Nutritional status and weight making practices of professional male South African mixed martial arts fighters

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ABSTRACT

Background

Weight category combat sport athletes, including mixed martial arts (MMA) fighters, often 'make weight' or 'cut weight' to fight in lower weight divisions. Common weight-making practices include restriction of food and/or fluid intake and intentional fluid loss/sweating (e.g. sauna). However, a number of these weight-making practices can be detrimental to the performance, health and nutritional status of the fighters. MMA fighters are usually weighed-in 24 hours prior to competition, and then have a subsequent 24 hours to adequately recover/rehydrate for the match (Jetton *et al.*, 2013). Due to the fact that fighters have time to recover/rehydrate, it allows fighters to make use of extreme weight-making practices (i.e. extreme dehydration) to rapidly lose the last bit of unwanted body weight, usually being water weight, in a short time. Although literature is available on the weight making practices of MMA fighters, limited information is available regarding their general nutritional status. Since MMA is a rapidly growing sport with a lot of interest amongst youngsters as well, information on weight-making practices and the nutritional status of these athletes is warranted to enable coaches and allied health professionals to optimise their health and performance. This study therefore aimed to describe the nutritional status (dietary intake and body composition) and weight-making practices of professional male South African MMA fighters.

Objectives

The first objective was to determine the nutritional status, including dietary intake and body composition, of professional male South African MMA fighters at baseline (6-weeks prior to competition), 1-week prior to competition and at weigh-in (24-hours prior to weigh-in). The second objective was to determine the weight-making practices of professional male South African MMA fighters prior to weigh-in. The final objective was to determine the hydration status at weigh-in (proxy for fluid loss / extent of fluid weight-making practices).

Methods

Seventeen male South African MMA athletes (aged 28.0±1.0 years, and competitive experience 7.0±1.0 years) participated in this observational study with a descriptive longitudinal study design. Dietary intake was recorded by means of a validated quantified food frequency questionnaire at baseline (6-weeks prior to competition) and again 1-week prior to competition. Anthropometric measures (weight, height and skinfold measurements) were performed by an ISAK level 1 anthropometrist at baseline (6-weeks prior to competition), 1-week prior to competition, and at weigh-in (24-hours prior to weigh-in for weight). A previously validated weight-making practices

questionnaire was adjusted and administered to the MMA athlete's 1-week prior to competition. Urine samples were collected at weigh-in, and hydration status was determined with urine specific gravity using a digital hand-held compact refractometer (P10S).

Main findings

Median dietary energy intake at baseline was 17170 (15598-26376) kJ. Macronutrient intake for carbohydrate (CHO), protein and fat were 411 (291-632) g, 194(134-216) g, and 209 (161-305) g, respectively. Dietary protein intake (expressed in g/kg body mass) was in-line with the recommendations for athletes, however median CHO intake at baseline [5.2 (3.2-11.7) g/kg] and 1-week prior to competition [3.1 (2.1-10.5) g/kg] was below the recommendations of 6-10g CHO/kg body mass for athletes performing one to three hours of moderate to high-intensity exercise. Fat intake (expressed in percentage) at baseline [44.0 (32.3-61.5)%] and 1-week prior to competition [40.9 (32.8-47.2)%] were above the recommended macronutrient distribution range (>35% of total energy), however athletes that do regular high-volume training may increase their fat intake up to 50% of total energy intake. Vitamin D intake at baseline [8(1-22) µg/d] and1-week prior to completion [5(0-9) µg/d] were both below the RDA of 15 µg/d. Calcium intake 1-week prior to competition [826 (522-1120) mg/d] was below the RDA of 1000mg/d. Magnesium at baseline [26 (21-334) mg/d] was below the RDA of 400 mg/d. The median body mass index (BMI) of the participants at baseline was classified as overweight (>24.9kg/m^2), however, their median body fat percentage was low [7.6 (6.5-8.5) %]. All (100%) of the fighters reported the use of one or more weight-making practice to make weight before competition. Gradual weight loss was the most common weight-making practice reported in this study, with a prevalence of 88%, followed by hot baths (82%), water loading (71%), increasing exercise more than usual (59%) and training in rubber or plastic suits (59%). Seventy one percent (71%) of the MMA fighters restricted fluid intake in order to lose weight. Although body mass decreased significantly from baseline [80.4 (73.3-86.5) kg] to 1-week prior to weigh-in [76.9 (71.8- 81.2) kg], with an additional significant decrease to weigh-in 24-hours prior to competition [70.4 (66.8- 106.6) kg], body fat percentage did not change between baseline and pre-competition. At weigh-in 24-hours prior to competition, all of the participants that provided a voluntary urine sample were classified as moderately (57%) to severely (43%) dehydrated.

Conclusion

The MMA fighters in the present study had a borderline high BMI but a healthy body fat percentage. Their dietary intake was in line with the macronutrient recommendations for athletes for protein, fat and the majority of micronutrients, however, CHO intake as well as vitamin D and calcium were below the recommended amounts. It is clear that MMA fighters in the present study are engaging in weight-making practices, particularly rapid weight loss practices that involve fluid loss and/or fluid restriction and that their influence on how to make weight mainly from their coaches and training colleagues, and not from a registered dietitian.. Although the MMA fighters lost a significant amount of weight from baseline to 1-week prior to weigh-in, they continued losing weight during the few days leading up to weigh-in 24-hours prior to competition. Based on the fact that all the MMA fighters who provided a urine sample at weigh-in were moderately to severely dehydrated, the weight lost during the few days prior to weigh-in was presumably water weight as a result of rapid weight loss practices. It should be recommended that the rule changes made by the California State Athletic Commission (CSAC) for Ultimate Fighting Championships (American based) that only allow a maximum of 8% weight difference between a week prior to weigh-in and weigh-in, should be implemented in Extreme Fighting Championships (in South Africa) as well to encourage fighters to enter realistic weight categories and limit the use of extreme weight making practices resulting in dehydration prior to weigh-in.

Key words: rapid weight loss techniques, body composition, dehydration, dietary intake, mixed martial arts, weight-making practices.

LIST OF ABBREVIATIONS

BCAA	Branched-chain amino acid
Ca	Calcium
CSAC	California state athletic commission
EA	Energy availability
EFC	Extreme fight championship
Fe	Iron
FFQ	Food frequency questionnaire
IJSNEM	International journal of sports nutrition and exercise metabolism
mg	Milligram
Mg	Magnesium
MMA	Mixed martial arts
QFFQ	Quantified food frequency questionnaire
RDA	Recommended daily allowance
RED-S	Relative energy deficiency syndrome
RWL	Rapid weight loss
TBF	Total body fluid
UFC	Ultimate fight championship
µg	Microgram
UK	United Kingdom
USA	United States of America
USG	Urine specific gravity
Zn	Zinc

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CHAPTER 1: INTRODUCTION

1.1 Background

Mixed martial arts (MMA), is a weight category combat sport that incorporates a variety of martial arts including; muay thai, kickboxing, boxing, wrestling, taekwondo and jiu jitsu (Lenetsky & Harris, 2012). In 1993 MMA was included in the Ultimate Fighting Championships (UFC), a competition based in the United States of America (USA) that was created for all types of professional martial arts to compete against each other. By 2005 MMA had become so popular that a reality show was made, and since then this rapidly growing sport has continued to gain popularity (Bishop *et al.*, 2013; La Bounty *et al.*, 2011). MMA now has 'mainstream status' where fights are streamed online, reaching up to half a billion households across 149 countries (www.UFC.com, 2012).

MMA fighters can compete as amateur or professional athletes in eight weight categories ranging from flyweight (<57 kg) to heavyweight (>93 – 120kg). A professional MMA fighter is classified worldwide as a fighter who is registered with an accredited professional body. In South Africa, a fighter is considered a professional fighter if he has competed in a recommended 15 amateur fights with a 70% win rate. The fighter can then register with MMA South Africa – an accredited professional body – where he has to pass a theoretical and practical examination. Once fighters achieve professional status they can compete in major national and international events such as Extreme Fighting Championships (EFC) and UFC. Similar to a number of other combat sports, MMA requires fighters to compete in specific weight categories in an attempt to level the playing field and ensure fair fighting between opponents. MMA is a physically taxing combat sport that incorporates, amongst others, strikes and grappling (Bishop *et al.*, 2013; La Bounty *et al.*, 2011). An important aspect of MMA fighting is therefore 'reach' – i.e. the length of a fighter's arm. The more reach a fighter has on his opponent the bigger the competitive advantage he has when attacking. Fighters therefore usually enter the lowest weight category possible so that they have a bigger height-to-reach ratio advantage over their opponent (Crighton *et al.*, 2016).

Currently in EFC, fighters are weighed-in 24 hours prior to competition and will be penalised if they weigh more than the cut-off for the weight category that they have entered. Fighters are consequently pressured to make the required weight for weigh-in, often resulting in rapid weight loss practices. Rapid weight loss (RWL) is defined as "the reduction of a significant amount of body weight (typically 2-10 % and even more) in a few days prior to weigh-in (mostly

in the last 2-3 days) achieved by a combination of methods that include starvation, severe restriction of fluid intake and intentional sweating" (Artioli *et al.*, 2016). These practices aid athletes to lose the last bit of unwanted body weight, usually being water weight, in a short time. Since weigh-in occurs 24 hours prior to competition, fighters can make use of extreme weight-making practices prior to weigh-in (i.e. extreme dehydration), and use the subsequent 24 hours to recover/rehydrate before the match (Jetton *et al.*, 2013). Although the California State Athletic Commission (CSAC) passed a new rule in 2017, allowing a maximum of 8% weight difference 1-week prior to weigh-in and weigh-in, this rule currently only applies to UFC, and not to EFC (CSAC memorandum, 2017). Professional MMA fighters competing in South Africa can therefore still weigh-in at the lowest possible weight 24-hours prior to competition, making use of extreme weight-making practices, and regain as much weight as possible during the 24-hours subsequent to weigh-in.

According to Anyżewska *et al.* (2018) 58% of the Polish MMA fighters in his study used rapid weight loss practices, including restricted diets (61%) and increased exercise intensity (39%), two to three days before a competition. A study from Matthews and Nicholas (2017) reported that 100% of MMA fighters in their study used one or more weight-making practices, to make weight, prior to competition. The prevalence of rapid weight loss methods was high and included restricting fluid ingestion (100%), water loading (100%), additional exercise (85%), hot baths (72%) and training in a plastic or rubber suit (71%). In another study done on 30 MMA fighters, it was seen that 67% of the fighters practiced water loading, 17% used methods to increase sweating (sweet sweat) and 37% used diuretics (Crighton *et al.*, 2016). The weight loss resulting from these methods is mostly water weight that can leave an athlete dehydrated. Rapid weight loss practices, particularly those focused on fluid loss often result in dehydration. Indeed Anyżewska *et al.* (2018) reported that 69% of the MMA fighters were dehydrated at weigh-in. Matthews and Nicholas (2017) also found the MMA fighters in their study to be dehydrated, with 57% of the MMA fighters classified as dehydrated, and 43% as severely dehydrated at weigh-in. Jetton *et al.* (2013) also investigated the magnitude of dehydration in MMA fighters 24-hours prior to competition and reported that 39% of the MMA fighters were classified as dehydrated, with a urine specific gravity (USG) higher than 1.021.

Studies have also shown combat athletes such as wrestlers, boxers and jiu-jitsu athletes reduce their energy intake 24-48 hours prior to weigh-in, and restricting their carbohydrate intake to below the recommended guidelines for optimal sport performance (Andreato *et al.*, 2016; Lingor & Olson, 2010; Reljic *et al.*, 2015; Thomas, 2017).

Rapid weight loss methods, however, can potentially be very dangerous and have detrimental consequences on fighters' health. Acute dehydration (6-10% water loss) resulted in the heat-related death of three wrestlers in 1997, and the death of an MMA fighter in 2013 during a sauna session after attempting to lose 20% of his body mass (approximately 15 kg) in only one week (Crighton *et al.*, 2016; Jetton *et al.*, 2013). Another serious case documented is that of a Canadian MMA fighter who required cardiopulmonary resuscitation after fainting as a result of weight-making practices (Crighton *et al.*, 2016).

Although rapid weight-making practices such as dehydration and acute energy restriction are more common, weight category sports, including MMA fighters, also engage in more chronic practices such as low energy or restricted energy diets over more prolonged periods of time (e.g. more than just 2-3 days). Brito *et al.* (2012) reported that 67.7% of the combat athletes (including judo, jujitsu, karate, taekwondo) that participated in his study used low-energy diets. Crighton *et al.* (2016) reported that 100% of the MMA participants in his study engaged in complete fasting and/or ingesting a low carbohydrate diet in the final 3-5 days prior to weigh-in. All these fighters were characterised as "promoting relative energy deficiency" (RED-S) due to fasting or having a low carbohydrate diet in the final 3–5 days prior to weigh-in, which in the long run could put them at risk of an impaired metabolic rate, decreased bone health, decreased immunity, a decrease in protein synthesis, as well as an impaired cardiovascular health (Robertson & Mountjoy, 2018).

