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Worth the Weight? Post Weigh-In Rapid Weight Gain is Not Related to Winning or Losing in Professional Mixed Martial Arts.

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Article

1 **Worth the weight?: Post weigh-in rapid weight gain is not related to winning or**
2 **losing in professional mixed martial arts**

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34 **Abstract**

35 Body mass (BM) manipulation via rapid weight loss (RWL) and rapid weight gain (RWG) is

36 common practice amongst mixed martial art (MMA) athletes to ensure qualification for the

37 division in which the athlete wishes to compete in. Professional MMA competitors in

38 California are required to weigh-in twice: 24 hours (h) prior to competition and immediately

39 prior to the bout, after which they have typically engaged in RWG. In analysing data from 5

40 MMA events sanctioned by the Californian State Athletic Commission, we used Bayesian

41 analyses to compare bout winners (n=31) and losers (n=31) in terms of in-competition BM

42 (CompMass, kg) and the amount of BM regained between the two weigh-ins (MassDiff, kg).

43 These data do not support the hypothesis that differences in CompMass (BF_{10}=0.667, d = 0.23)

44 or MassDiff (BF_{10} = 0.821, d = .23) determines winning or losing. In addition, there was no

45 statistical difference between bouts ending via strikes, submission or decision for either

46 CompMass (BF_{10}=0.686, $\omega^2 < 0.01$) or MassDiff (BF_{10}=0.732, $\omega^2 = 0.054$). In conclusion, we

47 report for the first time that the magnitude of RWG does not predict winning or losing in a

48 professional cohort of MMA athletes. Additionally, we also report that MMA athletes typically

49 compete at a BM that is at least 1-2 divisions higher than the division in which they officially

50 weighed-in. These analyses may provide impetus for governing bodies and coaches to enact

51 change at both professional and amateur levels to reduce negative health consequences

52 associated with extreme RWL and RWG.

53 **Key words**:Body composition; body mass regulation; weight cutting

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55 **Word count = 2,210**

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59 **Introduction**

60 Mixed martial arts (MMA) is combat sport characterised by striking and grappling based

61 actions, in which the participants compete in specified divisions (colloquially known as 'weight

62 classes') according to their body mass (BM). There is a strong belief amongst participants and

63 coaches that having a BM greater than the opponent provides a direct competitive advantage

64 (Langan-Evans, Crighton, Martin, & Wilson, 2017), with evidence suggesting that this offers

65 psychological support for performers (Pettersson, Ekström, & Berg, 2013). To achieve the BM

66 required for their chosen division, MMA participants regularly engage in rapid weight loss

67 (RWL) prior to their official weigh-in, followed by rapid weight gain (RWG) in the 24 hours

68 (h) between the weigh-in and the bout itself (Gann, Tinsley, & La Bounty, 2015). Methods

69 employed are a combination of diet restriction and activities designed to induce extreme

70 hypohydration including: fluid restriction, training in plastic clothing, use of saunas and

71 excessive fluid consumption (water loading). The magnitudes of RWL reported amongst MMA

72 participants is typically greater than related sports such as boxing, wrestling and Brazilian jiu

73 jitsu (Barley, Chapman, & Abbiss, 2017; Daniele, Weinstein, Wallace, Palmieri, & Bianco,

74 2016; Horswill, Scott, Dick, & Hayes, 1994). It is noteworthy that MMA athletes often partake

75 in RWL and RWG practices on the basis of advice from coaches and training partners with

76 little intervention from medical professionals or dieticians (Barley et al., 2017; Crighton, Close,

77 & Morton, 2016; Hillier et al., 2019; Matthews & Nicholas, 2017; Santos-Junior et al., 2019).

78 There is emerging evidence that the magnitude of RWG may be an important factor for success

79 in grappling sports such as judo (Reale, Cox, Slater, & Burke, 2016), though this effect is

80 apparently absent in striking sports such as boxing (Reale, Cox, Slater, & Burke, 2017). In

81 relation to MMA, Coswig et al. (2018) demonstrated that winners of competitive MMA bouts

82 regained 3% more BM than bout losers after both groups lost 7-8% BM prior to weigh-in.

