

No relationship between nutritional knowledge and rapid weight loss in male amateur boxers

Freddy C. W. Brown^{1*}, Macauley Owen¹, Neil D. Clarke¹, Doug Thake¹

¹*School of Life Sciences, Coventry University, Coventry, UK*

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ABSTRACT

Amateur boxing is a weight-categorized combat sport in which rapid weight loss (RWL) is prevalent prior to competition. Although many boxers believe such practices enhance perceived size and relative strength, potential benefits must be considered against the risks to performance and health. It is unknown whether RWL behaviours are related to nutritional knowledge. Accordingly, the Nutritional Knowledge Questionnaire for Athletes (NKQA) and the Rapid Weight Loss Questionnaire (RWL-Q) were administered to 63 male amateur boxers (mean \pm SD; age 23 ± 3 years, body mass 69.6 ± 10.0 kg). Respective scores were analysed descriptively and assessed for correlation. All 63 boxers (100 %) had lost weight to compete, with pre-competition weight loss characterised by a 2.9 ± 1.0 kg (4.2 ± 1.4 %) average reduction in 8 – 10 days. Fluid restriction and the use of sweat suits were the most prevalent methods of RWL (87 % each) with ‘extreme’ methods (diuretics, laxatives, diet pills and self-induced vomiting) having been used by 21 % of boxers. Total scores for NKQA (52 ± 13 %) compared unfavorably to athletes previously studied. No relationships were observed between NKQA and RWL-Q for either total scores ($r = -0.044$, $p = 0.731$) or any NKQA subsection (r from 0.001 to -0.127 , $p > 0.05$). While coaches (49 %) and other boxers (40 %) exerted the greatest influence on weight loss behaviours, medical professionals had the lowest influence ($p < 0.05$). Nutritional knowledge was not related to weight loss behaviours. Furthermore, amateur boxers should be encouraged to seek professional advice for safe and reliable information.

1. Introduction

Amateur boxing is a weight-categorized combat sport contested over either 3 x 3 min (elite), 3 x 2 min or 4 x 2 min (novice) rounds. Victory is awarded either by knockout (whereby a boxer knocks down their opponent for 10 seconds), by the referee deeming one boxer unable to continue, or to the boxer who has scored the greater “number of *quality blows* on the target area” at the conclusion of the bout (England Boxing, 2019). Accordingly, strength and power are key determinants of success (Chaabène et al., 2015).

Combat athletes frequently aim to compete in a weight category below their habitual body mass to maximise perceived advantages in size and strength, or to be “big for the weight” (Pettersson, Ekström, & Berg, 2013; Reale, Slater, & Burke, 2017b). As championship weigh-ins must occur at least three

hours before amateur boxing competition (England Boxing, 2019), boxers frequently “make weight” to achieve a particular weight class, before regaining body mass by the time they box (Reale, Cox, Slater, & Burke, 2017a).

England Boxing currently has no limit for weight regain before competition, potentially encouraging the use of rapid weight loss (RWL) methods (England Boxing, 2019; Reale, Slater, & Burke, 2017c). Indeed, although amateur boxers weigh-in on the day of competition, magnitudes of RWL and subsequent regain commonly range from 2 – 5 % body mass (Barley, Chapman, & Abbiss, 2018a; Reale, Slater, & Burke, 2018). However, RWL practices frequently involve severe dehydration and dietary restriction (Reale et al., 2017b), which are likely to impair performance (Franchini, Brito, & Artioli, 2012). As weight-making practices in amateur boxing are constantly evolving (Reale et al., 2017c), it is essential to frequently evaluate

*Corresponding Author: Freddy C. W. Brown, School of Life Sciences, Coventry University, Coventry, UK, ad1385@coventry.ac.uk

the prevalence of RWL in amateur boxing to inform educational strategies.

