC CK TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC TL POMS	BM UO sIgA SC CK TL POMS

Comparison across final five weeks of camp   Comparison across final seven days of camp
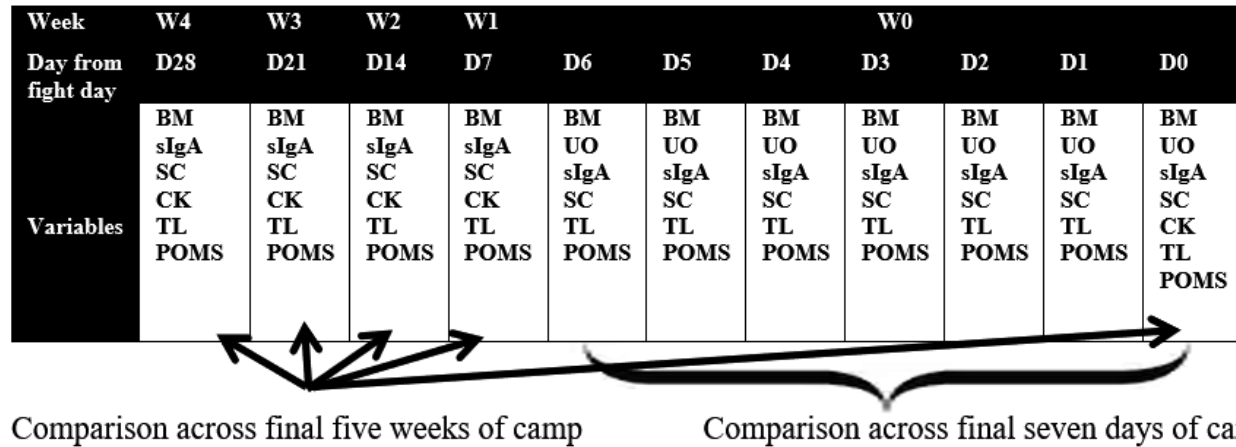
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494   Figure 1.— Research Design – 11 testing points across 5 weeks. Body Mass (BM), Urine Osmolality (UO), Salivary Immunoglobin-A (sIgA),

495   Salivary Cortisol (SC), Creatine Kinase (CK), Training Load (TL), Profile of Moods State (POMS).

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