Original Investigation

High Prevalence and Magnitude of Rapid Weight Loss in Mixed Martial Arts Athletes

ABSTRACT

The practice of rapid weight loss in mixed martial arts (MMA) is an increasing concern but data remains scarce. The aim of this study was to investigate the prevalence, magnitude, methods and influencers of rapid weight loss in professional and amateur MMA athletes. MMA athletes (n=314; 287 men, 27 women) across nine weight categories (strawweight to heavyweight), completed a validated questionnaire adapted for this sport. Sex-specific data were analysed, and sub-group comparisons were made between athletes competing at professional and amateur levels. Most athletes purposefully reduced body weight for competition (men: 97.2%; women: 100%). The magnitude of rapid weight loss in one week prior to weigh-in was significantly greater for professional athletes compared to those competing at amateur level (men: 5.9% v 4.2%; women: 5.0% v 2.1% of body weight; $p<0.05$). In the 24 h preceding weigh-in, the magnitude of rapid weight loss was greater at professional than amateur level in men (3.7% v 2.5% of body weight; $p<0.05$. Most athletes 'always' or 'sometimes' used water loading (72.9%), restricting fluid intake (71.3%) and sweat suits (55.4%) for rapid weight loss. Coaches were cited as the primary source of influence on rapid weight loss practices (men: 29.3%, women: 48.1%). There is a high reported prevalence of rapid weight loss in MMA, at professional and amateur levels. Our findings, constituting the largest enquiry to date, call for urgent action from MMA organisations to safeguard the health and wellbeing of athletes competing in this sport.

Key words: martial arts; combat sport; dieting; health risks; rapid weight loss; weight loss.

Introduction

Mixed martial arts (MMA) is a combat sport, with bouts defined by weight divisions (Reale et al., 2017a) with the aim of endorsing balanced and stimulating matches whilst reducing potential injuries that may result from substitutional differences in weight (Mendes et al., 2013). For the athlete, the process of 'making weight' is imperative, because failure to make weight results in bout cancellation or deduction from the athlete's payment.

MMA athletes engage in gradual and rapid weight loss (RWL) prior to competition and then re-gain weight post weigh-in (Jetton et al., 2013; Matthews & Nicholas, 2017; Coswig et al., 2018). Gradual weight loss includes long-term energy restriction and exercise training. Energy and other nutrient deficits can lead to altered hormonal milieu, muscle atrophy, fatigue, altered bone metabolism, depressed immune system and decreased energy metabolism, all of which are particularly problematic for athletes (Zanker and Hind, 2007; Mountjoy et al., 2014). RWL describes the practice of reducing weight over a short period of time. RWL is an ongoing problem in combat sports, indicated by reports that athletes are using controversial and potentially harmful practices to achieve entry into the lowest weight class possible (Artioli et al., 2010a; Crighton et al., 2015). Given that RWL is detrimental to health and performance with risks to cognitive function (Franchini et al., 2012), and a higher risk of injury (Green et al., 2007), calls to action have been published (Crighton et al., 2015). At its worst, RWL has been implicated in the deaths of combat athletes in the days/hours prior to competition. Three collegiate wrestlers died from complications arising from RWL in 1997 (Centers for Disease Control, Prevention, 1998). The first death of an MMA athlete during RWL was reported in 2013 (Crighton et al., 2015). Since then, the number of reported fatalities during RWL have increased in martial arts with similarities to MMA (Matthews & Nicholas, 2017) including the death of a Scottish martial arts athlete prior to a Muay Thai fight in 2017.

Despite growing concerns, published data on the extent of RWL in MMA remains scant. Therefore, the purpose of this study was to provide robust data on the prevalence, magnitude, methods and influencers of gradual and rapid weight loss in professional and amateur MMA athletes.