Existing literature suggests that improved nutritional knowledge may impact sporting performance. For example, while greater nutritional knowledge is associated with improved body composition, strength and dietary practices in young team sport athletes (Debnath, Chatterjee, Bandyopadhyay, Datta, & Dey, 2019), insufficient dietary knowledge may compromise athletes' fueling and recovery strategies (Trakman, Forsyth, Hoye, & Belski, 2018). The need to manipulate body mass may make nutritional knowledge even more important for amateur boxers (Reale et al., 2017a). However, weight loss and nutritional knowledge are more frequently informed by coaches and other athletes than by qualified health professionals, which may lead to false beliefs and inappropriate practices (Artioli et al., 2010b). It is currently unknown whether the prevalence of RWL is related to nutritional knowledge in amateur boxers.

No data exists on the nutritional knowledge of competitive, senior amateur boxers. Furthermore, no study has yet investigated the relationship between nutritional knowledge and RWL behaviours in weight-categorized athletes. Accordingly, this study was designed to examine the relationship between nutritional knowledge and RWL, as well as to investigate the sources of nutritional information used by amateur boxers. It was hypothesized that nutritional knowledge would be negatively associated with the prevalence and severity of RWL behaviours. These findings could be used to guide future education strategies with the aim of moderating potentially dangerous RWL behaviours, whilst maintaining the health and performance of amateur boxers.

2. Methods

2.1. Participants

Following ethical approval, 63 competitive male amateur boxers (mean \pm SD; age 22 ± 3 years, self-reported body mass 69.6 ± 10.0 kg, height 177 ± 9 cm, age started boxing 13 ± 4 years-old) were recruited and provided informed consent. Participants were recruited following gatekeeper approval from club coaches, in person and via email. Inclusion criteria were aged >18 years, >2 years' boxing experience, >5 contests. Female boxers were excluded from the investigation due to limited numbers. Boxers were asked for their England Boxing championship weight division (46-49, 49-52, 52-56, 56-60, 60-64, 64-69, 69-75, 75-81, 81-91, 91+ kg) and competition experience (5-10 bouts novice, 11-20 bouts intermediate, 21+ bouts open class) for grouping analysis and categorisation purposes (England Boxing, 2019).

2.2. Instruments

The Nutritional Knowledge Questionnaire for Athletes (NKQA) (Furber, Roberts, & Roberts, 2017) and Rapid Weight Loss Patterns Questionnaire (RWL-Q) (Artioli et al., 2010c) were utilised.

The NKQA tests respondents on their knowledge of the nutritional contents of food, as well as consensus guidelines in

sports nutrition. The questionnaire was scored out of a maximum possible 136 marks, which are distributed as follows: Protein (19 marks), Carbohydrates (21 marks), Fats (23 marks), General (31 marks), Fluid (14 marks) and Sport (28 marks). Higher scores indicate superior nutritional knowledge, with the original authors reporting a test-retest Pearson's correlation of 0.98, ($p < 0.05$).

The RWL-Q was originally developed in judo and quantifies the frequency with which specified RWL techniques are used; assigning greater scores to more severe methods and higher rates of weight loss. Furthermore, this questionnaire distinguishes between 'rapid weight loss methods' (training in sweat suits or in heated rooms, sauna use, wearing additional clothing, various methods of manipulating fluid/food intake) and 'extreme rapid weight loss methods', defined as the use of diuretics, laxatives, diet pills and self-induced vomiting (Artioli et al., 2010c). A continuous scoring system is used to attain numeric scores for anthropometrics, competition history and previous RWL patterns. For example, when asked if they had used sweat suits in training for rapid weight loss, boxers' answers were scored as follows: 'Always' = 3 points, 'Sometimes' = 2 points, 'Almost never' = 1 point, 'Not anymore' = 0.5, 'Never used it' = 0 points. The length of time over which boxers lose weight prior to weigh-in is scored as follows: '>15 days' = 0 points, '11 – 14 days' = 1 point, '8 – 10 days' = 2 points, '6 – 7 days' = 3 points, '4 – 5 days' = 4 points, '1 – 3 days' = 5 points. The RWL-Q also questions athletes on the extent to which various sources of information (e.g., coach, other boxer, social media etc.) influence their nutritional knowledge and weight loss behaviours ('none', 'little', 'some', 'high'). Higher scores for RWL-Q indicate more aggressive rapid weight loss behaviours. The validation of the original questionnaire (Artioli et al., 2010c) demonstrated excellent reliability from a highly significant correlation between test-retest scores ($r = 0.92$, $p < 0.05$).