83 Nonetheless, the small sample size of 8 winners and 7 losers precludes the conclusion that the

84 magnitude of RWL and subsequent RWG is an important determinant of success. Despite

85 such limited data in this area, professional MMA athletes partake in large magnitudes of RWL

86 and RWG, the result of which can be detrimental to health. For example, a recent case study

87 (n=1) conducted by our laboratory reported that of the 18.1% (14.5 kg) BM lost by the

88 participant during an 8 week period, 9.3% (7.3 kg) was due to severe hypohydration in the final

89 24 h before weigh-in. This led to reduced resting metabolic rate, hypogonadal endocrine profile

90 and acute kidney injury (Kasper et al., 2018). The influences of severe hypohydration on brain

91 trauma (Kempton et al., 2009) and hormonal changes (Coswig, Fukuda, & Del Vecchio, 2015)

92 have been suggested as the main physiological causes of injury, sickness, kidney disease and

93 in extreme situations, death (Crighton et al., 2016; Langan-Evans et al., 2017; Matthews &

94 Nicholas, 2017; Murugappan et al., 2018).

95 To combat these issues, the California State Athletic Commission (CSAC) now conduct a

96 second weigh-in on the day of competition to determine whether participants have regained

97 more than 10% of their weigh-in BM (CSAC, 2017). Since the introduction of this process in

98 2017, CSAC have released the day of bout weigh-in results of five professional MMA events

99 to the public domain. Through analysing these data, the aim of the present study was to test the

100 hypothesis that the amount of RWG between the official weigh-in and the day of bout weigh-

101 in would be predictive of who won the bout, and whether the bout ended due to strikes,

102 submission or decision (Kirk, 2018). It was also hypothesised that different divisions would

103 display different magnitudes of RWG.

104

105 **Methods**

106 The data used for this study were collected at five professional MMA events (four Ultimate

107 Fighting Championship and one Bellator MMA) held in the state of California, USA by the

108 CSAC. As previously discussed, participants were required by the CSAC to weigh-in 24 h prior

109 to their bout and again on the day of the bout. These data represent the occasions released to

110 the public domain by the CSAC via the media. The following analyses were completed

111 following institutional ethical approval, and approval from the CSAC. Data were recorded by

112 the authors from various media outlets, cross referencing between each to ensure accuracy. The

113 CSAC reported each of the following variables in lbs, converted by the authors into kg in

114 keeping with SI units: participant's official BM as measured 24 h prior to the bout (OffMass);

115 participant's BM after RWG on the day of the bout (CompMass). It is not known how or

116 precisely when CompMass measurements were taken, other than they occurred on the day of

117 the bout prior to competition. The amount of BM regained between these two points by each

118 participant (MassDiff) was then calculated as follows:

119 $$CompMass - OffMass = MassDiff$$

120 The winner of each bout, the bout outcome (strikes, submission or decision (Kirk, 2018)), and

121 the division in which the bout took place was also recorded. Draws, disqualifications and no

122 contests were excluded from the sample, as were bouts where any participant's CompMass was

123 not recorded/reported.

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125 **Statistical Analyses**

126 Bout winners and losers were compared for statistically relevant differences in CompMass and

127 MassDiff via two-tailed Bayesian t tests using a JZS Cauchy prior = 0.707. Cohen's d effect

128 size was calculated using the standard deviation of the mean scores as the denominator.

129 Bayesian one-way ANOVA with omega squared (ω^2) effect size was calculated for differences

130 in CompMass and MassDiff between each bout outcome. Bayesian one-way ANOVA with ω^2

131 was calculated for MassDiff between divisions. ANOVA post-hoc comparisons were

132 calculated using a default t-test with a Cauchy prior. The data were also viewed to determine

133 which division participants would, on average, be classed as based on their CompMass,

134 regardless of the their OffMass.

135 The following Bayes factor (BF) thresholds were used for each Bayesian test: 1-2.9 =

136 anecdotal; 3-9.9 = moderate; 10-29.9 = strong; 30=99.9 = very strong; ≥ 100 = decisive

137 (Wetzels & Wagenmakers, 2012). Each BF was used to specify evidence in favor of either the

138 hypothesis (BF_{10}) or the null hypothesis (BF_{01}). Due to a default prior being used BF robustness

139 checks were also performed. Where a BF was found to cross a threshold using a wider prior,

140 both thresholds are reported (Quintana & Williams, 2018). Cohen's d thresholds were set at:

141 trivial $d \leq 0.1$; small $d \geq 0.2$; moderate $d \geq 0.6$; large $d \geq 1.2$. ω^2 thresholds were set at: small

142 $\omega^2 \geq 0.01$; moderate $\omega^2 \geq 0.06$; large $\omega^2 \geq 0.14$. Each of the named statistical tests were

143 completed using JASP 0.10.2.0 (JASP Team, Amsterdam, Netherlands).