Methods

Participants

Professional and amateur MMA athletes over the age of 18 years (strawweight to heavy-weight categories) were recruited from MMA gyms, events, competitions and websites. Participants were categorised by the level at which they competed at the time of completing the questionnaire. Professional level athletes participated under the rule set of Unified Rules of Mixed Martial Arts (URMMA) and received payment to compete. Amateur level athletes did not receive payment for competing and participated under the rule sets of Amateur A, B or C; which have shorter rounds (3 x 3 min) and a more restricted rule set. Of the 318 athletes who replied to the study invitation, 314 were eligible to take part. One athlete was excluded for not specifying their weight category, whilst three athletes responding online were under 18 years and were also excluded from the study. Additionally, 24 athletes submitted incomplete answers to questions on usual weight loss practices. Therefore, the final sample size was 290 (264 men, 26 women) for data relating to weight loss magnitude and 314 (287 men, 27 women) for data relating to the method of weight loss and key influencers. The study was approved by the University Research Ethics Committee, was conducted in accordance with the Declaration of Helsinki (2013) and all participants provided informed consent.

Validated questionnaire

With approval from the authors (Artioli et al., 2010b) the validated Rapid Weight Loss Questionnaire (RWLQ) was adapted for the current study to ensure appropriateness to MMA. The questionnaire was divided into 3 sections with a total of 21 questions, incorporating a Likert Scale using a range of 1-5 to measure the prevalence and magnitude of dieting methods (1-Always, 2–Sometimes, 3–Almost never, 4–I don't use anymore, 5–Never used). The questions covered the level and frequency of competition, training, athletic achievements, weight history, diet and RWL. The adapted questionnaire was piloted through completion by local MMA athletes, and feedback was provided on the suitability and clarity of the questions. Following minor amendments arising from the piloting process, the final questionnaire was deemed appropriate for the study objectives and the target population (Appendix).

Statistical analysis

Statistical analyses were completed using SPSS (Version 22.0, IBM Corp., Armonk, NY). MANCOVA analysis was used to compare levels of weight loss across the independent variables (sex & competition level), whilst controlling for age. A series of Chi-square analyses were conducted to test the relationships between the independent variables, weight loss methods used and key influencers for weight loss. Standardised residual values were observed to identify the responses that were over or under represented within the independent variable groups. Standardised residual values of +/- 1.9 were identified as being significant due to corresponding to an alpha level of $p<0.05$. Cohen's d effect size was calculated where appropriate and interpreted in accordance to Cohen, (1988). Data are presented as mean (SD), with range where appropriate.

Results

The descriptive results are given in Tables 1 and 2.

Prevalence and magnitude of weight loss and RWL

One hundred percent of women and 97.2% of men athletes reported engaging in purposeful weight loss. For the purpose of this study, total weight loss encompasses both gradual weight loss and late RWL. The average reported total weight lost was 7.3 ± 3.4 kg (range 0-18.0 kg) in men and 5.1 ± 2.7 kg (range 2–11 kg) in women, representing 9.0 ± 3.9% (range 0-20.5%) and 7.7 ± 3.3% (range 2.5-13.7%) of body weight in men and women, respectively. The most amount of weight lost for a fight (not specific to RWL) was 10.2 ± 4.6 kg (0-25 kg) in men and 7.0 ±3.6 kg (2-14 kg) in women, representing 12.5 ± 5.0% (0-25.9%) and 10.7 ± 4.5% (2.8-20.6%) of body weight in men and women, respectively.