2.3. Task

A cross-sectional questionnaire-based study was carried out across 10 amateur boxing clubs, nationwide.

2.4. Procedure

Questionnaires were administered using the Bristol Online Survey (JISC Software, Bristol, UK). Sport-specific questions referring to track and field in the NKQA and Judo specific questions in the RWL-Q were amended to suit amateur boxing. Data was collected following pilot work, conducted to ensure that all questions were easily understood by the population. Participants were asked to complete the online questionnaires alone, with no assistance from other sources.

2.5. Statistical Approach

Descriptive statistics are presented as means and standard deviations. Data were analysed using statistical software (SPSS Statistics 25, IBM, New York, USA). Pearson's correlation coefficient was used to investigate the relationships between RWL-Q and NKQA scores in the whole cohort, as well as in subgroups defined by

weight category and competitive experience. Repeated measures ANOVA was used to identify differences in NKQA subsection scores, which were reported as percentages to allow comparisons with existing literature. Where appropriate, differences are given as Cohen's *d* effect sizes (Cohen, 1988), alongside the 95 % confidence interval (ES ± [LCL, UCL], where LCL and UCL are the lower and upper confidence limits, respectively). Frequency analysis was used to examine the magnitude of influence on athletes' current nutritional knowledge and weight loss behaviours from external sources, before Friedman's test was used to assess differences between sources ($p < 0.05$). Significant differences were investigated with *post hoc* analyses, using the Bonferroni correction.

3. Results

3.1. Boxer demographics

Complete data-sets were obtained from 63 boxers (Table 1), representing 10 clubs from five of the 11 geographical regions sanctioned by England Boxing. Of the 39 open class boxers included, 20 had previously won regional championships, of which nine had gone on to become national champions.

3.2. Relationships between scores on the Rapid Weight Loss Questionnaire and the Nutrition Knowledge Questionnaire for Athletes

No relationships were found between RWL-Q scores and either total NKQA ($r = -0.044$, $p = 0.731$) or any subsection scores (r lowest = 0.001, greatest = -0.127, $p > 0.05$).

3.3. Nutrition Knowledge Questionnaire for Athletes scores

Total NKQA scores (Table 1) averaged 52 ± 13 % and did not vary with experience (novice = 48 ± 13 %, $n = 13$; intermediate = 51 ± 15 %, $n = 11$; open class 54 ± 13 %, $n = 39$; $F = 0.960$, $p = 0.389$; ES = $-0.16 \pm [-0.82, 0.51]$ to $0.45 \pm [-0.16, 1.06]$). There was a significant difference between NKQA subsection scores ($F = 3.27$, $p < 0.001$; Figure 1). Scores for protein (62 ± 16 %) were greater than all other sub-sections ($p < 0.05$; ES = $0.46 \pm [0.11, 0.81]$ to $0.95 \pm [0.58, 1.32]$). Fluid (43 ± 19 %) and carbohydrate (47 ± 21 %) represented the lowest scoring sub-sections (Figure 1), and were not significantly different from each other ($p = 0.214$; ES = $0.18 \pm [-0.17, 0.53]$).