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145 **Results**

146 **Effect of Rapid Weight Gain on Winning and Losing**

147 Descriptive results are presented in Table 1. When comparing RWG between bout winners and

148 losers, the difference between the in-bout mass of winners and losers was anecdotal

149 (CompMass BF_{10} = 0.667, d = 0.23). The median [IQR] difference between winner's and

150 loser's CompMass = 0.8 [-0.7:2.7] kg, with range = -9 – 14 kg. Importantly, the evidence in

151 favour of bout winners regaining more mass than bout losers was also anecdotal (MassDiff

152 BF_{10} = 0.821, d = .23). The median [IQR] difference between winner's and loser's MassDiff =

153 0.95 [-0.6:2.3] kg, with range = -8.5 – 13.4 kg.

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156 **Differences between Bout Outcomes**

157 Differences in CompMass ($BF_{10} = 0.686$, $\omega^2 < 0.01$) and MassDiff ($BF_{10} = 0.732$, $\omega^2 = 0.054$)

158 did not appear to have any effect on whether the bout ended via strikes, submission or decision.

159 Though there was a trend for winners to regain a greater %BM in bouts ending due to strikes

160 or submission, these differences were not found to be statistically relevant. When considering

161 bouts ending due to strikes, the data favoured the null hypothesis that CompMass did not affect

162 the outcome ($BF_{01} = 2.129 - 3.761$, $d = 0.27$), with the evidence for MassDiff having an effect

163 in these bouts being anecdotal ($BF_{10} = 0.651$, $d = 0.33$). Similarly, in terms of bouts that were

164 won by submission, there was only anecdotal evidence for either CompMass ($BF_{10} = 1.1$, $d =$

165 0.6) or MassDiff ($BF_{10} = 1.8$, $d = 0.72$) differentiating between winners and losers. For bouts

166 that ended in decision, the evidence favoured the null hypothesis of there being no effect on

167 the result for both CompMass ($BF_{01} = 4.8$, $d = 0.05$) and MassDiff ($BF_{01} = 4.8$, $d = 0.06$).

168   ***INSERT TABLE 1 HERE***

169

170 **Differences between Divisions**

171 When comparing MassDiff between divisions (Table 2), there was found to be anecdotal

172 evidence of each division regaining BM at different magnitudes ($BF_{10} = 1.3$, $\omega^2 = 0.05$). Post

173 hoc testing did, however, find the following differences between individual divisions: light

174 heavyweight (LHW) and women's strawweight (WSW) $BF_{10} = 5.4$ (moderate); welterweight

175 (WW) and featherweight (FW) $BF_{10} = 3.7$ (moderate); WW and flyweight (FlW) $BF_{10} = 7.5$

176 (moderate); FW and WSW $BF_{10} = 5.4$ (moderate); FlW and women's featherweight (WFW)

177 $BF_{10} = 4$ (moderate); FlW and WSW $BF_{10} = 25.9$ (strong).

178   The mean CompMass of each division placed the participants in at least the division above

179   which they were competing in. Six divisions displayed a mean CompMass placing the

180   participants near to the upper limit of two divisions above their OffMass. It should be noted,

181   differences between heavyweight (HW) and other individual divisions were not calculated as

182   no HW participants reduced BM prior to official weigh-in.

183   ***INSERT TABLE 2 HERE***

184

185   **Discussion**

186   Despite widespread perceptions amongst athletes and coaches, we provide novel data

187   demonstrating that the amount of BM regained after official weigh-in appears to provide no

188   competitive advantage in professional MMA athletes. Indeed, these data suggest that the

189   magnitude of RWG does not predict success, regardless of whether the bout ends due to strikes,

190   submission or decision.