Good nutrition is therefore very important for athletes, not only on the day of competition but also during training cycles and to maintain good health all year round. Optimal nutrition and a healthy nutritional status help to maintain general health and provide fuel for training, optimise recovery, and improve sporting performance (Gunzer *et al.*, 2012). Optimal nutrition also protects long-term health and helps reduce the risk of chronic diseases such as diabetes, hypertension, obesity and cardiovascular diseases (Mann & Truswell, 2017). MMA is a physically taxing sport which requires strength and energy. The fighters usually go through a 6-10 week 'fight camp'/ training cycle in preparation for competition that includes extra training sessions and longer hours in the gym. During this time, they also potentially restrict their diets to lose the extra weight put on during non-training cycle periods. Considering the importance of nutrition, it is surprising that only a few studies have examined the habitual dietary intake of combat sports. In a recent study by Anyżewska *et al.* (2018) food frequency questionaries' (FFQ) and a single 24-hour dietary recall were administered in order to determine portion size and frequency of food group consumption by Polish MMA fighters. It was found that nutritional education is needed due to the fighters having an inadequate consumption of dairy products,

grain products, fruit, and vegetables. It was also seen that carbohydrate intake [3.5 (1.9-5.1)] g/kg and calcium [719 (120-1318) mg] was below the recommendations for athletes. Andreato *et al.* (2016), Reljic *et al.* (2015) and Książek *et al.* (2014) found protein consumption to be adequate, with an intake of 2.2±1.0 g/kg,1.5±0.4 g/kg and 1.81±0.49 g/kg, respectively. Andreato *et al.* (2016) found carbohydrate consumption to be adequate with a 6.3±2.3 g/kg intake, however Reljic *et al.* (2015) and Książek *et al.* (2014) both found the boxers to have an inadequate intake of only 3.8±1.1 g/kg and 4.48±1.05 g/kg respectively.

Data regarding weight-making practices and specifically the nutritional status and habitual dietary intakes of MMA fighters are limited. Information on weight-making practices in South African male MMA fighters is also lacking, and it is not clear whether the nutritional status of MMA fighters is being affected only during the period of weight-making, as a result of weight-making, or if they have an optimal nutritional intake throughout the year.

1.2 Problem statement

It is known that combat sports, including mixed martial arts (MMA) fighters, 'make weight'/ 'cut weight' to fight in lower weight divisions, and that certain weight-making practices can be detrimental to the performance, health and nutritional status of the fighters. Limited information is available on the nutritional status and weight-making practices of professional South African male MMA fighters. Since MMA is a rapidly growing sport with a lot of interest amongst youngsters as well, it is important to examine the weight-making practices and nutritional status of SA male MMA fighters with the aim to provide optimal nutritional education, protect health and improve performance

1.3 Aim and objectives

The aim of this MSc study is to describe the nutritional status, including dietary intake and body composition, and weight-making practices of professional male South African mixed martial arts fighters.

Objectives:

•To determine and compare the nutritional status, including dietary intake and body composition, of professional male South African MMA fighters at baseline (6-weeks prior to competition), 1-week prior to competition and at weigh-in (24-hours prior to weigh-in).

•To determine the weight-making practices of professional male South African MMA fighters prior to weigh-in.

•To determine hydration status at weigh-in (proxy for fluid loss / extent of fluid weight-making practices).

1.4 Research team

Table 1-1 summarises the research team, including each member's role and responsibilities.

Table 1-1: Research team members, roles and responsibilities

Partner name	Team member	Qualification	Professional registration	Role and responsibility
North-West University	Prof L. Havemann-Nel	PhD, Exercise Science BDietetics	Dietitian, HPCSA	Principal investigator and supervisor for MSc student
North-West University	Miss Kiah Bengis	BSc Dietetics	HPCSA student registration	MSc Student researcher responsible for writing protocol, data collection, data analysis and writing of MSc mini-dissertation
North-West University	Dr Cristian Ricci	PhD Statistics	N/A	Qualified statistician

1.5 Structure of mini-dissertation

This mini-dissertation is presented in article format and has four chapters. Chapter one includes the introduction and background of this master's study. This chapter also includes the problem statement, aim and objectives. The research team, structure of the mini-dissertation and the reporting of the results are also outlined in this chapter. Chapter two presents the literature review that will include an outline of MMA, the weight categories used in MMA, rules and weigh-in procedures, and physical and nutritional requirements.

Subsections that follow include the type of weight-making practices used (chronic vs rapid weight loss) and the health risks and consequences of such practices. Chapter three is the research article that is written according to the author instructions of the International Journal of Sport Nutrition and Exercise Metabolism (IJSNEM), and Chapter four presents the summary and conclusion of the study. Following chapter four is a reference list according to the NWU Harvard style of all the references cited in chapters one, two and four.

1.6 Dissemination and reporting of results

A mini-dissertation on this topic was written for the purpose of obtaining an MSc Dietetics degree. The mini-dissertation will be published on the North-West University (NWU) (Potchefstroom Campus) website and thus in the public domain. Results of the study will also be presented to the respective MMA clubs after completion of the study, and the manuscript will be submitted for publication in the International Journal of Sport Nutrition and Exercise Metabolism.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Combat sports athletes, including mixed martial arts (MMA) fighters, often ‘make weight’ or ‘cut weight’ to fight in lower weight divisions. In fact, weight-making practices in weight category sports are very common and can include a combination of acute/rapid and chronic methods (Crighton *et al.*, 2016). Rapid weight-making practices include those that result in increased body fluid loss, for example sauna, exercising in sweat suits and increased exercise, whilst chronic weight-making practices focus on longer term dietary energy restriction. It has previously been reported that certain weight-making practices can be detrimental to the performance, health and nutritional status of the fighters (Artioli *et al.*, 2014; Coswig *et al.*, 2015). MMA is a rapidly growing sport with a lot of interest amongst youngsters as well. The scope of this literature review mainly covers MMA and provides a description of MMA as a weight category sport, the background to MMA, the weight categories used in MMA and its rules and weigh-in procedures. This literature review also provides an overview of the nutritional status and weight-making practices commonly used in combat sports and the consequences of these practices on health and performance.

2.2 Mixed martial arts (MMA) as a weight category sport

2.2.1 Background on MMA

Mixed martial arts (MMA), is a weight category combat sport that incorporates a variety of martial arts including muay thai, kickboxing, boxing, wrestling, taekwondo and Jiu Jitsu (Lenetsky & Harris, 2012). MMA originated in as early as 649 B.C, and in 221 B.C different aspects from other combats sports including grappling from wrestling and strikes (i.e. hand movements and punches) from boxing and Muay Tai were introduced into the sport. Only towards the 1960’s did MMA become a competitive sport with strict rules. MMA became more popular globally, and in 1993 MMA was included in the Ultimate Fighting Championships (UFC), a competition created for all types of professional martial arts to compete against each other. By 2005 MMA became so popular that a reality show was made and since then this rapidly growing sport has continued to gain popularity (Bishop *et al.*, 2013). MMA now has a “mainstream status” where fights are streamed online, reaching up to a half a billion households over 149 different countries (www.UFC.com, 2012).

MMA fighters can compete as amateur or professional athletes in eight weight categories ranging from flyweight (<57 kg) to heavyweight (>93 – 120kg). A professional MMA fighter is classified worldwide as a fighter who is registered with an accredited professional body. In South Africa, a fighter is considered a professional fighter if he has competed in a recommended 15 amateur fights with a 70% win rate. The fighter can then register with MMA South Africa – an accredited professional body – where he has to pass a theoretical and practical examination (www.UFC.com, 2012).

2.2.2 Weight categories used in MMA

Most combat sports compete in certain weight categories in an attempt for fair matching of opponents. MMA has eight weight categories ranging from <57kg (flyweight) to a cut-off weight of 120kg (heavyweight) (www.efcworldwide.com, 2018). Table 2-1 provides a summary of the different weight categories.

Table 2-1: MMA weight categories

Weight category	Required weight range
Flyweight	<57 kg
Bantamweight	57 kg - 60kg
Featherweight	61 kg - 65 kg
Lightweight	66 kg - 69 kg
Welterweight	70 kg - 76 kg
Middleweight	77 kg - 83 kg
Light heavy weight	84 kg - 92 kg
Heavyweight	93 kg - 120 kg

The 'reach' – i.e. the length of a fighter's arm – is an important aspect in a MMA fight, and the more reach an MMA fighter has on his opponent, the bigger the competitive advantage he has when attacking. MMA fighters therefore usually enter the lowest weight category possible so that they have a bigger height-to-reach ratio advantage on their opponent (Crighton *et al.*, 2016).

Rules and weigh-in procedures of MMA

In MMA, fighters are usually weighed-in 24 hours prior to competition, at a public weigh-in. Fighters are disqualified if they weigh more than the recommended weight of the respective weight category they have entered, and are therefore under pressure to 'make the weight' for that category. Although the California State Athletic Commission (CSAC) passed a new rule in 2017, allowing a maximum of 8% weight difference 1-week prior to weigh-in and weigh-in this rule currently only applies to UFC, and not to EFC (CSAC memorandum, 2017). It is known that fighters engage in weight-making practices to lose weight rapidly prior to weigh-in. Many of the MMA fighters enter into divisions that are lower than their usual weight not only to benefit from a bigger height-to-reach ratio as mentioned above, but also to gain a competitive advantage over a lighter opponent (Crighton *et al.*, 2016).

In terms of fighting attire, all fighters must wear a mouthpiece during competition and male fighters must wear a groin protector. Fighters must wrap their hands and wear gloves (www.efcworldwide.com, 2018).

Fouls include head butting, eye gouging of any kind, biting, hair pulling, groin attacks of any kind, putting a finger into any orifice or into any cut or laceration on an opponent, small joint manipulation, striking the spine or the back of the head, striking downward using the point of the elbow, throat strikes of any kind, including, without limitation, grabbing the trachea. Other fouls include clawing, pinching or twisting the flesh, kicking or kneeing the head of a grounded opponent, kicking to the kidney with the heel, spiking an opponent to the canvas on his head or neck, throwing an opponent out of the ring or fenced area. Fighters may not hold the shorts or gloves of an opponent, spit at an opponent or engage in an unsportsmanlike conduct that causes an injury to an opponent. If a foul is committed, the opponent will get a warning. If the foul is made again he will get another warning, and then if done again he will be disqualified (www.efcworldwide.com, 2018).

In terms of victories, there are four main ways to win a bout namely: i) a physical tap out and/or a verbal tap out; ii) a technical knockout by the referee stopping the contest; iii) decision via the scorecards where judges decide on the winner; and, iv) a win through the opponent being disqualified (www.efcworldwide.com, 2018).

Bout duration: According to the EFC Africa rules, a typical professional MMA fight, also referred to as a bout, has three to five rounds, with each round lasting five minutes. All non-

championship bouts consist of three rounds, whilst title bouts have five rounds. A one-minute rest period will occur between each round.

Title bout: There are no specific criteria for fighters to qualify for a title bout. Fighters are selected to fight for a title bout by the EFC committee. This committee usually selects fighters that are winning all their fights and/or are finishing their fights quickly (i.e. those who knock their opponents out before three rounds / 'knockouts') (www.efcworldwide.com, 2018).

2.2.3 Physical and nutritional requirements of MMA

MMA is a physically taxing sport that constantly tests the fighter's speed, strength, endurance and specific skills (flexibility, sparring, Muay Thai, kickboxing, boxing, wrestling, taekwondo and Jiu Jitsu) and therefore tests both aerobic and anaerobic capacity. A typical week of training includes 15-20 hours of training ranging from low to high intensity cardiovascular training and specific drills (personal communication with several MMA fighters). Since MMA is a combat sport with high impact contact, many of the training sessions per week also incorporate conditioning sessions, weight bearing and/or resistance training. Table 2-2 provides an example of a typical week of training.

Table 2-2: Typical week of training

Type of training	Intensity	Days per week	Hours per day
Drills and skills (striking, takedowns, kicking, punching and combinations)	Medium	5x/week	1 hour
Jiu jitsu*	Medium-High	4x/week	1.5 hours
Wrestling	Medium-High	2x/week	1 hour
Sparring	High	1x/week	1 hour
Conditioning (anaerobic and aerobic) Includes: weight training, sprints, cardio.	Low-High	5x/week	1 hour

* A grappling combat sport (Andreato *et al.*, 2017).

