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Rapid weight gain predicts fight success in mixed martial arts - evidence from 1,400 weigh-ins

(Article begins on next page)

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Each pound matters: the influence of weight regain on fight success in mixed martial arts - an analysis of 1,474 weigh-in

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3 **Each pound matters: the influence of weight regain on fight success in mixed**

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2 **martial arts - an analysis of 1,474 weigh-in**

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4 **Abstract:**

5 We aimed to verify whether the weight regained (%WR) between the official weigh-in

6 and the time of the fight is associated with fight success in MMA. A total of 1,474 MMA

7 weigh-ins/fights from 21 MMA companies regulated by the California State Athletic

8 Commission were analyzed. Logistic regression with the odds ratio (OR) performed using

9 the %WR as the independent variable and the fight outcome (win and loss) was used as

10 the dependent variable (controlled for sex, division, and weight difference from the

11 opponent) with p<0.05. Bantamweight division presents the highest median of %WR

12 (9.72%) and one athlete from the lightweight division presented the highest individual

13 %WR (20.44%). The %WR was a significant predictor of fight outcome (ß=0.044;

14 OR=1.045; 95%CI=1.014–1.077; p=0.004) so that for each 1%WR increased the chance

15 of winning by 4.6%. The results suggest that the magnitude of weight regain is linked to

16 the chance to win. Considering the regulatory commissions, confederations, and events'

17 organizers should consider defining limits for weigh-regain, considering the potential

18 advantage with high weight regain found. Otherwise, the athletes might invest in RWL

19 and RWR after official weight-in, to increase their chance of winning.

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21 **Keywords:** Martial arts; Weight loss; Weight gain.

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24   **INTRODUCTION**

25   Mixed Martial Arts (MMA) is a combat sport that uses mixed techniques from

26   different martial arts (12). The combats are divided into three rounds (five rounds for title

27   fights) of five minutes with a one-minute interval. The fight might be interrupted if there

28   is a submission or knockout (5). The victory in MMA is determined by actual or technical

29   knockout (i.e. KO/TKO), submission, or by judges' decision (i.e., by points) (6). MMA

30   gained popularity in the earlies 1990 when The Ultimate Fighting Championship (UFC)

31   was created (7). The first events lacked weight-divisions, but after rules reformulation,

32   divisions based on weight were created, similarly to others combat sports (6,12). This rule

33   was created to equalize strength between opponents (1,6,11) so that the only difference

34   between them would be their technical skills and/or strategy.

35   Despite the divisions by weight, most athletes choose to fight in a weight-division

36   in which the weight limit is several pounds below their habitual weight (11). To ensure

37   qualification, rapid weight loss (RWL) followed by rapid weight regain (RWR) strategies

38   are adopted in order to get an advantage related to weight, size, and strength (5,11,17).

39   The use of RWL strategies generally begins approximately seven days before the official

40   weigh-in and has the characteristics to be acute and aggressive (7,14). The use of

41   laxatives, diuretics, plastic or rubber clothing, and sauna are the most frequently reported

42   method for RWL in combat sports (11). Specifically, in MMA, the most common

43   strategies self-reported by the fighters are caloric and hydric restriction, sauna, diuretics,

44   clothes that increases sweat production, high volume of low-intensity exercise, and water

45   load (17,19). Moreover, some of these methods are used in combination (17,19). These

46   results indicate that dehydration is the main strategy of RWL. Dehydration decreases

47   blood volume, plasma volume, free testosterone, and blood creatine concentration

48   (1,11,17). In this sense, Jetton et al. (12) compared the hydration status by urinary analysis

49   of 40 MMA fighters at 24h and two hours before the combat. The results showed that

50   even after ~4.4% of weight regain (WR), 39% of fighters were still significantly

51   dehydrated and 11% were seriously dehydrated two hours before the combat (12).

52   Therefore, considering that the RWL strategy may impair performance and negatively

53   impact the athletes' health, ways of avoiding it are warranted.