191   Similar to other grappling inclusive sports such as judo (Reale et al., 2016), previous

192   observations from Coswig et al. (2018) provided preliminary evidence to suggest that the

193   magnitude of RWG amongst MMA winners was significantly greater than losers. However,

194   using a larger sample size, the present data suggest this is not the case for those participants

195   studied here. Importantly, our data also extend recent research conducted on a mixed cohort of

196   amateur and professional MMA athletes (Brechney, Chia, & Moreland, 2019) which suggested

197   that bout losers engaged in a greater magnitude of RWL than bout winners. Furthermore, it is

198   noteworthy that MMA athletes in the present study were, on average, regaining an absolute

199   BM large enough to place them in a division that was 1-2 divisions above their OffMass,

200   regardless of winning or losing. Given the apparent lack of a competitive advantage and also

201   the dangers of engaging in extreme RWL and RWG (Kasper et al., 2018), these data therefore

202 suggest that athletes may be better served by reducing the magnitude of RWL and competing

203 at least one division higher.

204 In contrast to judo (Reale et al., 2016) and the initial MMA findings by Coswig et al. (2018),

205 any potential benefits of RWG appear to be absent in striking-based events (Reale, Cox, et al.,

206 2017). A separate analysis of 71 boxing championship bouts found no effect of RWG on

207 success (Daniele et al., 2016). Given that MMA is a sport where the technical requirements of

208 successful performance can vary widely between grappling and striking movements (Kirk,

209 2018), the assumption that having a greater BM is a prerequisite for success does not seem to

210 hold true. It appears more likely that a strategy of RWL/RWG that accommodates the middle

211 of the striking-grappling spectrum would be more suitable. This may allow participants to

212 achieve a BM applicable to both grappling and striking modes whilst reducing or potentially

213 avoiding any negative health related outcomes.

214 The belief that RWG offers a competitive advantage appears to be most pronounced in the

215 lighter mass divisions of FW, BW and FlW, where participants regained more relative BM than

216 those in lightweight (LW) and above. This result also occurred in the three female divisions.

217 Though these data cannot directly infer the magnitude of RWL, it would be reasonable to

218 assume that this would be similar or greater to the amount of BM regained via RWG (Barley

219 et al., 2017). Overall, the evidence presented here and by others (Brechney et al., 2019)

220 represents emerging data that extreme RWL and RWG is not predictive of success. At present,

221 there may be concerns amongst MMA athletes that those who do reduce RWL and change

222 divisions would be at a disadvantage to those who do not. To that end, there should be a

223 consistent, co-ordinated effort for researchers to work directly with athlete facing practitioners

224 to induce cultural change within the sport. As this would take some time, competitors in the

225 interim will need systems in place to ensure adequate health and safety alongside optimal

226 performance. Such systems have been successfully utilised in Olympic combat sports (Reale,

227   Slater, & Burke, 2017) and should be developed within MMA. We suggest these analyses

228   presented here are replicated periodically as more data become available.

229

230   **Novelty Statement**

231   In summary, we report for the first time that the magnitude of RWG does not predict winning

232   or losing amongst professional MMA athletes. Additionally, we also report that MMA athletes

233   typically compete at a BM that is at least 1-2 divisions higher than the division in which they

234   officially weighed-in.

235

236   **Practical Application**

237   Given that our analyses do not support the notion that extreme RWL and RWG is required for

238   success in MMA, the present data may provide impetus for governing bodies to enact

239   legislative change at both professional and amateur levels to discourage extreme RWL and

240   RWG. Our results should also be used to encourage athletes and coaches to make use of more

241   sustainable RWL and RWG practices.

242

243   **Acknowledgments**

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Table 1 – Descriptive statistics of bout winners and bout losers (mean ± SD), as categorised according to the full cohort and bouts won by strikes, submission or decision.

	Bout Winner		Bout Loser	
	CompMass (kg)	MassDiff (kg)	CompMass (kg)	MassDiff (kg)
Full Cohort	77.3 ± 13.8	6.9 ± 2.9 [10.1 ± 0.04%]	76.4 ± 13.4	6 ± 2.8 [9.1 ± 0.05%]
Strikes	79.5 ± 14.2	6.9 ± 3.4 [10.4 ± 0.05%]	78.3 ± 15.3	5.7 ± 3.2 [8.5 ± 0.05%]
Submission	77.3 ± 11.2	5.7 ± 2.4 [8.3 ± 0.04%]	75.1 ± 2.4	4.2 ± 2.3 [6.2 ± 0.03%]
Decision	75.4 ± 13.8	7.2 ± 2.5 [10.6 ± 0.03%]	75.2 ± 12.5	8.6 ± 8.9 [10.5 ± 0.04%]