In men, 96.1% (professional: 95.2%, amateur: 96.9%) and 90.2% (professional: 93.4%, amateur: 87.2%) reported engaging in RWL in the one week and 24 hours prior to weigh-in, respectively. Men reported losing an average of 4.1 ± 2.5 kg (0-13 kg) or 5.0 ± 3.1% (0-14.0%) of body weight one week before weigh-in and 2.5 ±1.8 kg (0-10 kg) or 3.1 ± 2.2% (0-10.8%) of body weight in the 24 hours before weigh-in. In women, all and 78.3% (professional: 88.9%; amateur: 71.4%) athletes reported engaging in RWL in the one week and 24 hours prior to weigh-in, respectively. Women reported losing an average of 2.5 ±1.4 kg (1-7 kg) or 3.8 ± 2.0% (0.9-9.6%) of body weight one week before weigh-in and 1.5 ± 1.3 kg (0-5 kg) or 2.3 ± 1.9% (0-6.9 %) of body weight in the 24 hours before weigh-in. One third (n = 9) of women athletes reported missing 3 or more consecutive menstrual cycles within the last 12 months.

To determine whether sex or competition level effected reported weight lost, controlling for age, %total weight loss, %weight lost in the final week, and %weight lost in the final 24 hours were tested in a 2 (men v women) x 2 (amateur v professional) MANCOVA. There was a significant main effect for competition level, F (3,280) = 3.64; p <0 .05, using the *Wilks' lambda* criterion. Total weight loss was greater in professional athletes (10.0 ±3.9 % v 7.9 ±6.6%; F (1,282) = 5.5; p <0.05; d =-.37; small effect). Professional athletes also lost more weight in the final week (5.9 ± 2.9% v 4.1 ± 2.5%; F (1,282) = 9.97; p <0.05; d= −.69; medium effect) and 24 h (3.7 ± 2.1% v 2.5 ± 2.0%; F (1,282) = 9.39; p <0.05; d=-.62; medium effect). There were no interaction effects with sex in any models.

Methods of weight loss and RWL

Methods of weight loss are reported in Table 3. The most common method was gradual dieting, with 81.2% reporting to always use this. Approximately half of athletes (50.6%) reported *'always'* using water loading. The least common method was self-induced vomiting, with 94.6% of athletes claiming to never use this method.

Chi-square analysis indicated women athletes (44.4%) were significantly more likely to have 'never used' water loading methods, in comparison to men athletes (15.7%). With regard to restricting fluids, professionals (57.4%) were significantly over represented for the response *'Always'*. For water loading, professionals (4.7%) were over represented for the response 'I don't use anymore' and amateur athletes (25.3%) were over represented for the response *'Never use'*. For sauna use, amateur athletes (31.3%) were over represented for the response *'Never use'*. For laxative use, amateur athletes (94.9%) were significantly over represented for the response *'Never use'*. Professionals were over represented for the *'Always'* and *'Sometimes'* responses (7.4% and 8.9%, respectively). With regard to diuretics use, amateur athletes (81.9%) were significantly over represented for the response *'Never* *use'* and professionals were over represented for the *'Always'* response (14.9%). There was a significant difference in diet pill use, with professional athletes (6.8%) more represented than amateur athletes (2.4%) for the response *'Always'*, however the residual score did not correspond to an alpha level of 0.05. For sweat suit use, professionals (39.2%) were significantly over represented for the response *'Always'*. Professional athletes (7.4%) were significantly over represented for the *'I don't use anymore'* response. Amateur athletes were also significantly over represented (39.8%) for the *'Never use'* response.

Influences on weight loss practices

There were significant sex differences in reported influencers of weight loss practices, x^2 (8, N = 314) = 26.45, p <0 .01 (Table 4). There were no differences in reported influencers between professional and amateur athletes, x^2 (8, N = 314)=14.12; p >0.05.

Discussion

The purpose of this study was to investigate the prevalence, magnitude and influencers of weight loss prior to competition in professional and amateur MMA athletes. In this largest enquiry to date, the major finding was that most men and all women MMA athletes reported engaging in gradual and rapid weight loss leading up to competition, with coaches being key influencers of their weight loss practices. Our findings also indicate that a significant proportion of athletes are using strategies that reduce body water stores (e.g. water loading, fluid restriction, increasing sweat losses through exercise and/or heat exposure) as a primary means of RWL both at professional and amateur levels.