The fighters usually go through a 6-10 week 'fight camp'/training cycle in preparation for competition that includes extra training sessions, longer hours in the gym and potentially restricting their diets to lose the extra weight put on during non-training periods. In order to train optimally, it is important for fighters to recover and restore their energy after training sessions and to stay physically and mentally strong (personal communication with MMA coach).

Good nutrition is extremely important for athletes, not only on the day of competition but also throughout the year and to maintain good health. Good nutrition and a healthy nutritional status are important for maintaining general health, providing fuel for training, optimising recovery, avoiding exercise-related injury, and improving sporting performance (Gunzer *et al.*, 2012). Optimal nutrition also protects long-term health and helps reduce the risk of chronic diseases such as diabetes, hypertension, obesity and cardiovascular diseases (Mann & Truswell, 2017).

According to Artioli *et al.* (2014) and Hoffman and Maresh (2011), both macro- and micronutrients play a vital role in maximising training effort and competitive performance. Carbohydrates (CHO) play a major role in energy supply for the body to function optimally and to sustain the exercise being done. Sports that have an extreme exercise programme of 4–6 hours and more per day should ingest 8-12 g/kg/day of CHO for optimal recovery and performance (Burke *et al.*, 2011; Thomas *et al.*, 2016). Protein is just as important in the diet, as protein intake plays a key role in the maintenance of muscle mass and strength. Muscle mass is particularly important for MMA fighters as they rely on their strength and power when fighting. Combat fighters want to stay in a positive or neutral protein balance by consuming between 1.4-2.0 g/kg of good quality protein (Artioli *et al.*, 2014; Jäger *et al.*, 2017). For combat athletes however their protein intake ranges can be slightly higher ranging from 1.8-2.4 g/kg (Artioli *et al.*, 2014). Fighters could have an increased requirement for vitamins and minerals, such as water-soluble vitamins and minerals, due to their losing micronutrients through sweat, for an increased rate of synthesis as well as increased rate of repairing the muscle tissues. It is specifically important for fighters to meet their micronutrient needs, as physical performance can be impaired by a micronutrient deficiency (Artioli *et al.*, 2014; Tang *et al.*, 2016). Fighters that constantly restrict food intake and/ or exclude certain food groups in order to lose weight are not only at risk for a negative protein balance, but also at an increased risk for micronutrient deficiencies. If these athletes follow the recommendations set out in Table 2-3, their training

quality and training adaptions should improve as well as ultimately their sporting performance. Fighters that fast or cut out food groups could become micronutrient deficient, lose muscle, compromise training quality and recovery and impair physical performance (Artioli *et al.*, 2014; Tang *et al.*, 2016).

Table 2-3: Important macro and micro-nutrient recommendations

	Recommendation	**Relevance/Importance**
Carbohydrate recommendations for fuel and recovery (Burke *et al.*, 2011)		
Daily CHO needs	7-12 g/kg/24 hours	To ensure that fuel requirements are met
Before training >60 min	**1-4 g/kg** consumed1-4 hours before training	
During training	Exercise duration of 45-75 min (Small amounts, including mouth rinse)	Carbohydrate intake provides a basis of fuel for the muscles to supplement endogenous stores.
	Exercise duration of 1-2.5 hours: 30-60 g/hour	
1-3 hours/day moderate to high-intensity exercise	6-10g/kg	To ensure that fuel requirements are met
After >4-5 hours/day moderate to high-intensity exercise	8-12 g/kg/day	To ensure that fuel requirements are met
Protein recommendations (Jäger *et al.*, 2017; Thomas *et al.*, 2016)		
General	1.2 - 2.0 g/kg/day Or 1.8-2.4 g/kg/day	Required for the support of metabolic adaptation, repair, remodelling, and for protein turnover
0 - 2 hours after exercise	10 g essential amino acids after exercise	To enhance muscle protein synthesis
Fat recommendations (Thomas *et al.*, 2016)		
General	>20% of total energy intake	Provides a fuel substrate that is both relatively abundant and

		increased in availability to the muscle as a result of endurance training
	<10% saturated fats	
Micronutrients (Artioli *et al.*, 2014; Thomas *et al.*, 2016)		
	Recommendation	**Relevance/Importance**
Vitamin D	1,500 to 2,000 IU/day	Vitamin D regulates calcium and phosphorus absorption and metabolism, and plays a key role in preserving bone health
Iron	RDA >8 mg/day	Iron deficiency can weaken muscle function and limit work capacity leading to compromised athletic performance
Calcium	1,500 mg/day	Calcium is especially important for growth, maintenance, and repair of bone tissue. It regulates muscle contraction and normal blood clotting
Antioxidants	-	Antioxidant nutrients play important roles in shielding cell membranes from oxidative damage

In a study done on taekwondo fighters, nutrient intake was observed. From this study it was clear that these fighters were making unsuitable nutritional decisions. Not only was their habitual intake inadequate in terms of macro and micronutrients, but these fighters significantly reduced their mean habitual energy intake by 35% prior to competition (Fleming & Costarelli, 2007). As mentioned previously, macro as well as micronutrients play a key role in an athlete's health and performance. Decreasing total energy intake was therefore not beneficial for their overall health and performance (Fleming & Costarelli, 2007). Two other studies showed that the recommended amount of CHO intake was not met either by the elite combat sports fighters (including boxing, judo, wresting and taekwondo), or the elite amateur boxers (Pettersson & Berg, 2014; Reljic *et al.*, 2015). Both these studies show a diet that is below the recommended

guidelines for >4-5 h/d moderate to high-intensity exercise of 8-12g/kg/d of CHO (Thomas, 2017).

Two different studies showed a similar trend in terms of a very low or inadequate amount of CHO taken in pre-competition. Both in the elite boxing group and the jiu jitsu studies, CHO intake was low with intakes of 2.2g/kg and 6.3g/kg respectively. These values are lower than the recommended amount of 8-12g/kg/d of CHO (Andreato *et al.*, 2016; Reljic *et al.*, 2015; Thomas, 2017).

Dietary supplementation has been seen to enhance performance and recovery (Campbell *et al.*, 2011; Petkova *et al.*, 2018). It therefore not uncommon for combat sport athlete to use supplementation during and after training sessions in order to help with their training performance as well as help boost their recovery. According to Anyżewska *et al.* (2018) 81% of the MMA fighters in his study reported the use of supplementation. Some of the supplementation used included isotonic drinks (82%), branch chain amino acids (BCAA) (46%), carbohydrate supplements (44%), protein supplements (32%) creatine (20%). Zaggelidis *et al.* (2008) also reported the use of supplementation among judo fighters (60.9%).

2.3 Weight-making practices in combat sports

As mentioned above, fighters are weighed-in 24 hours prior to the competition and are at risk for being penalised if they are outside the recommended weight range for the weight category entered. This 24-hour period also allows fighters to adequately recover/rehydrate before the fight (Jetton, 2012). It is not uncommon for fighters to enter a weight category below their usual weight, and as a result they are pressured to make a certain weight prior to weigh-in, often resulting in intentional weight loss practices. Weight-making practices in weight category combat sports, including MMA, are very common and can include a combination of acute/rapid and/or chronic methods. Rapid weight loss (RWL) is defined as “the reduction of a significant amount of body weight (typically 2-10 % and even more) in a few days prior to weigh-in (mostly in the last 2-3 days) achieved by a combination of methods that include starvation, severe restriction of fluid intake and intentional sweating” (Artioli *et al.*, 2016). These practices aid athletes to lose the last bit of unwanted body weight, usually being water weight, in a short time. Table 2-4 summarises some of the common weight loss methods used. According to Artioli *et al.* (2014), there are several surveys that report 60%-90% of combat sports competitors using rapid weight loss techniques in order to make weight. According to Lingor and Olson (2010), most of the wrestlers that took part in their study significantly restricted their

fluids 48 hours prior to weigh-in. When referring to Table 2-5, one can see that restriction of fluid ingestion has a very high prevalence among MMA fighters (96%) and combat fighters (89.5% and 32.7%) (Brito *et al.*, 2012; Reale *et al.*, 2018; Ribas *et al.*, 2017).

Although RWL methods are the most common, fighters sometimes use a long-term strategy of chronic caloric restriction to keep a low weight. Popular chronic weight-making practices used by judo, wrestling, Jiu jitsu, karate, taekwondo and boxing athletes, include energy restricted diets (Crighton *et al.*, 2016).

Table 2-4: Common weight loss methods used in combat sports

Weight loss methods
Gradual weight loss (2 weeks or more)
Hot bath
Skipping 1-2 meals
Restricting fluid ingestion
Water loading This is where fighters ingest an excessive amount of water during a few days, which in turns causes polyuria (Reale et al., 2017)
Fasting (not eating the entire day)
Increased exercise (more exercise than usual training)
Training in plastic or rubber suits This is where fighters put on these suits in order to increase their sweating and therefore increasing their fluid loss.
Sauna
Salt baths Using Epsom salt in a hot bath acts as a natural laxative, and therefore helps one lose excess water (Marks, 2015)

From Table 2-5 it is clear that the use of weight loss practices among combat athletes, including MMA, is very common. Weight-making practices include gradual dieting, restricting fluid ingestion, skipping meals, fasting the entire day, an increase in exercise, wearing of plastic suits and using a sauna, and water loading techniques.

When focusing specifically on three studies that included MMA fighters, we can see that the use of sauna (76%, 43% and 92% respectively) and rubber/plastic suites (63%, 43% and 88% respectively) has a high prevalence in all three studies (Barley *et al.*, 2017; Matthews & Nicholas, 2017; Ribas *et al.*, 2017). Both Ribas *et al.* (2017) and Barley *et al.* (2017) report a prevalence above 50% for the use of gradual weight loss, fluid restriction as well as increased exercise compared to other combat sports. Anyżewska *et al.* (2018) does not report increased exercise, however reports 39% of the MMA fighters increasing their training intensity in order to lose weight.

Table 2-5: Summary of studies exploring weight loss practices in combat sports

Author	Study Population	Weight loss practices	Prevalence
(Anyżewska *et al.*, 2018)	MMA fighters (n=62)	Restricted diets	61%
		Increased exercise intensity	39%
		Thermogenics	17%
(Crighton *et al.*, 2016)	MMA fighters (n= 30)	Increase sweating (not specified)	17%
		Diuretics	37%
		Nutritional supplements	73%
		Fasting or having a low carbohydrate diet in the final 3–5 days prior to weigh-in	100%
		Water loading	67%
(Ribas *et al.*, 2017)	MMA fighters (n= 25)	Gradual diet -always -sometimes	Total 92% 56% 36%
		Restricting fluid intake -always -sometimes	Total 96% 72% 24%
		Exercise more than usual -always -sometimes	Total 80% 52% 28%
		Training in heated rooms -always -sometimes	Total 84% 32% 52%

		Sauna -always -sometimes	Total 92% 60% 32%
		Rubber/plastic suits -always -sometimes	Total 88% 44% 44%
Author	**Study Population**	**Weight loss practices**	**Prevalence**
(Brito *et al.*, 2012)	Total of 580 combat athletes, including judo (n=145), jui jitsu (n=155), karate (n=130) and taekwondo (n= 150)	Increase in exercise activities	90.7%
		Low-calorie diet for 2-3 days?	67.7%
		Sauna or plastic clothing	50.0%
		Carbohydrate restriction	44.9%
		Fat restriction	33.1%
		Fluid restriction	32.7%
		Use of diuretics and/or laxatives	34.1%
(Matthews & Nicholas, 2017)	MMA fighters (n= 7)	Sauna	43%
		Plastic suits	43%
(Reale *et al.*, 2018)	Total of 229 combat athletes, including boxing (n=71), judo (n=68), taekwondo (n=57) and wrestling (n= 33)	Always gradual dieting	90.8%
		Always skip 1 or 2 meals	79.9%
		Always fast	64.1%
		Always restrict fluid	89.5%
		Always increase exercise	87.3%
		Always use saunas	78.1%
		Always train in plastic suits	58%
		Always water load	40.6%
(Barley *et al.*, 2017)	MMA (n= 70)	Always gradual dieting	93%
		Always skip 1 or 2 meals	57%
		Always fast	48%
		Always restrict fluid	76%
		Always increases exercise	78%
		Always use saunas	76%
		Always train in plastic suits	63%

The most common weight-making practice reported from the studies summarised in Table 2-5 is fluid restriction with a prevalence of 96% (Ribas *et al.*, 2017) followed by gradual weight loss (93%) and sauna (92%) (Barley *et al.*, 2017; Ribas *et al.*, 2017).

When looking at MMA fighters and other combat fighters, is it clear that they lose weight in order to fight. Water loading prevalence is higher in MMA fighters (67%) when compared to other combat sports (40.6%) (Crighton *et al.*, 2016; Reale *et al.*, 2017). One can also see that fluid restriction prevalence is higher in MMA (96%) when compared to other combat sports (32.7%) (Brito *et al.*, 2012; Ribas *et al.*, 2017). When focusing on the study done by Brito *et al.* (2012), which consists of a large sample size of 580 combat fighters including judo, Jui Jitsu, karate and taekwondo, 63.1% lost weight in order to compete, and from this study population 31.7% lost >5% of their body mass.