3.4. Rapid Weight Loss scores

Total RWL-Q scores (30 ± 10), showed no significant difference ($F = 1.534$, $p = 0.224$) between experience levels (Table 1). All 63 boxers (100 %) had lost weight to compete, with mean pre-competition weight loss was 2.9 ± 1 kg, commencing on average "8 - 10 days" prior. Significant differences were observed in the frequencies of RWL methods previously or still used by boxers ($\chi^2 = 220$; $p < 0.001$), with 'Restricting fluid intake' (87 %; mean rank 9.17), 'Training in sweat suit' (87 %; mean rank 8.90) and 'Skipping meals' (78 %; mean rank 7.82) the most popular methods (Figure 2). Descriptive statistics showed that an 'extreme' method was used by at least 21 % of boxers, with diuretics (21 % with history of use) being the least used RWL method (Figure 2).

Table 1: Participant characteristics

	Novice n = 13	Intermediate n = 11	Open class n = 39	Total n = 63
Age (y)	22 ± 3	22 ± 2	22 ± 3	22 ± 3
Body mass (kg)	72.0 ± 10.2	72.8 ± 10.0	69.7 ± 10.0	69.6 ± 10.0
Height (cm)	180 ± 8	177 ± 10	176 ± 9	177 ± 9
NWLPS	1 ± 1	3 ± 4	4 ± 3	3 ± 3
Usual WL (kg)	3.6 ± 1.0	3.0 ± 1.0	3.0 ± 1.0	2.9 ± 1.0
ΔBM (kg)	8.5 ± 4.0	5.6 ± 2.0	6.5 ± 4.0	7.0 ± 4.0
NKQA _{RAW}	65 ± 17	70 ± 21	73 ± 18	71 ± 18
NKQA (%)	48 ± 13	51 ± 15	54 ± 13	52 ± 13
ES _{NKQA}	-0.28 ± [-1.07, 0.51] ⁺	-0.16 ± [-0.82, 0.51] ^Δ	0.45 ± [-0.16, 1.06] [#]	
RWL-Q	26 ± 10	30 ± 10	31 ± 10	30 ± 10
ES _{RWL-Q}	-0.39 ± [-1.18, 0.41] ⁺	-0.17 ± [-0.84, 0.50] ^Δ	0.55 ± [-0.07, 1.17] [#]	

Note: NWLPS = number of weight loss bouts in previous season; Usual WL (kg) = self-reported weight loss usually undertaken prior to competition; ΔBM (kg) = difference between off-season body mass and championship weight limit; NKQA = Total scores on the Nutrition Knowledge Questionnaire for Athletes (given both as raw scores and percentages). ES = effect size (Cohen's *d*); ⁺ = versus intermediate; ^Δ = versus open class; [#] = versus novice; RWL-Q = Total scores on the Rapid Weight Loss Patterns Questionnaire

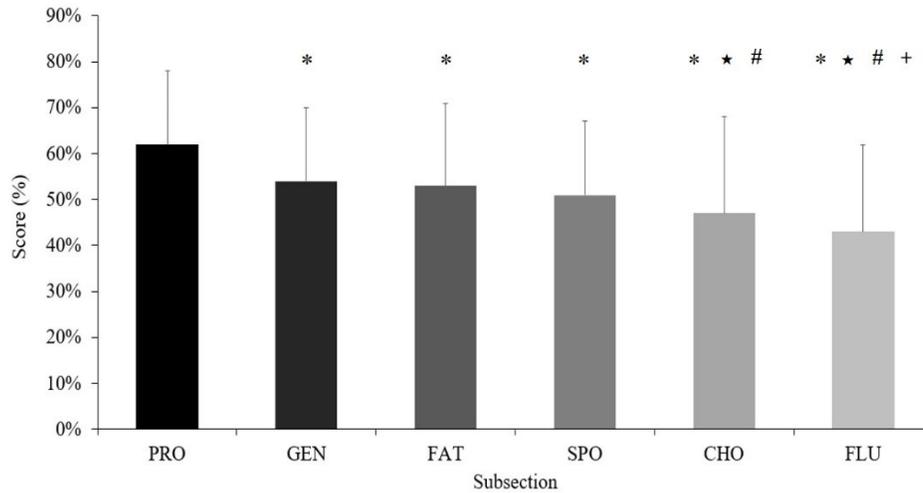


Figure 1: Results of the Nutritional Knowledge Questionnaire for Athletes, divided into subsections. PRO = Protein. GEN = General nutrition knowledge. FAT = Fat. SPO = Sports nutrition. CHO = Carbohydrate. FLU = Fluid.