In the present study, the prevalence of weight loss in MMA athletes ranged from 97.2 to 100%. With RWL in the week or final 24 hours before weigh-in ranging from (90.2-100%). This is similar or higher than rates reported for other combat sports athletes (Kiningham et al., 2001; Jetton et al., 2013; Horswill, 2009; Artioli et al., 2010a; Brito et al., 2012; Barley et al., 2017). In judo, 62-90% of athletes report to engage in RWL (Artioli et al., 2010a; Brito et al., 2012; Barley et al., 2017) in wrestling, 60-97% (Kiningham et al., 2001; Barley et al., 2017), in Brazilian jiu-jitsu, 56.8-88% (Brito et al., 2012; Barley et al., 2017), in Muay Thai/kickboxing, 94% (Barley et al., 2017) and in taekwondo, 63.3-85% (Brito et al., 2012; Barley et al., 2017). The higher prevalence in the current study of MMA athletes may reflect rapid growth in popularity of the sport and prize money, but might also reflect the broad weight categories and/or the extended time between weigh-in and competition for most events (usually 24-36 hours) compared to that of judo (2.5-5 hours) and amateur boxing (0-8 hours). Whilst most previous studies of RWL in combat sports have focused on men, we found that the prevalence of RWL in women MMA athletes is equivalent to men. While there were some significant differences for weight loss between amateur and professional level men athletes for weight loss in the week and 24 h before weigh-in and total weight loss, the absolute differences were small. Together the findings infer that RWL in the final week and 24 hours before weigh-in is not exclusive to professional men athletes - rather it appears to be a significant problem across the board.

The reported range of weight loss varied in the current study. A number of athletes reported losing significant amounts of weight, including one professional men MMA athlete who reported losing as much as 25.8% of body weight. The reported average amounts of RWL for professional MMA athletes were 5.9% (men) and 4.2% (women) with the most extreme being 14% of body weight across the week leading up to competition and 3.7% (men) and 2.5% (women) with the most extreme being 10.7% of body weight over the 24 hours before weigh-in. These percentages are similar to those reported by smaller studies (Andreato, et al., 2014; Crighton et al., 2015; Coswig et al., 2015; Matthews & Nicholas, 2017) and similar or higher than rates reported for other combat sports such as Brazilian jiu-jitsu (4%) (Brito et al., 2012), taekwondo (4%) (Brito et al., 2012), wrestling (5%) (16) and kickboxing (4%) (Boguszewski et al., 2010). Our findings are concerning especially given reports of fatalities in combat athletes reducing similar amounts of body weight (Crighton et al., 2015; Centers for Disease Control, Prevention, 1998).

The health risks associated with RWL are predominantly complications arising from severe dehydration and energy deficiency. A recent study of MMA athletes (*N* = 7) engaging in RWL leading up to competition reported raised urine omsolality indicative of significant /severe dehydration in athletes at weigh-in (Matthews & Nicholas, 2017). (Jetton et al., 2013) reported similar findings, with significant dehydration present immediately before competition and following average RWL of ~4% of body weight.

Energy deficit through weight cycling in weight class sports is known to effect metabolic, endocrine, and immune function (Turocy et al., 2011). A recent study has reported effects on endocrine status and a status of hypercholesterolemia, as well as acute kidney injury with 10% loss of body mass by RWL (Kasper et al., 2018). Another study found that 4% weight loss before competition was accompanied by a 33% increase in markers of bone resorption and an 81% rise in cortisol in men and women judokas (Green et al., 2007). Raised cortisol in the short term will disrupt other endocrine networks and diurnal variation of this hormone. In the longer term raised cortisol would contribute to adverse effects on bone. In women, energy deficit can suppress mentrual function and in the current study, one third of women athletes reported amenorrhea in the last 12 months. It is possible that this figure is an underestimation because women using oral contraceptives were not excluded from the study. Low energy availability and disruption of mentrual functioning also negatively impacts bone metabolism and cardiovascular function (Artioli et al., 2010a; Mountjoy et al., 2014). Adverse effects on cardiovascular system include reduction of endothelial reactivity and disruption of lidid profile due to low oestrgen levels, as seen in post-menapausal women where there is marked increase in incidence of cardiovascular disease. There is growing concern that RWL might increase the risk for brain injury in MMA compared to other combat sports, given that head trauma can still occur after an athlete has fallen unconscious/fainted (Crighton et al., 2015). In terms of effects on performance, energy deficit can impair judgement, concentration and coordination (Mountjoy et al., 2014).