2.4 Consequences of weight-making practices and its effects on health and performance

2.4.1 Dehydration as a consequence of RWL

The most common rapid weight loss technique used across the board is dehydration. Urine specific gravity (USG) has been proposed to be the most commonly used dehydration marker for combat athletes (Zubac *et al.*, 2016). The hydration status in elite wrestlers, judokas, boxers and taekwondo fighters was observed by Pettersson and Berg (2014) by examining the USG via refractometry. The results of this study showed that 89% of these athletes were extremely dehydrated on the competition day, with USG values ≥1.020. A study on elite amateur boxers done by Reljic *et al.* (2013), showed that the RWL of the fighters' body mass was done nearly entirely by dehydration. According to Jetton *et al.* (2013), at the official weigh-in 24 hours prior to competition, 57% of athletes were classified as dehydrated (USG >1.021) and of the rest of the fighters, 43%, were classified as severely dehydrated (USG > 1.030). Dehydration is commonly defined as a deficit in total body fluid (TBF) (Castro-Sepulveda *et al.*, 2015; Cheuvront & Kenefick, 2014). Although previous studies, as shown above, have found their combat athletes to be dehydrated using USG markers; new research by Zubac *et al.* (2018) found USG to be an unreliable diagnostic method in order to track actual body weight lost. According to Zubac *et al.* (2018) USG readings were inconsistent with the intra-class correlation coefficients ranging from 0.52 to 0.55.

Table 2-6 shows the USG cut off values for different severity of dehydration.

Table 2-6: Severity of dehydration

Severity of dehydration	USG values
Minimally dehydrated	USG 1.010 – 1.020
Moderately dehydrated	USG 1.021 – 1.030
Severely dehydrated	USG > 1.030

Adapted from (Castro-Sepulveda *et al.*, 2015)

There are two strategies used for the reduction in total body fluid. These strategies are fluid restriction (little to no fluid intake) and fluid loss (respiration, urination and perspiration). Figure 2-1 provides a summary of the three techniques used to lose fluid.

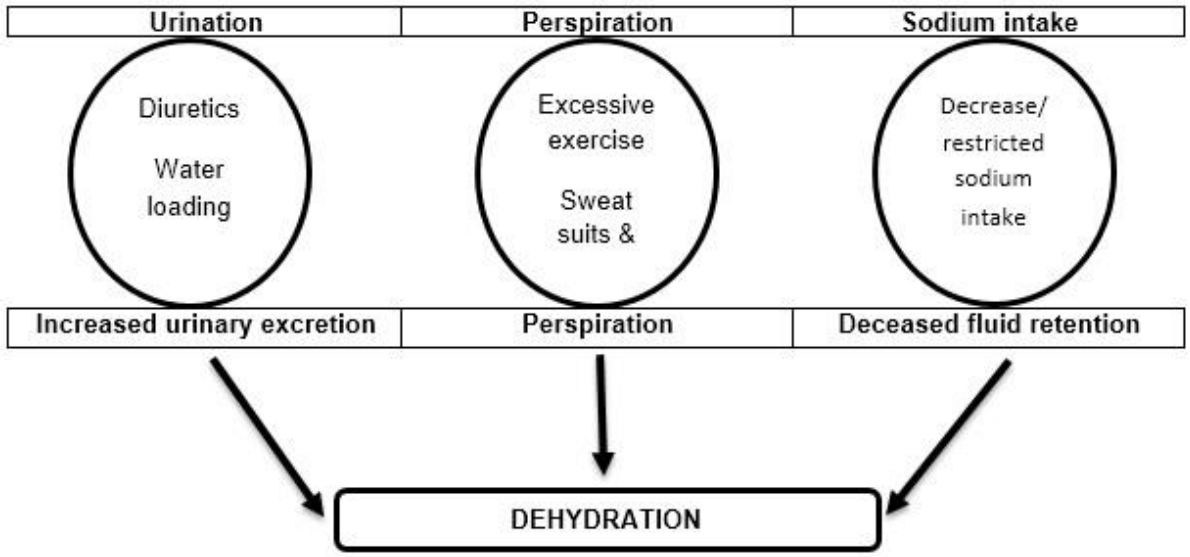

Figure 2-1: Fluid loss techniques

When focusing on fluid loss, there are three techniques used: urination, sweating (perspiration) and restricting sodium intake. According to Reale *et al.* (2017), combat sports fighters are known to increase their urinary output and lose more water weight through the use of diuretics. Another way these fighters increase their urine output is by 'water loading' where fighters ingest an excessive amount of water during a few days, which in turns causes polyuria (Reale *et al.*, 2017). Fighters also most commonly increase perspiration by excessively exercising (active) and/or increasing their core and skin temperature (passive), by wearing

sweat suits and using a sauna. The third most common technique used is sodium restriction. This has become a trend due to a high sodium intake causing fluid retention, therefore restricting sodium intake reverses this process (Reale *et al.*, 2017).

2.4.2 Health risks of Rapid Weight Loss (RWL)

As mentioned above, the most common weight-making practices are RWL techniques. The health risks of RWL include both acute and chronic effects. Although there is a long list of health effects, common acute effects include dehydration and reduced plasma volume (Artioli *et al.*, 2016). These effects can cause acute cardiovascular problems. Dehydration has been seen to impair the body's ability to regulate its temperature. Not only are the fighters not able to regulate their temperature, they make it worse by further putting their body under more heat-related stress in a sauna. Heat stress and dehydration are a fatal combination that can lead to hypothermia (Artioli *et al.*, 2016; Hoffman & Maresh, 2011). Other common side effects of dehydration include nausea, vomiting, dizziness, headaches, 'flu-like symptoms and declined performance. According to a study done on MMA fighters that explored the effects of acute dehydration (5% body mass loss) on their performance, it was seen that acute dehydration of 5% had a negative influence on their performance (vertical jump, medicine ball throw, hand grip and repeated sled push), 3h and 24h after the dehydration occurred (Barley, 2016). In a literature review by Cheuvront and Kenefick (2014), it was seen that dehydration of ≥2% body mass loss impaired endurance (aerobic) and strength and power (anaerobic) performance. From 60 separate observations done on endurance exercise, 68% (41/60 observations) showed performance was significantly impaired by a 2% body mass dehydration. It was also seen, although a smaller percentage, that out of 276 separate observations on strength and power, 20% (54/276 observations) showed strength and power were significantly impaired by the dehydration of 2% body mass (Cheuvront & Kenefick, 2014). Another study done on MMA fighters showed that the use of RWL methods, including increased exercise, dietary restriction as well as the use of sauna, increased muscle damage markers (creatine kinase, aspartate aminotransferase and lactate dehydrogenase) and catabolic markers, which also affect the performance and recovery of the fighters (Coswig *et al.*, 2015).

These rapid weight loss methods can potentially be very dangerous and have detrimental consequences on the fighters' health. Acute dehydration (6-10% water loss) resulted in the heat-related death of three wrestlers in 1997, and the death of an MMA fighter during a sauna session in 2013 after attempting to lose 20% of his body mass (approximately 15 kg) in only one week (Crighton *et al.*, 2016; Jetton *et al.*, 2013). Another serious case documented is that

of a Canadian MMA fighter who required cardiopulmonary resuscitation after fainting as a result of weight-cutting practices (Crighton *et al.*, 2016).

2.4.3 Relative energy deficiency syndrome (RED-S)

Chronic energy reduction as a weight-making practice can potentially result in relative energy deficiency syndrome (RED-S). RED-S refers to the impaired physiological function of the metabolic rate, bone health, protein synthesis, immunity and cardiovascular problems. The effects of RED-S can have an impact on one's short-term and long-term health, thereby affecting one's physiological function and athletic performance (Robertson & Mountjoy, 2018). Long-term low energy availability (EA) can lead to nutrient deficiencies, chronic fatigue and suppressed immunity, increasing the risk of infection and illness. A carbohydrate deficiency resulting from RED-S can result in a decrease in glucose use and the slowing down of the metabolic rate (Robertson & Mountjoy, 2018). In a case study by Kasper *et al.* (2018), on a professional male MMA fighter, is was clear that there were signs of relative energy deficiency. The fighter had a reduced metabolic rate, was unable to complete performance tests, and had marked alterations to his endocrine hormones, as well as hypercholesterolemia.

2.5 Conclusion

Weight-making practices among combat sports, including MMA, are prevalent. Fighters use rapid weight loss methods in order to lose fluid and fight in lower weight divisions. The most prevalent consequence of RWL is dehydration; it has been seen that dehydration of >2% body mass can cause an impairment in endurance and strength performance of these fighters. Due to MMA being a physically taxing sport, nutrition plays a vital role in their general health, performance, and in their recovery.

CHAPTER 3: ARTICLE

Abstract

Athletes competing in weight category sports, including mixed martial arts (MMA), often employ weight-making practices to fight in lower weight divisions. These weight-making practices often result in dehydration and can be detrimental to the health and performance of these athletes. Although literature is available on the weight-making practices of MMA fighters, limited information is available regarding their general nutritional status. Thus, this study aims to describe the nutritional status (dietary intake and body composition) and weight-making practices of professional male South African MMA fighters. Dietary intake was recorded with a quantitative food frequency questionnaire at baseline (six weeks prior to competition) and again at 1-week prior to competition. A weight-making practice questionnaire was administered 1-week prior to competition to determine weight-making practices. Seventeen MMA fighters (aged 28.0±1.0 years) participated in this observational, longitudinal study. Although median BMI of the participants at baseline was classified as overweight (>24.9 kg/m^2), their median body fat percentage was low. Although body mass decreased significantly from baseline to weigh-in (80.4 (73.3-86.5) kg to 70.4 (66.8- 106.6) kg, $p<0.05$), body fat percentage did not significantly change between the baseline and pre-competition period. Dietary protein and fat intake (g/kg) was in-line with the recommendations, however median CHO intake at baseline [5.2 (3.2-11.7) g/kg] and 1-week prior to competition [3.5 (2.5-7.8) g/kg] was below the recommendations. All the fighters reported the use of one or more weight-making practices. Gradual weight loss was the most common weight-making practice reported (88%), followed by hot baths (82.4%), restricting fluid ingestion (70.6%), water loading (70.6%), and meal skipping (70.6%). Furthermore, all the participants that provided a voluntary urine sample at weigh-in 24-hours prior competition were classified as dehydrated. This study reported a high prevalence of weight-making practices in professional South African MMA fighters, particularly rapid weight-making practices that result in dehydration.

Key words: rapid weight loss techniques, body composition, dietary intake.

Introduction

Mixed martial arts (MMA) is a popular weight category combat sport that incorporates a variety of martial arts, including muay thai, kickboxing, boxing, wrestling, taekwondo, and jiu jitsu (Lenetsky & Harris, 2012). MMA fighters can compete as amateur or professional athletes in eight weight categories ranging from flyweight (<57kg) to heavyweight (>93-120kg). Once fighters achieve professional status they can compete in major national and international events, such as extreme fighting championships (EFC) and ultimate fighting championships (UFC) – an American-based competition. MMA is a physically taxing combat sport that incorporates, amongst other, strikes and grappling (Bishop *et al.*, 2013; La Bounty *et al.*, 2011). The length of the fighter's arms, known as the reach, is therefore an important aspect of MMA fighting. The greater the reach the greater the competitive advantage. Fighters therefore usually enter the lowest weight category possible so that they have a greater height-to-reach ratio advantage on their opponent (Crighton *et al.*, 2016).

Currently in EFC, fighters weigh in 24 hours prior to competitions, and they are penalized if they weigh more than the cut-off weight for the weight division they have entered. In order to make the required weight at weigh in, fighters often resort to rapid weight loss (RWL) practices. RWL is. Rapid weight loss is defined as the reduction of a significant amount of body weight (typically 2-10% and even more) in a few days prior to weigh-in (mostly in the last two to three days), and this is achieved by a combination of methods that include starvation, severe restriction of fluid intake, and intentional sweating (Artioli *et al.*, 2016). These practices aid athletes to lose every last bit of unwanted body weight, usually water weight, in a short time. Since weigh-in typically occur 24 hours prior to competition, fighters can engage in extreme weight-making practices prior to weigh-in (i.e. extreme dehydration), and use the subsequent 24 hours to adequately recover and/or rehydrate before their fights (Jetton *et al.*, 2013). Although the California State Athletic Commission (CSAC) passed a new rule in 2017, allowing a maximum weight difference of 8% between 1-week prior to weigh-in and weigh-in, this rule currently only applies to UFC, and not to EFC (Baldwin, 2016). Thus, professional MMA fighters competing in EFC can still weigh in at the lowest possible weight 24-hours prior to competitions, making use of extreme weight-making practices, and regain as much weight as they want during the 24-hour period up to the weigh-in.