Nb. [%] = mean ± SD %BM regained in each group (MassDiff as a percentage of OffMass)

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Table 2 – Mass variables by division (mean ± SD)

Division	Division Mass Limit (kg)	Full Divisional Cohort		Winners		Losers	
		CompMass (kg)	MassDiff (kg)	CompMass (kg)	MassDiff (kg)	CompMass (kg)	MassDiff (kg)
Heavyweight	120.5	109.1 ± 5.6	1.1 ± 2.2 [1 ± 2.1%]	109.1 ± 6.9	1 ± 2.3 [0.9 ± 2.1%]	109 ± 5.7	1.1 ± 2.5 [1.1 ± 2.3%]
Light heavyweight	93.1	100.1 ± 1.4	7.2 ± 1.4 [7.8 ± 1.5%] [a]	100.9 ± 1.5	8.2 ± 1.1 [8.9 ± 1.2%]	99.3 ± 0.7	6.2 ± 0.6 [6.6 ± 0.7%]
Middleweight	84	92.2 ± 3.2 ◊	7.7 ± 3.4 [9.1 ± 4%]	94.1 ± 2.6	9.5 ± 3 [11.3 ± 3.5%]	90.2 ± 2.5	5.9 ± 2.9 [7 ± 3.5%]
Welterweight	77.2	82.1 ± 2.9 ◊	5.6 ± 1.5 [7.4 ± 1.8%] [b, c]	82.3 ± 3.2	5.8 ± 1.6 [7.6 ± 1.9%]	82 ± 2.6	5.4 ± 1.5 [7.1 ± 1.8%]
Lightweight	70.5	77 ± 4.8 ◊	5.6 ± 4.6 [8 ± 6.6%]	77.7 ± 5.5	7.2 ± 5.2 [10.2 ± 7.3%]	74.7 ± 4.2	4.1 ± 4.1 [5.8 ± 5.8%]
Featherweight	65.9	73.6 ± 3 #	7.8 ± 2.7 [11.8 ± 4%] [b, d]	73.6 ± 3.1	7.8 ± 2.4 [11.8 ± 3.6%]	73.6 ± 3	8.7 ± 3 [11.8 ± 4.6%]
Bantamweight	61.3	68.5 ± 2 #	6.9 ± 1.9 [11.1 ± 3.1%] [f]	69 ± 1.7	7.3 ± 1.5 [11.9 ± 2.5%]	68 ± 2.2	6.4 ± 2.2 [10.4 ± 3.5%]
Flyweight	56.8	65 ± 1.2 #	8.2 ± 0.8 [14.4 ± 1.3%] [c, e]	65.3 ± 1.8	8.4 ± 1.3 [14.8 ± 2.1%]	64.8 ± 0.4	8 ± 0.4 [14 ± 0.6%]

Women's featherweight	65.9	71.6 ± 1 ◊	5.8 ± 1.2 [8.7 ± 1.9%] [e]	71.1 ± 0.4	5 ± 0 [7.6 ± 0%]	72 ± 1.5	6.5 ± 1.4 [9.9 ± 2.2%]
Women's bantamweight	61.3	68.5 ± 3.3 #	6.9 ± 3.4 [11.2 ± 5.5%]	66 ± 1.9	4.3 ± 1.8 [6.9 ± 2.7%]	71 ± 1.9	9.5 ± 2.1 [15.4 ± 3.3%]
Women's flyweight *	56.8	64 ± 3.1 #	7.1 ± 2.6 [12.4 ± 4.5%] [g]	66.2	8.9 [15.6%]	61.8	5.2 [9.2%]
Women's strawweight	52.3	57.5 ± 1.3 #	5 ± 1.3 [9.5 ± 2.4%] [a, d, f]	57.5 ± 1.4	5.2 ± 1.2 [9.9 ± 2.3%]	57.4 ± 1.3	4.9 ± 1.5 [9.2 ± 2.8%]

*Nb. ◊ = participants are on average near to the mass limit of the division above; # = participants are on average near to the mass limit of two divisions above; a/b/c/d/e/f = division displays moderate ANOVA post hoc differences in MassDiff to division with the same corresponding letter; g = division displays strong ANOVA post hoc differences in MassDiff to division with the same corresponding letter; * = one bout sampled in this division; [%] = mean ± SD %BM regained in each group (MassDiff as a percentage of OffMass)*

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