Note: * = significantly lower than PRO (Cohen's d effect sizes from $-0.46 \pm [-0.81, -0.11]$ to $-0.95 \pm [-1.32, -0.58]$), ★ = significantly lower than GEN (Cohen's d effect sizes from $-0.40 \pm [-0.75, -0.04]$ to $-0.60 \pm [-0.97, -0.25]$), # = significantly lower than FAT (Cohen's d effect sizes from $-0.31 \pm [-0.66, 0.04]$ to $-0.51 \pm [-0.87, -0.16]$), + = significantly lower than SPO (Cohen's d effect size = $-0.45 \pm [-0.8, -0.1]$)

The influence of each source of nutritional knowledge differed significantly ($\chi^2 = 71; p < 0.001$). The percentages of athletes influenced by different sources of information are shown in Figure 3A, while statistical analysis revealed mean ranks as follows; coach = 5.06, other boxer = 4.71, parent = 3.75, social media = 4.42, doctor = 2.60, dietitian/nutritionist = 3.48, strength and conditioning coach = 3.98. Post hoc analysis (Figure 3) revealed that doctors exerted significantly lower influence than all other sources, bar dietitians/nutritionists and parents ($p < 0.05$). Conversely, coaches exerted more influence than doctors, dietitians/nutritionists and parents ($p < 0.05$). Other boxers exerted more influence than both doctors and dietitians/nutritionists ($p < 0.05$).

The relative influence on weight loss behaviours (Figure 3B) also varied significantly between sources ($\chi^2 = 119, p = 0.001$). Statistical analysis revealed mean ranks as follows; coach = 5.66, other boxer = 5.09, parent = 3.48, social media = 3.73, doctor = 2.56, nutritionist = 3.42, strength and conditioning coach = 4.06. Post hoc analysis revealed that doctors exerted significantly lower influence than coaches, other boxers and social media ($p < 0.05$). Conversely, coaches exerted more influence than all other sources (Figure 3B) except other boxers ($p = 1.0$). Other boxers also exerted more influence than parents, doctors, dietitians/nutritionists and strength and conditioning coaches ($p < 0.05$).

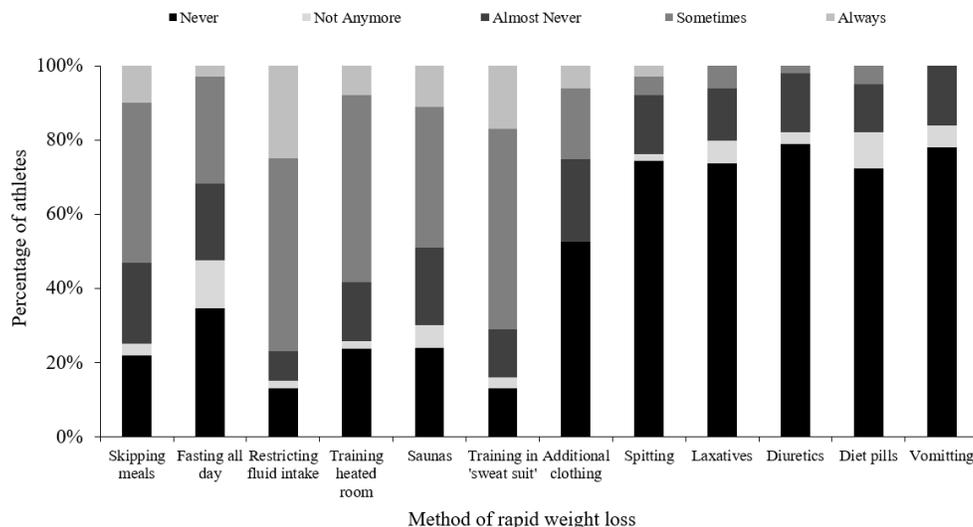


Figure 2: Frequency of rapid weight loss methods used by amateur boxers (percentage of boxers). A significant difference was apparent between the frequencies of methods used ($p < 0.001$).