54   Despite the risk involved in the RWL, several athletes still opt to compete in

55   divisions below their habitual weight, given that with RWR they may gain advantages

56   over shorter and lighter fighters on the day of the fight. In this regard, Brechney et al. (3)

57   investigated if the fight outcome was related to the weight loss magnitude in 75 MMA

58   fighters and found that athletes who lost the fight lose more weight than the winners

59   (10.6% vs 8.6%). However, most athletes included in their sample were amateurs (n =

60   59) (3). Considering that aggressive RWL is repeated throughout one's athletic career,

61   there is a fear of the consequences of the athletes' health (1). Most importantly, there are

62   reports of deaths that were caused as the consequence of RWL (7,14). On the other hand,

63   the magnitude of WR has been suggested to be a decisive factor for fight success in MMA,

64   more influential than the magnitude of weight loss (6,14). Thus, considering that the

65   majority of events have the official weigh-in from 24h to 36h before the combat (4), the

66   athletes consume high quantities of high energy macronutrients (i.e. carbohydrates) and

67   use intravenous and oral rehydration methods, to recover as much as possible the weight

68   lost (1,6,7,14).

69   MMA athletes lose ~10% of body weight in approximately seven days, with ~5%

70   in the last 24h before the official weigh-in, to fit the division's weight limit

71   (2,4,5,7,14,15). Hence, it has suggested that regulatory agencies create ways to inhibit the

72   RWL process in combat sport for both athlete safety and fairness of sport. However,

73   whether WR impacts on the outcome of combat is less discussed. Currently, there is no

74   formal consensus regarding the limit of weight loss or regain in MMA. However, some

75   commissions have been monitoring the magnitudes of WR in order to create new rules in

76   this regard. For instance, since 2016 the California State Athletic Commission (CSAC)

77   recommends that athletes who exceed 10% of WR compete in the division above their

78   current division (8). In 2019, CSAC approved the new rule stating that a fight must be

79   canceled if one of the athletes regained >15% of WR (9). Although previous studies

80   showed that the WR magnitude is a fundamental element for increasing the chances of

81   winning, few studies verified this fact on a large scale. Thus, we aimed to verify whether

82   the WR between the official weigh-in and the fight influences the chances of winning.

83   We hypothesize that greater WR would positively associate with greater chances of

84   winning.

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METHODS

87   **Study Design**

88   To test whether the WR between the official weigh-in and the fight influence the

89   chances of winning the present study analyzed the data of 1,474 weight-ins in professional

90   MMA events from 20 MMA companies under the California State Athletic Commission

91   regulation (CSAC). The CSAC regulates, licentiate, and supervise combat sports events

92   in the California State, USA. The CSAC provided datasheets containing all information

93   used in the present study. These data were acquired in 21 different locations, from national

94   and international professional MMA events from January 2015 and August 2019 at the

95   California state.

96

97   **Subjects**

98   The report from 1,550 fights was provided, involving both sexes. The events

99   involved professionals MMA fighters divided into 11 weight divisions (Table 1). To be

100   included, sufficient information regarding the study variables such as the fight outcome

101   (win or lose, not draw), weight at weight-in day within the category limit should be

102   reported. The data of 76 fighters were excluded: 31 did not present the weight at the fight

103   day, 44 fight outcomes as a draw, one athlete exceeded his/her weight division limit.

104   Therefore, the final analysis included the data on 1,474 fights (Female = 110; Males =

105   1,364).

106   The data were collected from the following MMA companies: BAMMA, Bellator

107   MMA, Cage Fury Fighting Championship (CFFC), California Extreme Fight (CXF),

108   California Fight Championship (CFC), California Fight League (CFL), Combat

109   Americas, Dragon House MMA, Extreme Fighters, In Sync Promotions, Invicta MMA,

110   King of the Cage (KOTC), Legacy Fighting Alliance (LFA), No Limit/Goodman, PR

111   Promotions, Roy Englebrecht Events, Smash Global, Tachi Palace Fight, Titans Cage

112   MMA, TS-1 Combate, and Ultimate Fight Championship (UFC).

113   The CSAC provided datasheet including the official weight-in date, event dates,

114   official body weight at the weigh-in, at the fight day, and the difference between them

115   (i.e., WR), and the difference in weight from the opponent (WD), sex, and divisions of

116   the athletes. The official weigh-in (OW) was measured between 24-36h before the

117   combat, while the re-weighing (RW) was performed ~3h before de fight. From these data

118   was possible calculated the WR (WR = RW OW), and the percentage of WR: [%WR =

119   (WR/OW)x100] (12).