Matthews and Nicholas (2017) reported that 100% of MMA fighters in their study used one or more weight-making practice to make weight prior to competitions. The prevalence of RWL methods was high and included water loading (100%), restricting fluid ingestion (100%),

additional exercise (85%), hot baths (72%), and training in plastic or rubber suits (71%). In a study that included 30 MMA fighters, it was observed that 67% of the fighters practiced water loading, 17% used methods to increase sweating (sweet sweat), and 37% used diuretics (Crighton *et al.*, 2016). According to Anyżewska *et al.* (2018), 58% of Polish MMA fighters use RWL practices, including dietary restriction (61%), and increase exercise intensity (39%) in the two to three days before competitions. Studies have also shown that combat athletes such as wrestlers, boxers, and jiu jitsu athletes reduce their caloric intake 24-48 hours prior to weigh-in, and restricted their carbohydrate intake to below the recommended guidelines for optimal sport performance (Andreato *et al.*, 2016; Lingor & Olson, 2010; Reljic *et al.*, 2015; Thomas *et al.*, 2016).

RWL practices, particularly those focused on fluid loss, often result in dehydration. In fact Anyżewska *et al.* (2018) reported that 69% of MMA fighters were dehydrated at weigh-in. Matthews and Nicholas (2017) found 100% the MMA fighters in their study were dehydrated, of which 43% were classified as severely dehydrated at weigh-in. Jetton *et al.* (2013) also investigated the magnitude of dehydration in MMA fighters 24-hours prior to competition, and reported that 39% of the MMA fighters were classified as dehydrated, with a urine specific gravity (USG) higher than 1.021.

Dehydration can potentially be very dangerous and have detrimental consequences on the fighters' health. Indeed, acute dehydration (6-10% water weight loss) resulted in the heat-related deaths of three wrestlers in 1997, and the death of an MMA fighter during a sauna session in 2013, after he attempted to lose 20% of his body mass (approximately 15kg) in only one week (Crighton *et al.*, 2016; Jetton *et al.*, 2013). Another serious documented case is that of a Canadian MMA fighter who required cardiopulmonary resuscitation after fainting as a result of weight-making practices (Crighton *et al.*, 2016).

Although rapid weight-making practices, such as dehydration and acute energy restriction, are more common, weight category athletes, including MMA fighters, also engage in chronic practices such as low or restricted energy diets over more prolonged periods of time (e.g. more than just two to three days). Due to MMA being a physically taxing sport that requires strength and energy. The fighters usually go through a six to 10 week "fight camp" or training cycle to prepare for competitions, which includes extra training sessions and longer hours in the gym in comparison to their usual day-to-day training schedules. During this time fighters also potentially restrict their diets to lose the extra weight gained during non-training cycle periods. Brito *et al.* (2012) reported that 67.7% of the combat athletes (including judo, jujitsu,

karate, and taekwondo) that participated in their study ingested low-energy diets. Crighton *et al.* (2016) reported that 100% of the MMA participants in his study engaged in complete fasting and/or ingesting a low carbohydrate diet in the final three to five days prior to weighing in. More prolonged dietary and energy restrictions can also have detrimental effects on athletes' health and can result in, amongst other, relative energy deficiency syndrome (RED-S) (Robertson & Mountjoy, 2018).

Considering the important role of nutrition in exercise and sport (Artioli *et al.*, 2014), it is surprising that only a few studies have examined the habitual dietary intake of combat athletes. In one of the only studies looking at MMA fighters food intake, Anyżewska *et al.* (2018) administered food frequency questionnaires (FFQ) and a single 24-hour dietary recall to Polish MMA fighters, and the authors reported a low consumption of dairy products, grain products, fruit, and vegetables. As a result, carbohydrate [3.5 (1.9-5.1) g/kg] and calcium [719 (120-1318) mg] intake levels were below the recommendations. Andreato *et al.* (2016) and Książek *et al.* (2014) reported a protein intake of 2.2±1.0 g/kg, and 1.81±0.49 g/kg respectively, both in line with the recommendations for athletes. The jiu-jitsu athletes in the study from Andreato *et al.* (2016), reported a sufficient carbohydrate intake of 6.3±2.3 g/kg, however, the boxers in Reljic *et al.* (2015) and Książek *et al.* (2014) studies both reported carbohydrate intakes below the recommendations (3.8±1.1 g/kg and 4.48±1.05 g/kg respectively).

Although combat sport fighters may restrict their dietary intake in order to make weight prior to competition, data regarding MMA fighters' nutritional status, including their habitual dietary intake and body composition, is limited. Information on weight-making practices in South African male MMA fighters is also scarce. Therefore, the aim of this study was to describe the nutritional status – with specific reference to dietary intake and body composition, and weight-making practices of professional South African male mixed martial arts fighters.

Methods

Study design

This was an observational study with a longitudinal study design that included quantitative data collection by means of validated research questionnaires and measurements. Data was collected at baseline (six weeks prior to competition), 1-week prior to competition, and at weigh-in, i.e. 24-hours prior to competition.

Study population and sample selection

Seventeen Professional South African male MMA fighters between the ages of 18-40 years were purposively recruited from the five largest MMA clubs in Gauteng province, representing 39.4% of the total MMA population size. MMA clubs from other provinces were not included as it is unlikely that the weight-making practices and nutritional status off MMA fighters differ between provinces. Ethical approval was obtained from the North-West University's Health Research Ethics Committee (HREC) (HREC approval number NWU-00120-17-S1), and all participants gave their written informed consent before the study commenced.

Research setting

Data collection was performed in private rooms or offices at the largest MMA club in Pretoria and at the four largest MMA clubs in Johannesburg. The respective competition venues were also visited to record weight and hydration status at weigh-in (24 hours prior to competition).

Procedures

•Anthropometry and body composition

An International Society for the Advancement of Kinanthropometry (ISAK) level 1 anthropometrist performed anthropometric measures for descriptive purposes at baseline (six weeks prior to competition), as well as 1-week prior to competition. The weights measured 24-hours prior to competition were recorded at the competition venue, where weights were publicly announced at the official weigh-in. All the anthropometric measurements were performed in a private room or enclosed space. Participants were required to remove their shoes, heavy clothing, and accessories. Height and weight measurements were performed using a calibrated digital scale with a stadiometer (Seca 264, Hamburg, Germany), and measurements were recorded to the nearest decimal point. Height was measured whilst participants stood barefoot with their heels together and their heads set in the Frankfort plane position. Participants' body mass index (BMI) (kg/m^2) was calculated using the following equation: weight (kg) divided by height (m) squared. Each measurement was performed twice, and the average was calculated. In the event where the two measurements differed by more than 5%, a third measurement was taken.

To determine body fat percentages (%), skinfold measurements were performed according to the ISAK, and the following equation was applied to calculate body fat %: 0.1051 (sum of

triceps, subscapular, supraspinale, abdominal, thigh, calf) + 2.585 (Stewart *et al.*, 2011; Yuhasz, 1974).

• Weight-making practices questionnaire and training

On week prior to competition, each participant completed a weight-making practices questionnaire, administered by the researcher. A previously validated weight-making practices questionnaire that was developed for judo fighters (Artioli *et al.*, 2010) was adjusted for MMA (e.g. the judo-specific terminology was replaced with MMA-specific terminology) and administered (Appendix 2). The questionnaire included a number of demographic questions, e.g. weight history, and questions related to weight-making practices. Training programs were obtained from the coaches at the respective gyms, in order to estimate the fighters' daily training hours.

•Dietary intake

A quantified food frequency questionnaire (QFFQ) that has previously been validated in a South African population (Venter *et al.*, 2000) and that has shown to be reproducible in a similar population (Wentzel-Viljoen *et al.*, 2011) was adapted for the MMA study population. The QFFQ was pre-tested in a number of MMA fighters who did not participate in the study, and the questionnaire was then adjusted accordingly. Based on this pre-testing, a question regarding the use of sport supplements was added. From the literature it is also not uncommon for strength and power sport athletes to use sport supplements (Anyżewska *et al.*, 2018; Campbell *et al.*, 2011; La Bounty *et al.*, 2012; Petkova *et al.*, 2018). The adjusted QFFQ was administered by the researcher, who is also a qualified dietitian, at baseline (six weeks prior to competition) and again 1-week prior to competition, to allow a detailed analysis of dietary intake. The quantities of all foods were recorded and subsequently converted and expressed in g/day. To assist the participant to report the correct quantities, a portion size estimation kit with household food measurement utensils (e.g. cups, teaspoons, tablespoons, ladles, etc.) and food models were provided. A conversion table was used to convert household measures into grams. Foods' nutrient compositions were calculated and all conversions were based on the South African food composition tables. Energy intake is reported in kilojoules and carbohydrate, protein and fat as total grams, gram per kilogram body mass, and percentage of total energy intake. Under-reporting was not assessed in this study, since it is not uncommon for weight category athletes to skip meals and restrict their dietary intake in order to make weight prior to weigh-in. Data were analysed using STATA software version 15. The

energy and macronutrient contributions from reported supplements were manually added after the relevant information was obtained from the supplements' labels.

•Hydration status:

To determine fighters' hydration status at weigh-in, urine samples were collected 24-hours prior to competition at the competition venue. Providing urine samples was voluntary and each participant was ensured that the urine would only be used to test their hydration status, and that no other metabolites would be assessed. Athletes were provided with sterile urine collection containers immediately following their weigh-in, and they were instructed to empty their bladders and collect a mid-stream urine sample in a private bathroom. The researcher collected the samples on site for immediate analysis. The fighters' hydration status was assessed by determining urine specific gravity (USG), using a handheld digital refractometer (PAL-10S) with a measuring range of 1.000 to 1.060, a minimum indication of 0.001, and a measurement accuracy of ± 0.001. The following cut-off values were applied: minimally dehydrated (USG 1.010-1.020); moderately dehydrated (USG 1.021-1.030); and severely dehydrated (USG > 1.030) (Castro-Sepulveda *et al.*, 2015).

Statistical analyses

Statistical analyses were performed by using the SPSS version 25.0 statistical software program. The Shapiro-Wilk and the Kolmogorov-Smirnov tests were performed to assess data distribution. Normally distributed data is reported as mean and standard deviation (SD), and non-parametric data is reported as median and interquartile range (IQR, 25-75 percentile). Paired T-tests and non-parametric Wilcoxon signed rank tests were performed to test differences in single variables between time points. The weight-making practices data was reported as relative frequencies. Correlations were determined by the Spearman Rank test. Statistical significance was accepted at $P<0.05$.

Results

Seventeen professional male South African MMA fighters participated in this study. The participants' characteristics are summarized in table 1

Table 1: Subject characteristics

Characteristic	**Mean (±SD) or Median (25th-75th percentile)**	**Range (min-max)**
Age (years)	28.0±1.0	21.0-38.0
Weight (kg)	80.5 (73.3-86.5)	61.4-123.1
Height (cm)	179.2 (175.6-183.4)	155.0-189.4
BMI (kg/m^2)	25.2 (24-26.2)	21.2-39.2
Body fat percentage (%)	7.6 (6.5-8.5)	5.0-18.2
Sum of eight skin folds (mm)	58.6 (45.5-70.6)	29.1-185.5
Years competing in MMA	7.0±1.0	3.0-18.0
Distribution of study participants in the eight MMA weight categories		
Weight category	**Weight range of category**	**Number of study participants in category**
Flyweight	<57kg	n= 1
Bantamweight	57kg - 60kg	n= 3
Featherweight	61kg - 65kg	n= 2
Lightweight	66kg - 69kg	n= 4
Welterweight	70kg - 76kg	n= 2
Middleweight	77kg - 83kg	n= 3
Light heavyweight	84kg - 92kg	n= 0
Heavyweight	93kg - 120kg	n= 2

There was a good distribution of participants amongst the different weight categories ranging from flyweight to heavyweight. Although the median BMI of the study sample at baseline can be classified as overweight (>24.9kg/m^2), (World Health Organization, 1998), their median body fat% was low. The higher BMI in MMA athletes is thus not as a result of a high body fat%, but probably due to a high muscle mass. The average amount of hours that the fighters

train per day as reported by their coaches was 2.5-4 hours, and this typically included drills and skills (for one hour five times per week), jiu jitsu (an hour and a half, four times per week), wrestling (one hour twice a week), sparring (one hour once a week), and conditioning (one hour five times per week).

Body composition and hydration status

Median weights at baseline, 1-week prior to competition and recorded weight at weigh-in 24-hours prior to competition are depicted in Figure 1. The weight changes and reported maximum and average weight lost prior to competition are summarised in Table 2.