The methods of weight loss reported by athletes were predominantly related to manipulation of body water and inducing energy deficit through increased exercise and reduced dietary intake. Aside from energy deficit, water loading was the most frequently reported method of rapid weight loss for men and women, at both professional and amateur levels. Water loading is the practice of consuming significant volumes of water (~10 litres of water/day for 3-5 days) followed by complete restriction of fluid intake over the 24 hours before weigh-in, with the aim of inducing significant loss of body water, and hence weight reduction. Whilst acute dehydration might impair performance (James et al., 2017), the impairments in thermoregulatory and cardiovascular function (Cheuvront and Kenefick, 2014) are of particular concern, and may exacerbate any negative health effects related to heat exposure used to facilitate weight loss (Casa et al., 2015). This is particularly relevant given that heat exposure has been implicated in a number of the deaths reported in those attempting to make weight (Centers for Disease Control, Prevention, 1998). The popularity of water loading is also concerning given the potential risk of dilutional hyponatraemia if the large volume of water ingested is not spaced appropriately over the course of the day (Mohan et al., 2013). High volume intakes over a short time frame (e.g. >10 litres in 6 hours) has resulted in fatalities (Mohan et al., 2013). Progressive water loading over a 6 day period leading to competition may attenuate the risk of hyponatraemia (Adrogué and Madias, 2000) However, Reale et al, (2017b) recent study on water loading suggests MMA athletes may not be at risk hyponatraemia when waterloading. However, the timing of blood samples, as well as the restriction of food and fluid intake before blood samples leaves the effects of water loading on hyponatraemia risk uncertain. More research into water loading is needed before recommendations can be made on risks. Interestingly, the use of diuretics (18%) and fat burners (24%) were reported to be lower than for other methods of weight loss.

The key influencer of RWL for both professional and amateur MMA athletes, and for both sexes, was the coach. Professional women athletes were more likely to report consulting a dietician than their men counterparts. The use of the internet as the primary source of information on rapid weight loss was higher in men than in women MMA athletes. The lack of clinical input or support is concerning, as there can be individual variability in physiological response. If any underlying medical conditions have not been excluded, then extreme practices of inducing RWL through energy deficit and/or manipulation of intra and extracellular water could lead to increased risk of serious health consequences.

The authors acknowledge that while this is the largest enquiry of its kind to date, the self-report nature of the study is a limitation. The questionnaire was piloted prior to data collection to ensure comprehension and whilst responses were anonymously sought, we cannot guarantee full honesty in disclosure. Aside from RWL (weight loss in the 1 week before weigh-in), questions pertaining to gradual weight loss were not time bound.

In conclusion, our study indicates a high prevalence of RWL in MMA regardless of competition level and sex, with the deleterious practice of water loading as one of the most commonly reported methods for weight loss. Our findings, constituting the largest enquiry to date, call for urgent action from MMA organisations to safeguard the health and wellbeing of athletes competing in this sport.

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Competing interests

There are no competing influences to declare.

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Table 1. Mixed martial arts athlete demographics and weight classes (count), *N* = 314.