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121   **Statistical Analyses**

122   Descriptive data are presented as median and interquartile range as well as

123   minimum and maximum values. Logistic regression was performed using as the

124   independent variables all measures with a theoretical relationship with the dependent

125   variable, namely %WR, sex, division, and WD from the opponent. The outcome of the

126   fight (win and loss) was used as the dependent variable. The Odds Ratio (OR) with a 95%

127   confidence interval (95%CI) was calculated for each independent variable. Accordingly,

128   the probability of winning was calculated as the value exceeding OR of 1.00 multiplied

129   by 100, only for variables that achieved a significant level of 5%.

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131   **RESULTS**

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133   Table 1 describes the information about weight categories (separated by sex) and

134   %WR in each weight category. The highest %WR was found for the Bantamweight

135   division and the highest individual %WR was from one athlete of the Lightweight

136   division (20.4%). On the other hand, the heaviest categories (i.e. Heavy and Super

137   Heavyweight divisions) presented the smallest median %WR.

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139   **Insert Table 1**

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141   Table 2 presents the results of the logistic regression analysis. Only the %WR was

142   significantly associated with the fight outcome ($p = 0.004$). For each 1% of WR the

143   probability of winning increased by 4.6%.

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145　　　　　　　　　　　　　　　　**Insert Table 2**

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147　**DISCUSSION**

148　　　　This study aimed to verify the influence of weight regain on fight success in

149　MMA, analyzing 1,474 fights in events that occurred between 2015 and 2019 regulated

150　by the CSAC. The main finding was that %WR was a predictor of fight success,

151　independently of sex, division, and WD from the opponent. In fact, for each 1% of WR

152　increased the probability of winning by 4.6%, which confirmed our hypothesis. Previous

153　studies have suggested that the magnitude of WR, but not weight loss, was the main factor

154　for fighters' performance (6,14). However, to the best of the authors' knowledge, this is

155　the first study to investigate the influence of WR on fight success in an ecological and

156　large-scale study with professional MMA athletes.

157　　　　Our findings corroborate with Artioli et al. (1) statement that the RWL might be

158　an indirect method to gain an advantage in the fight. These authors suggested that this

159　method should be banned in combat sports and listed by World Anti-Doping Agency

160　(WADA) as doping because it might enhance sports performance indirectly, and put

161　athletes' health at risk and violating the spirit of the sport (1). One possible explanation

162　for RWL to enhance sports performance is because it has small or no impact in physical

163　capacities (1). This maintenance of performance has been associated with WR after the

164　official weight-in, with reports that the weight of the athlete in the day of the fight

165　corresponds to three weight divisions above the one he/she is fighting (14,15), which

166　reinforce the idea of violation of the sports spirit. Indeed, the Coswig et al. (6) study

167　concluded that WR was significantly higher in winners compared to losers. Interestingly,

168　WR was positively correlated with time spent at high intensity during the fight, lower

169   limb blows, and ground and pound actions of the athletes. It is noteworthy that WR did

170   not compensate for the weight loss (6), and only WR but not weight loss was correlated

171   with measures of performance, which reinforce the idea that WR is more important than

172   weight loss. Our study corroborates these findings, by showing that the magnitude of WR

173   has high relevance for fight success in MMA.

174   In recent years, RWL has been highly criticized for the dangers it poses to the

175   athletes. One fighter from Brazil and one from China died during the RWL process (7,14).