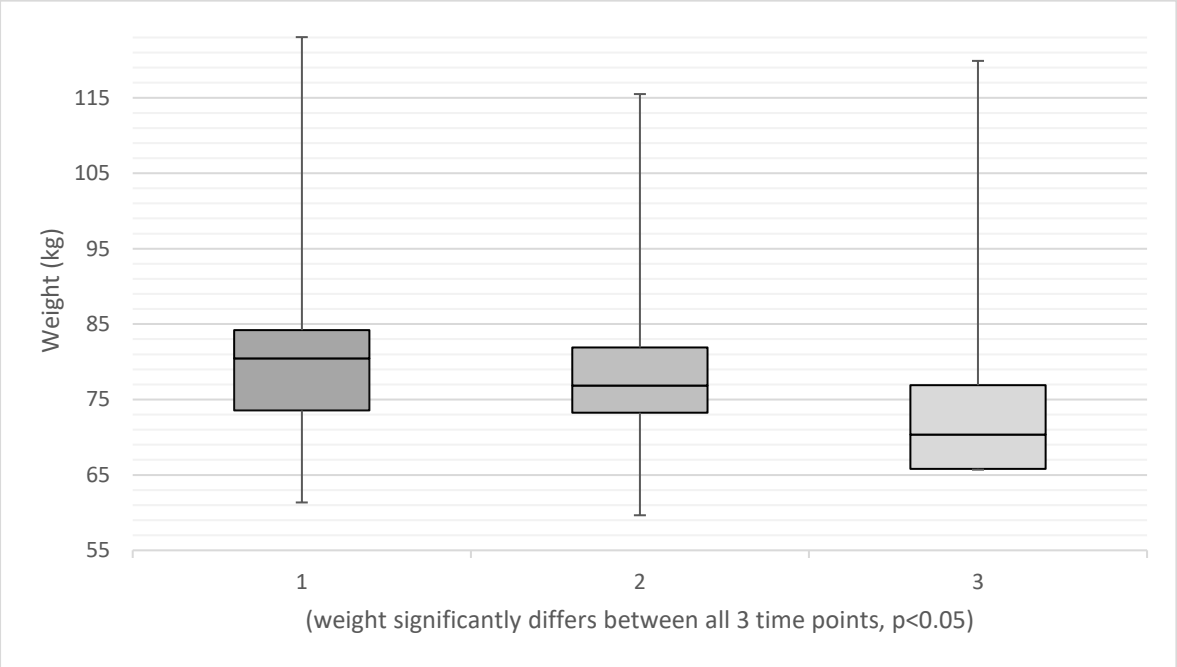

Figure 1: 1-Weight at baseline, 2-1-week prior to competition and at 3-official weigh-in.

From Figure 1, it is clear that the fighters did not only lose a significant amount of weight from baseline to 1-week prior to weigh-in, and also during the few days leading up to weigh-in, 24-hours prior to competition. The total median weight lost from baseline to weigh-in was 7.9 (4.7-12.9) kg, with the majority of weight [5.9 (5.0-7.6) kg] lost during the last week prior to weigh-in (Table 2). The total amount of weight lost during the six weeks leading up to competition is in line with the amount of weight that the fighters needed to lose in order to fight in the weight category they had entered (i.e. the weight difference between baseline weight/weight when they entered the specific weight category, and the respective weight category upper limit) (Table 2). Although weight decreased significantly, body fat% at baseline [7.6 (5.53-9.6) %]

and 1-week prior to competition [6.7 (2.7-10.7) %] did not differ significantly. Based on the USG results in a sub-sample of the study population (n=7), which classified 57% as mildly dehydrated and 43% as severely dehydrated, the weight lost in the days leading up to weigh-in was predominantly water weight.

Table 2: Weight changes and reported maximum and average weight lost prior to competition

Weight lost (kg)	**Median (25th-75th percentile)**	**Range (min-max)**
Weight lost between baseline and weigh-in (kg)	7.9 (4.7-12.9)	4.7-13.4
Weight lost between baseline and 1-week prior to competition (kg)	3.0 (0.3-5.7)	-0.3-6.2
Weight lost between 1-week prior to competition and weigh-in (kg)	5.9 (5.0-7.6)	1.0-9.1
Maximum weight lost reported before a competition (kg)	9.0 (8.0-9.50)	7.0-12.0
Usual weight lost reported before a competition (kg)	8.0 (5.0-9.0)	4.0-10.0
Weight difference between baseline weight and upper limit of weight category entered (kg)	8.5 (5.3-10.9)	1.2-15.2

Dietary intake

Table 3 provides a summary of the energy and macronutrient intake at baseline and 1-week prior to competition. The median reported energy intake at baseline was 17170 (15598-26376) KJ, and showed a tendency to decrease from baseline to 1-week prior to competition ($p=0.093$). Similarly, reported total protein decreased from baseline to 1-week prior to competition ($p=0.063$) (Table 3). Although dietary protein intake (express in gram per kg body mass) at baseline and 1-week prior to competition was in line with the recommendations for athletes (1.2 – 2.0 g/kg) (Jäger *et al.*, 2017), dietary carbohydrate (CHO) intake at baseline and 1-week prior to competition was below the recommendations of 6-10g CHO/kg body mass for athletes performing 1-3 hours of moderate to high-intensity exercise per day (Thomas *et*

al., 2016). Dietary fat intake both at baseline and 1-week prior to competition was high (>35% of total energy, although according to Kerksick *et al.* (2018) athletes that do regular high-volume training may increase their fat intake up to 50% of total energy intake.

Table 4 provides a summary of the micronutrient intake at baseline and 1-week prior to competition. Intake of Vitamin A and Vitamin C were above the RDA at baseline, as well as 1-week prior to competition. Calcium and zinc intake decreased significantly from baseline to 1-week prior to competition (Table 4).

With regard to the use of sport supplements, nine (53%) of the participants reported the use of one or more of the following supplements: 100% whey protein powder (n=8); branched-chain amino acids (BCAA) (n=6); L-glutamine (n=3); and creatine (n=3). The frequency of use varied between daily for whey protein, BCAA's, L-glutamine, and creatine, to weekly (whey protein).

Table 3: Reported macronutrient intake

Nutrients	**Baseline**		**Pre-competition**		**P-Value**
	Median Interquartile range (25th-75th percentile)	Range (min-max)	Median Interquartile range (25th-75th percentile)	Range (min-max)	
Energy (KJ)	17170 (15598-26376)	10413-39905	13805 (8016-20403)	5587-30803	P= 0.093
CHO (g)	411 (291-632)	60-992	271 (165-674)	60-930	P= 0.401
CHO (g/kg/day)	5.2 (3.2-11.7)	0.8-13.5	3.1 (2.1-10.5)	0.8-12.7	P= 0.889
CHO (% Total energy)	40.6 (26.3-55.3)	6.5-66.0	45.3 (28.3-55.5)	0.8-12.7	P= 0.889
Protein (g)	194 (134-216)	80-422	145 (116-197)	57-210	P= 0.063
Protein (g/kg/day)	2.1 (1.8-2.6)	1.6-4.3	1.9 (1.6-2.2)	0.7-2.8	P= 0.263
Protein (% Total energy)	14.6 (10.9-20.3)	9.9-21.1	16.7 (11.2-25.9)	11.1-38.4	P= 0.208
Fat (g)	209 (161-305)	84-515	165 (102-199)	44-309	P= 0.123
Fat (g/kg/day)	2.8 (2.1-4.2)	1.4-5.0	1.9 (1.3-3.0)	0.7-4.2	P= 0.208
Fat (% Total energy)	44.0 (32.3-61.5)	21.3-72.5	40.9 (32.8-47.2)	29.3-48.6	P= 0.484

Table 4: Reported micronutrient intake

Micronutrient	**RDA**	**Baseline**		**Pre-comp**		p- value
	19 -50 years	Median (25th-75th percentile)	Range (min-max)	Median (25th-75th percentile)	Range (min-max)	
Vitamin A (µg/day)	900	3210 (2067-5146)	792-13158	1900(1342-4648)	897-4868	P= 0.263
Vitamin B12 (µg/day)	2.4	10 (5-19)	0-26	4 (1-10)	0-11	P= 0.093
Vitamin C (mg)	90	243 (145-471)	64-1361	199 (98-818)	39-956	P= 0.327
Vitamin D (µg/day)	15	8 (1-22)	1-1019	5 (0-9)	0-26	P= 0.161
Iron (mg)	8	30 (22-40)	20-59	25 (18-33)	17-59	P= 0.327
Calcium (mg)	1000	1277 (801-1609)	490-2206	826 (522-1120)	423-2332	p= 0.050*
Zinc (mg)	11	26 (21-34)	17-52	20 (17-25)	9-43	P= 0.050*
Magnesium (mg)	400-420	26 (21-334)	326-1706	531 (355-820)	238-2165	P= 0.401

*Significant difference between baseline and 1-week prior to competition ($p<0.05$). RDA=Recommended Dietary Allowance, µg=microgram, mg=milligram (SUN, 2013).

Weight-making practices

A full hundred percent of the participants (n=17) reported engaging in one or more weight-making practices in order to make weight. Table 5 provides a prevalence and frequency summary of the 10 most commonly used weight-making practices.

Table 5: Prevalence and frequency analysis of the weight loss methods reported by MMA fighters (n=17)

Weight Loss Method	Prevalence of weight loss methods	Always (%)	Sometimes (%)	Almost never (%)	Not anymore/ Never (%)
Gradual weight loss (two weeks or more)	88.2%	65	23	0	12
Hot bath	82.4%	70	12	0	18
Restricting fluid ingestion	70.6%	53	18	0	29
Water loading	70.6%	53	12	0	35
Skipping one or two meals	70.6%	30	41	0	29
Fasting (not eating for the entire day)	64.7%	24	35	0	41
Increased exercise (more than usual)	58.8%	53	12	6	29
Training in plastic or rubber suit	58.8%	41	12	6	41
Sauna	58.8%	29	24	0	47
Salt bath	52.9%	47	12	0	41

As is evident in Table 5, the most prevalent weight-making practice was gradual weight loss (for two weeks or more), with the remainder of the top 10 methods all being RWL methods. Each of the top 10 weight-making practices mentioned above was reported by more than half of the study population. Other weight-making practices reported in this study, but not mentioned in the table, included training in heated rooms n= 6 (35%), spitting n=3 (18%), and diuretics n=1 (6%). One participant indicated that he no longer used diet pills. None of the participants reported using winter plastic or rubber suits, laxatives, or vomiting. A new type of method called 'Sweet sweat' was reported by two participants, one stated that he "always used" this method and the other stated "not anymore".

When fighters were asked to rate on a Likert scale, how much influence certain persons had on how they lose weight and which weight-making practices to use, it was established that the most influential persons (score 4 and 5) were MMA training colleges and MMA coaches with a prevalence of 52.9% and 58.8% respectively, while dietitians were among the least influential, having only a 17.7% influence.

Discussion

The aim of this study was to describe the weight-making practices and nutritional status, in particular the dietary intake and anthropometric status, of professional South African male MMA fighters. All of the participants in the current study reported the use of one or more weight-making practices prior to competitions in order to make the required weight for the specific weight categories they had entered. Similar to our study, Anyżewska *et al.* (2018), Ribas *et al.* (2017), and Barley *et al.* (2017) also reported that a high percentage of MMA fighters in their studies (58%, 100% and 95%, respectively) reported using weight-making practices to lose weight.

MMA fighters enter lower weight categories in order to obtain a competitive height-to-reach ratio advantage over their opponents (Crighton *et al.*, 2016). They usually enter a weight category six to 10 weeks prior to a competition and are then required to fight in that specific weight category for the competition. The MMA fighters in the present study all entered weight categories that were 1.2-15.2 kg below their baseline weight 6-weeks prior to competition, and therefore had to lose excess weight. In fact, total weight loss over the six-week period was 7.9 (4.7-12.9) kg with most of the weight [5.9 (5.0-7.6) kg] lost during the last week prior to competition. Ribas *et al.* (2017) also reported an average weight loss of 9.3±3.2 kg among the MMA fighters in the three to six days before a competition. Similarly Matthews and Nicholas (2017) reported a mean weight loss of 5.6±1.4 kg in seven MMA fighters during the week prior to competition. Since the body fat% of

the participants in the current study did not change from baseline to 1-week prior to competition, and the fact that all the participants whom provided a urine sample were dehydrated at weigh-in, weight lost during the final week was most likely water weight lost facilitated by rapid weight-loss practices Although gradual weight loss was the most commonly reported weight-making practice in the present study (88.2%), the remainder of the top ten reported weight-making methods were indeed RWL methods. Barley *et al.* (2017) and Ribas *et al.* (2017) also show that the most common weight-making practice in their studies was gradual weight loss, with a prevalence of 93% and 92%, respectively.