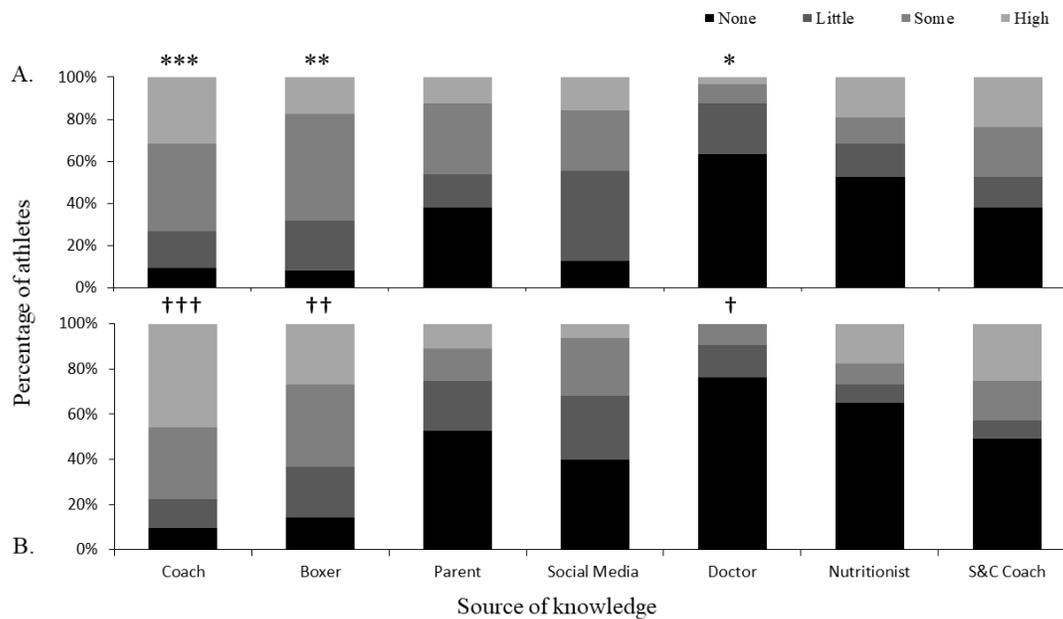


Figure 3: Relative influence of external sources of information for A. Nutritional knowledge, and B. Weight loss behaviours, represented as the percentage of athletes who received different levels of influence from each source (n = 63). Boxer = other boxer; Nutritionist = dietitian/nutritionist; S&C Coach = strength and conditioning coach.

Note: * = less than coach, other boxer, social media, strength and conditioning coach ($p < 0.05$); ** = greater than doctor, dietitian/nutritionist ($p < 0.05$); *** = greater than parent, doctor, dietitian/nutritionist ($p < 0.05$); † = less than coach, other boxer, social media ($p < 0.05$); †† = greater than parent, doctor, dietitian/nutritionist, strength and conditioning coach ($p < 0.05$); ††† = greater than parent, social media, doctor, dietitian/nutritionist, strength and conditioning coach ($p < 0.05$)