176   Moreover, kidney injury (13) and rhabdomyolysis (16) cases were reported as a

177   consequence of the RWL process. Despite that, few actions have taken to inhibit RWL

178   methods. The Asian event ONE Championship banned since 2015 the weight loss by

179   dehydration and has increased weight limits for each category compared to other events

180   (14). On the other hand, UFC increased the time between official weigh-in and fight time

181   to 24h to 36h in 2016, justifying as a protection for the athletes. However, it may have

182   influenced the athletes to adopt even more aggressive methods for RWL, because the time

183   window for regain is larger (14). In 2019, UFC together with U.S. Anti-doping Agency

184   (USADA), prohibited the use of intravenous solutions for WR (20). This is important

185   because athletes have been using this method to speed up the WR process (7). Whilst all

186   these measures are important, the lack of control and limit about the magnitude of WR

187   remains. In this sense, some researchers reported that superior values of WR comparing

188   weight loss are influenced by the time available for WR (14,15). Thus, a decrease in the

189   use of aggressive RWL methods could occur only when the time available for WR

190   decreases considerably or if the official weigh-in is performed very close to the fight (4).

191   In the "real-world", athletes still use RWL methods because a high percentage of weight

192   loss can be regained after the weigh-in. In fact, seven out 11 divisions presented a median

193   %WR of >8%. Furthermore, one extreme example was the athlete from the lightweight

194   division that showed 20.44% WR.

195   In order to restrict both RWL and high WR, some changes to the rules of MMA

196   competitions should be made. First, the creation of intermediate weight division, between

197   the existent categories, which would avoid severe RWL, as seen at the present (7). This

198   is important because the difference of the limit of weight between some divisions reaches

199   20 pounds (i.e. between middle and light heavyweight divisions) and some athletes could

200   achieve the weight to be characterized in 2-3 divisions above of the one they are

201   competing in the fight day (15). Second, the official weigh-in should occur a few hours

202   before the combat, as it occurs currently in Brazilian Jiu-Jitsu competitions (10), which

203   prevents high weight loss and high WR. Some amateur events have adopted a similar

204   approach, weighting the athletes in the morning of the fight day (4). Third, make the re-

205   weighting official and put limits for the percentage of WR, under penalty of cancellation

206   of the combat and/or punishment to the athlete. This rule was adopted in judo, where the

207   extra weight-in has a limit of 5% of body weight (18). Fourth, events

208   promoters/companies obligate a change of division if the athlete exceeds 5% of WR on

209   the extra weight-in. This suggestion is limited because it depends on the voluntary

210   adhesion of the companies. Finally, organizations such as USADA and WADA could

211   consider high levels of WR as doping with its corresponding punishment, as it has been

212   suggested by other authors (1,7).

213   Our findings should be interpreted with caution, considering the limitations of the

214   present study. Considering the nature of data, it was not possible to include other variables

215   in the regression analysis such as age, off-season weight, time of experience, and cartel,

216   which could also influence the results. The data analyzed in our study came from only

217   one athletic commission of the USA. This is important because the CSAC has a specific

218 orientation when the athletes exceed 10% of WR (8). Lastly, the time variability between

219 official weight-in and re-weighing (i.e., between 24h and 36h) also is relevant and is was

220 no specified in the datasheet. For instance, in the study by Coswig et al. (6) the weight

221 loss (~6%) was not compensated by the WR, while in Matthews et al., (14) weight loss

222 (~7%) were surpassed by WR. The main difference between the two studies was the

223 measurement time of the re-weighing (24h vs 36, respectively).

224   Considering that the athletes regain ~8-10% of body weight and our findings

225 conclude that a single 1% of regaining increase de probability of winning by 4,5%, the

226 magnitude of WR is a strong variable linked to the chance to win. In this way,

227 commissions, confederations, and events' organizers should consider changing the rules

228 related to weigh-in, not only equalize the chances of athletes in the combat, mainly linked

229 to body size and strength level, but also for safety reasons considering the risks involved

230 in RWL. Until the rules are not changed, the athletes should invest in good ways to regain

231 weight fast after official weight-in, to increase their chance of a win.

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238 **DECLARATIONS**

239   The authors do not present any conflict of interest.

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Table 1. Distribution of athletes by division, sex, and percentage of weight regained by category.