Rapid weight loss is defined as the reduction of a significant amount of body weight (typically 2-10% and even more) in a few days prior to weigh-in (mostly in the last two to three days), and this is achieved by a combination of methods that include starvation, severe restriction of fluid intake, and intentional sweating (G. Artioli, Saunders, Iglesias, & Franchini, 2016). In this study, 70.6% of the participants restricted their fluid ingestion. Similarly Barley *et al.* (2017), Ribas *et al.* (2017), and Matthews and Nicholas (2017) also observed a high prevalence of restricting fluid ingestion, with 76%, 100%, and 100%, respectively. These authors also reported a high prevalence of training in plastic or rubber suits that ranged from 58%- 88% (Barley *et al.*, 2017; Matthews & Nicholas, 2017; Ribas *et al.*, 2017), in line with the prevalence of training in plastic or rubber suits that was reported in the current study (58.8%). Another way these MMA fighters increase their urine output is by “water loading” – this is where fighters ingest an excessive amount of water for a few days, which causes polyuria (Reale *et al.*, 2017). Similar to the prevalence of water loading in our study (71.6%), water loading was also in the top reported weight-making practice used by MMA fighters in Barley *et al.* (2017) and Matthews and Nicholas (2017) with a prevalence of 67% and 100%, respectively. Using hot baths as a weight-making method was the third most prevalent method in the current study (82%), and higher than the reported prevalence of 72% in the study from Matthews and Nicholas (2017). In contrast, the prevalence of fasting (71% vs. 65%), skipping meals (86% vs. 71%), and increased exercise (85% vs. 59%) were higher in Matthews and Nicholas (2017)compared to the present study.

According to Reale *et al.* (2017), combat sports’ fighters are also known to increase their urinary output and lose more water weight via the use of diuretics, however, the use of diuretics was not reported in the present study. This could be due to the fact that the fighters in the present study were not comfortable reporting the use of diuretics to the researcher. Reale *et al.* (2017) also reported that fighters commonly increase perspiration by excessively exercising and/or increasing their core and skin temperature by wearing sweat suits and using a sauna. In the present study these active dehydration techniques, including increased exercise (58.8%), and passive

dehydration techniques, such as sauna use (58.8%) and wearing plastic of rubber suits (58.8%), were also commonly used.

Rapid weight-making practices, particularly those focused on fluid loss, can result in dehydration. Indeed, in the current study, 100% of the participants that provided urine samples were dehydrated, of which 57% were classified as moderately dehydrated with a USG >1.021, and 43% classified as severely dehydrated with a USG > 1.030. In the study from Matthews and Nicholas (2017) 100% of their MMA fighters were also dehydrated, of which 43% were classified as severely dehydrated. Anyżewska *et al.* (2018) also reported that a high percentage (69%) of MMA fighters in their study were dehydrated at weigh-in. Rapid weight loss methods can potentially be very dangerous and have detrimental consequences on fighters' health. Acute dehydration (6-10% water loss) resulted in the heat-related death of three wrestlers in 1997, and the death of an MMA fighter in 2013 during a sauna session after attempting to lose 20% of his body mass (approximately 15 kg) in only one week (Crighton *et al.*, 2016; Jetton *et al.*, 2013). Another serious case documented is that of a Canadian MMA fighter who required cardiopulmonary resuscitation after fainting as a result of weight-making practices (Crighton *et al.*, 2016).

Based on the Likert scale results from the weight-making practices questionnaire in the present study, the most influential persons that influence how these fighters lose weight were the MMA training colleagues (52.9%) and MMA coaches (58.8%). Dietitians were the least influential, with only 17.7% of participants scoring Dietitians as most influential person. The most influential persons in the study from Reale *et al.* (2017) were the athletes' training colleagues and coaches, with a prevalence of 50% and 70% (boxing), 53.9% and 66.1% (judo), 44.6% and 64.4% (taekwondo), 43.7% and 65.6% (wrestling) respectively. Again, dietitians had the lowest influence with only 31.4% (boxing), 22.6% (judo), 28.6% (taekwondo) and 20.6% (wrestling) (Reale *et al.*, 2018).

Knowing that fighters engaged in weight-making practices to make weight prior to competition with little influence from registered dietitians, it was interesting to see the dietary intake results from this study. Good nutrition and a healthy nutritional status are important for general health, providing fuel for training, optimising recovery, and improving sporting performance (Campbell *et al.*, 2011; Gunzer *et al.*, 2012). Therefore, it is important that MMA fighters meet their macronutrient and micronutrient recommendations.

In the current study the median energy intake at baseline was 17170 (15598-26376) KJ and tended to decrease to 13805(8016-20403) KJ (p=0.09) 1-week prior competition. This could be expected, because once fighters start to prepare for an upcoming competition they start to pay more attention to what they eat. A study done on taekwondo fighters also demonstrated that these fighters significantly reduced their mean habitual energy intake by 35% prior to competition (Fleming & Costarelli, 2007). The range for energy intake at baseline (10413-39905 KJ) and 1-week prior to competition (5587-30803 KJ) in the present study was quite large, and this could be due to the fact that the study included participants from all weight categories, ranging from flyweight (<57kg) to heavyweight (>93-120kg).

In the present study it is evident that CHO intake both at baseline [5.1 (4.0-7.3) g/kg] and 1-week prior to competition [3.5 (2.5-7.8) g/kg], is less than the recommended 6-10g/kg body mass for athletes performing one to three hours of moderate to high-intensity exercise per day (Burke *et al.*, 2011; Thomas *et al.*, 2016). Similarly, Reljic *et al.* (2015) found that the CHO intake at baseline (3.8±1.1 g/kg) and pre-competition (2.2±0.8 g/kg) was below the recommendations. Książek *et al.* (2014) also found that the boxers in their study had an inadequate CHO intake of only 4.48±1.05 g/kg at baseline, however Andreato *et al.* (2016) found the jiu-jitsu athletes' CHO consumption was adequate, with a 6.3±2.3 g/kg intake at baseline. Although in the current study CHO at baseline was not far below the recommendation, it did decrease from baseline to 1-week prior to competition. It can be speculated that fighters may deliberately cut out certain food groups, especially CHO food groups, in order to assist in weight loss and water loss since glycogen storage lock water in as well.

From the literature we know that protein is an important macronutrient in an athletes' diet, as protein intake plays a key role in recovery and maintaining muscle mass and strength (Artioli *et al.*, 2014; Hoffman & Maresh, 2011). Muscle mass is particularly important for MMA fighters, as they require strength and power in their fights (Artioli *et al.*, 2014). Although protein intake in the MMA fighters tended to decrease from baseline [2.1 (1.8-2.6) g/kg] to 1-week prior to competition [1.9 (1.6-2.2) g/kg], both intakes fell within the recommended ranges of 1.8-2.4g/kg for combat fighters that want to stay in a positive or neutral protein balance (Artioli *et al.*, 2014). In the study from Reljic *et al.* (2015), the boxers significantly decrease their protein intake from baseline to pre-competition (1.5±0.4 g/kg to 0.8±0.4 g/kg, $p<0.05$), where both baseline and pre-completion protein intake was below the recommendations.

Reported fat intake in the present study [44.0(32.3-61.5)] was above the recommended macronutrient distribution range to promote health in the general population (i.e. >20-35% of total

energy), however a fat intake of up to 50% can be consumed by athletes during regular high volume training (Kerksick *et al.*, 2018). In the light of the low body fat percentage of the MMA fighters in the present study, one can conclude that their total energy intake, and percentage fat intake, does not exceed their energy requirements.

From above one can see that protein intake was adequate, fat intake was high and CHO intake was low. From this we may be able to speculate that fighters really concentrated on their protein intake, in order to maintain muscle mass, which may naturally be higher in fat, and then decreased CHO intake in order to aid them in losing weight.

The reported micronutrient intake at baseline in the present study was above the recommendations for the majority of micronutrients except for Vitamin D (53% of RDA) and magnesium (13% of RDA). An insufficient vitamin D intake in athletes could lead to athletes being at an increased risk for stress fractures, respiratory infections, and muscle injuries. This increase is due to the fact that vitamin D plays a major role in overall bone health, immune function support, as well as it helps with physical performance (Angeline *et al.*, 2013). However, magnesium intake increased to 531(355-820) mg (above the RDA) 1-week prior to competition. The present study demonstrated a significant decrease in calcium and zinc intake from baseline [1277 (801-1609) mg and 26 (21-34) mg for calcium and zinc, respectively] to 1-week prior to competition [826 (522-1120) mg and 20(17-25) mg for calcium and zinc, respectively]. The calcium intake was below the recommended daily allowance (RDA) of 1000mg 1-one week prior to competition. Similarly, Anyżewska *et al.* (2018) found a low median calcium intake of 719 (120-1318) mg as a result of a low consumption of dairy products during a training day. The median reported vitamin B12 intake at baseline was 10 (5-19) µg/day, and showed a tendency to decrease from baseline to 1-week prior to competition (p=0.09). Reljic *et al.* (2015) also reported a significant decrease in vitamin B12 from baseline (6.4±2.6 µg) to pre-competition (4.0±2.1 µg). Although vitamin B12 showed a tendency to decrease, it stayed above the recommendations. However possible reasons for the decrease may be due to fighters cutting out certain food groups in order to lose weight. Due to the study sample being low, it may also have been difficult to pick up differences in diet from the QFFQ.

Dietary supplementation has been seen to enhance performance and recovery (Campbell *et al.*, 2011; Petkova *et al.*, 2018). Thus, it is not uncommon for combat sports' athletes to use supplementation during and after training sessions in order to boost their training performance as well as their muscle recovery (i.e. replenishing muscle glycogen, increasing protein synthesis and reducing muscle soreness). In this study, nine (53%) of the participants reported using one or

more of the following supplements: 100% whey protein powder (47%), BCAA (35%), L-glutamine (18%), and creatine (18%). The frequency of use varied between daily for whey protein, BCAAs, L-glutamine, and creatine, to weekly (whey protein). Similarly, another study done on MMA fighters reported that 81% of the fighters used supplements, including isotonic drinks (82%), BCAA (46%), carbohydrate supplements (44%), protein supplements (32%), and creatine (20%) (Anyżewska *et al.*, 2018). Zaggelidis *et al.* (2008) also reported a high prevalence (60.9%) of supplement use among judo fighters. From these studies it is clear that whey protein, creatine and BCAA are common supplements used in combat sports. The use of these specific supplements is expected since the use of creatine and whey protein have been shown to improve muscle mass and muscle strength in power and strength athletes (Campbell *et al.* (2011).

There were a few limitations in this study, including high drop-out rates resulting in a small sample size that completed all the measurements; and dietary methodology limitations. Although a representative sample of MMA players were recruited to participate in the study, the drop-out rate in the present study was quite high and a total sample size of only 17 MMA fighters (~13% of total population sample size) completed the study. Reasons for high drop-out rate include fighters not fighting in the competitions that were scheduled during the period of data collection, injuries, and the fighter's opponents dropping out. The limitations that always accompany a QFFQ is that the participants need to recall from memory what was eaten during the past four weeks. There may have been over reporting of frequency in the food frequency questionnaire in the present study, and this was only seen after dietary analysis was done. In future this may be something to pay attention to

Although hydration status in the present study was determined by means of urine specific gravity (USG), a very recent study (Zubac *et al.*, 2018) shows that this method has high variability and is not as a diagnostic tool to determine actual body-weight loss in real life, and therefore is also not reliable in showing hydration status. As this is only one study, more research on reliable methods must be done and then those new methods should be used as a tool in future studies. Until further research has been done, USG should be continued being used.

The strengths of this study include the use of a previously validated weight-making practices questionnaires on a similar population (Judo). The quantified food frequency questionnaire was also pre-tested on MMA fighters and adjusted for this specific population (i.e. questions on supplement use was added). All measurements were done by a trained researcher with expertise in measurements (ISAK level 1 qualified). Not only was dietary data collected by a trained dietitian, but it was also analysed using updated software (STATA software version 15).

Summary and practical applications

The results of the current study conclude that the nutritional status, regarding dietary intake, is in line with the recommendations for combat sport athletes, with the exception of CHO, Vitamin D, and calcium, which were all below the recommendations. It is also concluded that the prevalence of weight-making practices, particularly rapid weight making practices resulting in dehydration, is high among professional South African mixed martial arts fighters. It has also come to light that their engagement with weight-making practices are mainly influenced by their coaches and training colleagues, and not by a registered dietitian.

I would recommend that all professional MMA fighters consult a registered dietitian when seeking to compete in a weight category lower than their baseline weight. Although fighters had a low body fat percentage and in general met their dietary intake requirements, fighters still use unsafe practices in order to lose weight and make their weight category. A dietitian could help guide these fighters and help find alternative and safer options on how to lose this weight. It is recommended that weigh-in should be moved to two to three hours prior to competition time to effectively minimise RWL practices.