4. Discussion

This is the first study to investigate the relationship between nutritional knowledge and RWL in amateur boxers. Importantly, contradicting our hypothesis, nutritional knowledge was not associated with improved RLW practices. Such a finding may appear to contradict previous findings in Australian Rules football and soccer players, in whom a moderate correlation was reported between nutritional knowledge and body composition (Devlin, Leveritt, Kingsley, & Belski, 2017). However, as there is a strong motivation for combat athletes to avoid conceding size and strength to their opponents (Pettersson et al., 2013), RWL behaviours may be independent of nutritional knowledge. Indeed, evidence in mixed martial arts (Coswig et al., 2018), and judo (Reale, Cox, Slater, & Burke, 2016), sports in which combatants weigh-in the day before competition, suggests that weight regain may actually correlate with subsequent success. While a recent study in elite MMA athletes concluded there was no difference in weight regain between winners and losers (Kirk, Langan-Evans, & Morton, 2020), it must be noted that this was in the context of both groups increasing body mass by around 10 % following weigh-in. However, it should be noted that post weigh-in increases in body mass have not correlated with success in amateur boxing, where athletes weigh-in on the day of competition (Reale et al., 2017a). While it seems unlikely that nutrition education alone will improve boxers' weight loss behaviours, future research is required to explore the perceived

advantages associated with RWL in boxers of different competitive levels.

All participants in the current study reported having to reduce body mass to compete in their specific weight class, with total RWL-Q scores similar to those observed recently in other combat sports (Reale et al., 2018). Similarly to previous studies on amateur boxers, the athletes studied used both gradual and acute weight loss methods prior to competition (Reale et al., 2018). Of concern, the average rate of pre-competition weight loss (4.2 % body mass in 8 - 10 days) surpasses recommended safety guidelines of 1.5 % body mass per week (Artioli et al., 2010a), therefore necessitating RWL. Such practices may increase the loss of functional mass, reduce aerobic and anaerobic capacity, and increase the perception of discomfort in athletes (Franchini et al., 2012). Tragically, a fatality associated with RWL was recently reported after an athlete lost 6.8 kg from sauna bathing, before subsequently suffering from exertional rhabdomyolysis (Zhuo, Li, & William, 2019). Furthermore, higher rates of weight loss are also associated with psychological consequences such as disordered eating behaviours (Williams, 2016), while hormonal disturbances from weight loss have been observed to disrupt appetite regulation (Dulloo, Jacquet, Montani, & Schutz, 2015). Such effects could potentially add to difficulties in maintaining body mass between contests (Dulloo et al., 2015).

The use of "extreme" RWL methods (Furber et al., 2017) was particularly prevalent in the current population (Figure 2), being used more frequently (21 - 27 %) than in judoka (6.5 - 20 %) studied previously (Artioli et al., 2010b). Despite not qualifying

as “extreme” on the RWL-Q, and being linked to multiple fatalities (Control & Prevention, 1998; Zhuo et al., 2019), sauna use is popular across combat sports (Reale et al., 2018) and was used by 75 % of the current population. Whilst dehydration by any means is likely to impair performance (Barley, Iredale, Chapman, Hopper, & Abbiss, 2018b; Walsh, Noakes, Hawley, & Dennis, 1994), “passive” methods like sauna bathing may impair thermoregulatory responses more severely to increase the likelihood of heat injury (Walsh et al., 1994). The present findings indicate a high prevalence of RWL in amateur boxing, which may pose risks to health and performance.

The current study found no differences between competitive standard for RWL, with a high prevalence of RWL observed across all competition levels. These findings are in contrast to existing evidence which suggests that international standard combat athletes report higher RWL-Q scores than those competing at regional level (Artioli et al., 2010b; Reale et al., 2016). This conflict may be explained by cultural differences between combat sports, as well as the fact that any potential benefits of RWL would be highly sport-specific. For example, the study of Artioli et al. (2010b) was carried out in judo, while Reale, Slater, and Burke (2018) included judoka and wrestlers; sports in which athletes weigh-in the night before competition. This schedule may give athletes more time to recover from the harmful effects RWL, which necessitates at least some degree of glycogen depletion and muscular dehydration (Barley et al., 2018a; Reale et al., 2017c). Accordingly, such combat sports have reported associations between weight regain and competitive success (Coswig et al., 2018; Reale et al., 2016). In contrast, no such correlation has been observed in amateur boxers (Reale et al., 2017a), who weigh-in on the day of competition. Of note, it is frequently grappling sports where weight regain has been associated with success, potentially due to the greater relative importance of absolute strength than in striking sports (Davis, Connorton, Driver, Anderson, & Waldock, 2018; Reale et al., 2017c). The current findings demonstrate a high prevalence of RWL globally across all competition levels in amateur boxers, despite a lack of evidence to show a performance benefit from such practices.