	Men, n = 287	Women, n = 27
Mean age, years (SD)	27.2 (5.2)	28.8 (5.2)
Mean body mass, kg (SD)	81.8 (12.1)	63.2 (8.1)
Weight class (kg; range from previous category)	0	9
Straw (52.2)		
Fly (56.7; 4.5 kg)	19	4
Bantam (61.2; 4.5 kg)	40	10
Feather (65.8; 4.6 kg)	32	2
Light (70.3; 4.5 kg)	80	2
Welter (77.1; 6.8 kg)	52	0
Middle (83.9; 6.8 kg)	38	0
Light-heavy (93.0; 9.1 kg)	16	0
Heavy (120.2; 27.2 kg)	10	0

Table 2: Reported magnitude (mean ± SD, range) of weight cutting in mixed martial arts (n = 290)

	Men		Women	
	Professional, n =126	*Amateur, n = 138*	*Professional, n = 9*	*Amateur, n = 17*
Age, years	29.3 (5.1)	25.2 (4.5)	31.9 (2.7)	27 (5.5)
Walking weight, kg	83.6 (12.6)	80.3 (11.2)	62.1 (12.6)	63.9 (8.5)
Average total weight loss, kg	8.4 (3.5)	6.4 (3.1)	5.5 (2.7)	4.8 (2.7)
Average total weight loss, %	10.1 (3.9)	8 (3.6)	8.6 (3.4)	7.2 (3.2)
Weight loss in 1 week before weigh-in, kg	5 (2.6)	3.4 (2.1)	3.2 (1.7)	2.1 (1.2)
Weight loss in 1 week before weigh-in, %	5.9 (2.9)	4.2 (2.5)	5 (2.2)	3.1 (1.6)
Weight loss in 24 h before weigh-in, kg	3.1 (1.9)	2 (1.6)	2.1 (1.4)	1.2 (1.6)
Weight loss in 24 h before weigh-in, %	3.7 (2.1)	2.5 (1.9)	3.2 (1.9)	1.8 (1.6)

Table 3. Methods of weight loss in mixed martial arts (% of group; $N = 314$)

	Response (percentage)					*Chi-square* (χ^2)	
	Always	Sometimes	Almost never	I don't use anymore	Never used	Sex [a]	Competition level [a]
Gradual dieting	81.2	12.1	2.5	0.6	3.5	2.99	8.44
Skipping meals	8.6	27.1	19.4	6.7	38.2	7.94	6.62
Fat burners	8	14	4.8	6.1	67.2	2.25	3.47
Diet pills	4.5	8	3.5	3.5	80.6	4.21	11*
Laxatives	3.8	13.1	7.6	3.8	71.7	3.14	32.84***
Increased exercise	51	25.5	8.6	1.6	13.4	.86	2.35
Water loading	50.6	22.3	6.7	2.2	18.2	15.49**	23.9***
Restricting fluid intake	46.8	24.5	10.2	2.2	16.2	2.69	15.16**
Sweat suit	29	26.4	12.1	4.1	28.3	1.78	33.68***
Saunas	25.5	35	11.5	4.8	23.2	7.21	16.41**
Fasting	20.1	19.7	15.6	6.7	37.9	2.99	6.53
Heated training rooms	15.3	26.4	17.2	2.2	38.9	4.12	7.69
Diuretics	8	10.2	7.6	5.4	68.8	1.53	33.54***
Vomiting	0.3	0.6	3.5	1	94.6	5.55	6.3

***= p<.05, **=p<.01, ***=p<.001. [a]: df=4.**

Table 4. Distribution of responses for influential sources on weight loss (percentage within group).

	Sex		Competitive level	
Influencer	Men	Women	Professional	Amateur
Training partner	16.7	3.7	17.6	13.9
Fellow MMA athlete	15.7	3.7	18.9	10.8
Doctor	0.7	0.0	0.7	0.6
Physical trainer	3.1	7.4	3.4	3.6
MMA coach	29.3	48.1	22.3	38.6
Parents	0.3	3.7	0.7	0.6
Dietician	10.1	29.6	14.2	9.6
Internet	15.0	3.7	12.2	15.7

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