Weight Class	% of the sample	Sex (n)			Percentage of WR (%)	
		M	F	All	Median (IQR)	Range (min-max)
Atomweight	1.00	-	15	15	9.35 (6.48 –11.12)	0.85 – 12.39
Strawweight	3.30	-	48	48	8.06 (5.23 – 11.04)	-2.51 – 15.96
Flyweight	6.80	83	17	100	9.42 (7.30 – 11.77)	1.13 – 16.86
Bantamweight	16.1	224	13	237	9.72 (7.83 – 12.45)	-0.23 – 17.78
Featherweight	20.9	291	17	308	8.95 (6.46 – 10.80)	-0.14 – 16.58
Lightweight	16.3	240	-	240	8.45 (6.02 – 10.60)	-2.61 – 20.44
Welterweight	16.4	242	-	242	8.24 (5.79 – 10.41)	-1.89 – 16.78
Middleweight	10.6	156	-	156	5.82 (4.24 – 8.45)	-6.15 – 14.27
Light Heavyweight	4.40	65	-	65	5.69 (4.19 – 7.67)	-1.09 – 13.19
Heavyweight	3.90	57	-	57	0.75 (0.08 – 1.88)	-6.93 – 8.56
Super Heavyweight	0.40	6	-	6	1.05 (-0.38 – 1.89)	-0.44 – 3.27
Overall	100	1,374	100	1,474	8.26 (5.48 – 10.62)	-6.93 – 20.44

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Note: IQR; interquartile range; WR = weight regain

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Table 2. Logistic regression of independent variables to predict fight outcome (win) (n=1,474).

Variable	Fight outcome		
	ß (95%CI)	OR (95%CI)	p
%WR	0.044 (0.014 – 0.074)	1.046 (1.015 – 1.078)	0.004
Sex	0.007 (-0.450 – 0.465)	1.007 (0.637 – 1.592)	0.974
Official weight	-0.000 (-0.013 – 0.012)	0.999 (0.986 – 1.012)	0.954
WD from de opponent	0.001 (-0.010 – 0.012)	1.000 (0.990 – 1.012)	0.874
Division	0.024 (-0.140 – 0.190)	1.025 (0.869 – 1.209)	0.767
Constant	-0.601 (-1.833 – 0.630)	0.547 (0.159 – 1.889)	0.339

Note: CI = confidence interval; OR = odds ratio; WD = weight difference; WR = weight regain.

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Flyweight	6.80	83	17	100	9.42 (7.30 – 11.77)	1.13 – 16.86
Bantamweight	16.1	224	13	237	9.72 (7.83 – 12.45)	-0.23 – 17.78
Featherweight	20.9	291	17	308	8.95 (6.46 – 10.80)	-0.14 – 16.58
Lightweight	16.3	240	-	240	8.45 (6.02 – 10.60)	-2.61 – 20.44
Welterweight	16.4	242	-	242	8.24 (5.79 – 10.41)	-1.89 – 16.78
Middleweight	10.6	156	-	156	5.82 (4.24 – 8.45)	-6.15 – 14.27
Light Heavyweight	4.40	65	-	65	5.69 (4.19 – 7.67)	-1.09 – 13.19
Heavyweight	3.90	57	-	57	0.75 (0.08 – 1.88)	-6.93 – 8.56
Super Heavyweight	0.40	6	-	6	1.05 (-0.38 – 1.89)	-0.44 – 3.27
Overall	100	1,374	100	1,474	8.26 (5.48 – 10.62)	-6.93 – 20.44

Note: IQR; interquartile range; WR = weight regain

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Table 2. Logistic regression of independent variables to predict fight outcome (win)

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%WR	0.044 (0.014 – 0.074)	1.046 (1.015 – 1.078)	0.004
Sex	0.007 (-0.450 – 0.465)	1.007 (0.637 – 1.592)	0.974
Official weight	-0.000 (-0.013 – 0.012)	0.999 (0.986 – 1.012)	0.954
WD from de opponent	0.001 (-0.010 – 0.012)	1.000 (0.990 – 1.012)	0.874
Division	0.024 (-0.140 – 0.190)	1.025 (0.869 – 1.209)	0.767
Constant	-0.601 (-1.833 – 0.630)	0.547 (0.159 – 1.889)	0.339

Note: CI = confidence interval; OR = odds ratio; WD = weight difference; WR = weight

regain.