This is the first cross-sectional analysis to investigate the nutritional knowledge of senior amateur boxers. Mean NKQA scores (52 ± 13 %) were similar to those from individuals with no previous nutritional training (50 ± 7 %) (Furber et al., 2017), with a large range of nutritional knowledge apparent (16 % to 78 %). Such a spread may reflect diversity in amateur boxing, with boxers coming from a wide range of educational and cultural backgrounds (Agirbas, Keyf, Aggon, & Ozan, 2018; Chaabène et al., 2015; Morton, Robertson, & Sutton, 2010). However, not only were the NKQA scores of the boxers studied descriptively lower than those of the nutrition experts assessed in the original validation of this instrument (80 ± 7 %), but they were also lower than those of track and field athletes (61 ± 11 %) reported in the same paper (Furber et al., 2017).

Of note, NKQA subsections on carbohydrate and fluid were the lowest scoring (43 % for each), which may have serious implications for performance (Davis et al., 2018). Both gradual weight loss methods and RWL are dependent on manipulating

nutrient intake (Morton et al., 2010; Reale et al., 2017b), while the requirement for consecutive daily weigh-ins throughout boxing tournaments further increases the importance of knowledge relating to refueling and rehydration (Reale et al., 2017a; Spronk, Kullen, Burdon, & O'Connor, 2014). Accordingly, the poor nutritional knowledge shown in this sample highlights a need for nutrition education in amateur boxers, especially considering the importance of carbohydrate intake, fueling, recovery and hydration for performance in a weight-categorized sport (Folasire, Akomolafe, & Sanusi, 2015; Reale et al., 2018). However, it is also important to note the general nature of the NKQA, which may not assess the specific knowledge required by weight categorized athletes. For example, while the questionnaire assesses knowledge on appropriate dietary options for weight loss, there are no questions on the optimal rates, or adverse consequences of weight loss.

Coaches and other boxers were the most influential sources of knowledge on nutrition and weight loss in the current population (Figure 3). This finding is consistent throughout combat sports, both within amateur and professional settings (Artioli et al., 2010b; Park, Alencar, Sassone, Madrigal, & Ede, 2019). Weight loss practices are known to be passed on to successive generations by former athletes who transition into coaching, thus perpetuating a culture of RWL (Reale et al., 2018). However, mixed martial artists who have previously engaged with a dietitian showed reduced RWL behaviours compared to individuals consulting coaches and other athletes (Park et al., 2019). Limited interactions with nutrition professionals may explain the low NKQA scores and high prevalence of RWL reported in the current study.

5. Conclusions

The current findings are the first to demonstrate that nutritional knowledge has no relation to RWL practises in male amateur boxers, despite a high prevalence of RWL in this population. However, nutritional knowledge was lower than that previously reported in athletes, particularly regarding carbohydrates and fluid intake. This highlights the need for nutrition education in amateur boxers to support training and performance.

5.1. Practical applications

- Future educational strategies are required to inform amateur boxers on the potentially harmful effects of RWL and the lack of performance benefits so far reported in this population. Further research is needed to ascertain whether such education would be effective for mitigating the prevalence and severity of RWL.
- Amateur boxers should be encouraged to seek professional advice to ensure they are receiving safe and reliable information on nutrition and weight loss.
- Amateur boxers may benefit from nutritional education to support optimal fuelling, recovery and hydration practises.

Conflict of Interest

The authors declare no conflict of interests.

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