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Authorship

KMB and LHN conceptualised the study, KMB collected all the data, KMB analysed and interpreted the data, and wrote the first draft. LHN provided input and edited the final draft of the manuscript

Conflicts of Interest

The authors declare that there were no conflicts of interest.

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CHAPTER 4: GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATONS

4.1 Introduction

This final chapter will summarize, and conclude all main findings found in relation to the aim as well as the objectives of this mini-dissertation. The strengths and limitations are also discussed in order to provide guidance for future studies, on this scope, with some guidance. At the end of this chapter recommendations are made for future research on this scope.

4.2 Summary of main findings

The aim of this MSc study was to describe the nutritional status, including dietary intake and body composition, and weight-making practices of professional male South African mixed martial arts fighters.

The 3 objectives were:

•To determine and compare the nutritional status, including dietary intake and body composition, of professional male South African MMA fighters at baseline (6-weeks prior to competition), 1-week prior to competition and at weigh-in (24-hours prior to weigh-in).
•To determine the weight-making practices of professional male South African MMA fighters prior to weigh in.
•To determine hydration status at weigh-in (proxy for fluid loss / extend of fluid weight-making practices).

Objective 1: To determine and compare the nutritional status, including dietary intake and body composition, of professional male South African MMA fighters at baseline (6-weeks prior to competition), 1-week prior to competition and at weigh-in (24-hours prior to weigh-in).

I. Dietary intake

MMA fighters in the present study reported an adequate dietary intake of macro- and mircro-nutrients, with exception of CHO, Vitamin D, calcium (1-week prior to competition) and magnesium (at baseline) which were below the recommendations. Both calcium and zinc significantly decreased from baseline to 1-week prior to competition ($p=0.05$).

II. Body composition

The fighters in this study could be classified as overweight (>24.9kg/m^2) with a low median body fat % of 7.6 (5.53-9.6) % at baseline. The higher BMI in MMA athletes was thus not as a result of a high body fat%, but probably due to a high muscle mass. Based on the significant weight loss not only from baseline to weigh-in (80.4 [73.3-86.5] kg to 70.4 [66.8- 106.6], $p<0.05$), but also between 1-week prior to competition to weigh-in (76.9 [71.8- 81.2] kg to 70.4 [66.8- 106.6], $p<0.05$), the fighters entered a weight category lower than their baseline/habitual weight. Weight loss from baseline to weigh-in was 7.9 (4.7-12.9) kg.

Objective 2: To determine the weight-making practices of professional male South African MMA fighters prior to weigh in.

All (100%) of the MMA fighters in this study reported the use of one or more weight-making practices in order to make weight for their fight. Gradual weight loss was the most common weight-making practice reported in this study, with a prevalence of 88%, followed by hot baths (82%), water loading (71%), increasing exercise more than usual (59%) and training in rubber or plastic suits (59%). Seventy one percent (71%) of the MMA fighters restricted fluid intake in order to lose weight. The high prevalence of engaging in weigh-making practices was in line reported weight making practices from MMA fighters in other studies. From literature we know that RWL techniques can be harmful to fighter's health, and that is why it should be recommend that South Africa adopt the same rules used in UFC overseas.

Objective 3: To determine hydration status at weigh-in (proxy for fluid loss weight-making practices).

Only a sub-sample of fighters in the present study provided a urine sample and all of them was characterised as being dehydrated, highlighting the fact that fighters not only use rapid weight making practices focusing on fluid weight loss, to lose weight, but that they are successfully losing water weight prior to weigh-in Of concern is perhaps the high percentage of fighters that were classified as severely dehydrated (43%) with a USG > 1.030. Although these fighters have 24-hours to rehydrate and recover before the fight, severe dehydration can potentially be dangerous and it is not ideal for these fighters to reach their target weight by engaging in dangerous weight making practices. This study has also demonstrated that MMA players are influenced by the coaches and fellow athletes when it comes to making weight. Since MMA is a rapidly growing sport amongst youngster as well, the use of rapid weight making practices resulting in severe dehydration is a great concern.

4.3 Conclusion

The MMA fighters in the present study had a borderline high BMI but a healthy body fat percentage. Their dietary intake was in line with the macronutrient recommendations for athletes for protein, fat and the majority of micronutrients, however, CHO intake as well as vitamin D and calcium were below the recommended amounts. It is clear that MMA fighters in the present study are engaging in weight-making practices, particularly rapid weight loss practices that involve fluid loss and/or fluid restriction and that their influence on how to make weight mainly come from their coaches and training colleagues, and not from a registered dietitian. Although the MMA fighters lost a significant amount of weight from baseline to 1-week prior to weigh-in, they continued losing weight during the few days leading up to weigh-in 24-hours prior to competition. Based on the fact that all the MMA fighters who provided a urine sample at weigh-in were moderately to severely dehydrated, the weight lost during the few days prior to weigh-in was presumably water weight as a result of rapid weight loss practices. Due to fighters using RWL techniques, that could harm their health and performance, it should be recommended that the rule changes made by the California State Athletic Commission (CSAC) for Ultimate Fighting Championships (American based) that only allow a maximum of 8% weight difference between a week prior to weigh-in and weigh-in, should be implemented in Extreme Fighting Championships (in South Africa) as well to encourage fighters to enter realistic weight categories and limit the use of extreme weight making practices resulting in dehydration prior to weigh-in.

4.4 Limitations and strengths

There were a few limitations in this study, including high drop-out rates resulting in a small sample size that completed all the measurements, dietary methodology limitations; and hydration status test limitations.

1. Sample size and recruitment limitations

   Although a representative sample of MMA players were recruited to participate in the study, the drop-out rates were quite high and we ended up with a total sample size of only 17 (~13% of total sample population). Reasons for high drop-out rates include fighters not fighting in the competitions that were scheduled during the period of data collection, injuries and the fighter's opponents dropping out. EFC was not always able to announce the fight card 6 weeks in advance, as they had to find and match fighters for fights. This made it difficult because it was not possible to use fighters that only found out about their fights at a later stage, and because of this I lost out on a few competitors to enrol.

2. Dietary methodology limitations

The limitations that always accompany a QFFQ is that the participants need to recall from memory what was eaten for the past four weeks. There may have been over reporting of frequency in the food frequency questionnaire in the present study, and this was only seen after dietary analysis was done. In future the inclusion of a 24-hour recall and/or 3-day dietary record may provide valuable information in terms of the fighters' dietary intake – with specific reference to quantity and potentially frequency of intake. One example of potential over-reporting of frequency was the consumption of starches – e.g. rice, maize meal and potato that were eaten daily. Although the quantity of each starch may be realistic considering the study population did include a number of heavy fighters training up to 4-hours per day, they may not have consumed all three starches on a daily basis.

A 3-day dietary recall was actually handed out to the fighters' 1-week prior to competition to complete during the 3-days prior to competition. This data was not supposed to provide input into the fighters' habitual intake, since they are likely to 'make-weight' prior to weigh-in, but we were hoping to learn more from their actual dietary-related practices before weigh-in (24-hours prior to competition), but also during the 24-hours of recovery prior to competition. Fighters were reminded on the days they needed to fill in their diets to do so, and I expected the 3-day dietary recall back within 1 week of competing. However, I was unable to retrieve the 3-day dietary records, as fighters did not respond to my messages or phone calls, and some said they simply forgot to fill it in or did not have time due to focusing on the fights. This was something out of my control. Again, the use of 24-h dietary recalls may be an option where the researcher interview the participant and they do not have to complete the records at home. When there is only one opportunity to do a 24-hour recall, it can be used as long as one ensures that "days of diet monitoring accurately reflect usual food consumption during the period of interest" (Magkos & Yannakoulia, 2003).

Finally, according to a systematic review performed by Capling *et al.* (2017), there are limited full-bodied studies that evaluate dietary assessment methods in athletes. Capling *et al.* (2017) says that existing literature exhibits extensive variability between methods and there is a clear need for careful validation of dietary assessment methods for athlete populations.

3. Hydration

Although hydration status was tested via USG in the present study- new literature shows that this method has high variability and is not as a diagnostic tool to determine actual body-weight loss in

real life. More research on reliable methods must done and then those new methods should be used as a tool in future studies.

Strengths

The strengths of this study include the use of a previously validated weight-making practices questionnaires on a similar population (Judo). The quantified food frequency questionnaire was also piloted on MMA fighters in order to adapt the questionnaire for this specific population (i.e questions on supplement use was added). All measurements were done by a trained researcher with expertise in measurements (ISAK level 1 qualified). Not only was dietary data collected by a trained dietitian, but it was also analysed using updated software (STATA software version 15).

4.5 Recommendations and suggestions for future research and practice

It should firstly be recommended that all professional MMA fighters should see a registered dietitian to help lose weight correctly and in a reasonable amount of time. Secondly, it would be recommended that the new rules put in place and being used at UFC should be applied at other MMA competitions such as EFC. Furthermore, I would recommend that rapid weight loss methods should be banned and that weigh-in should be moved to 2-3 hours prior to competition to really minimise the chance of these practices. Fighters should only be allowed to weigh-in once and should pass a hydration test. Fighters should not be allowed to enter into a weight category that will lead to more than 1.5% of body mass reduction per week.

If/when a similar study is done, fighters in the heavy weight category should be excluded as this may skew results when looking at mean dietary intake and well amount of weight lost. The fighters in this category are also less likely to use RWL methods as they are in the heaviest weight category.

Researchers should keep up to date with the newest and most researched dietary methodology to assess true dietary intake and evaluate nutritional status.

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ANNEXURE A: INFORMED CONSENT FORM

Private Bag X1290, Potchefstroom
South Africa 2520

Tel: +2718 299-1111/2222
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Web: http://www.nwu.ac.za

HREC Stamp

INFORMED CONSENT DOCUMENTATION FOR professional male South African mixed martial arts fighters.

TITLE OF THE RESEARCH STUDY: Nutritional status and weight making practices of professional male South African mixed martial arts fighters

ETHICS REFERENCE NUMBERS: NWU-00120-17-S1

PRINCIPAL INVESTIGATOR: Prof. Lize Havemann-Nel

POST GRADUATE STUDENT: Ms. K.M. Bengis

ADDRESS: 11 Hoffman Street, North-West University (Building G16, room 146),

Potchefstroom, 2531

CONTACT NUMBER: 018 299 2399 / 084 3388221

You are being invited to take part in a **research study** that forms part of a Masters study. Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or person explaining the research to you any questions about any part of this study that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you might be involved. Also, your participation is **entirely voluntary** and you are free to say no to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part now.

This study has been approved by the Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (NWU-00120-17-S1) and will be conducted according to the ethical guidelines and principles of Ethics in Health Research: Principles, Processes and Structures (DoH, 2015) and other international ethical guidelines applicable to this study. It might be necessary for the research ethics committee members or other relevant people to inspect the research records.

What is this research study all about?

- We plan to
  - Record what you usually eat before and during competition season, take your body measurements (weight, height and skinfolds) and determine your hydration status.
  - Determine your weight making practices (i.e. what you do to make your fighting weight category).
- This study will take place at your gym in a private room and will be done by experienced health researchers trained in administering questionnaires (dietary questionnaire and weight making practices questionnaire) and taking body measurements (ISAK qualified). Approximately 50 participants will be included in this study.

Why have you been invited to participate?

- You have been invited to be part of this research because you are considered to be a professional male South African mixed martial arts fighter, which means you have probably won 70% or more of a recommended 15 amateur fights, and you have passed a theoretical and practical examination. You have also been selected as you are between 18 and 40 years old.
- You will unfortunately not be able to take part in this research if you do not meet the inclusion criteria.

What will be expected of you?

You will be expected to:

- Complete a written informed consent form which will be explained to you by the researcher. You will have the opportunity to read through the informed consent form again at home and return the signed consent form to a person independent from the study (e.g. the admin person at your gym). This process will take approximately 15 minutes of your time.
- After the informed consent, you will be asked to participate in 3 different days / contact sessions of data collection.
- Data collection contact session 1: 6-10 weeks pre-competition you will be asked to fill in a validated dietary questionnaire (a quantified food frequency questionnaire [QFFQ]). You will also be weighed, your height will be measured and 6 skinfolds will be taken to work out your body fat percentage. This process will take approximately 75-90 minutes of your time.

- Data collection contact session 2: 5-7 days pre-competition you will be asked to complete another dietary questionnaire (QFFQ), as well as a weight making practices questionnaire. Your weight and skinfolds will be taken again and the researcher will explain a 3-day dietary record to you that you need to complete at home during the 3-days before the competition. This process will take approximately 90-120 minutes of your time.
- Data collection contact session 3: 24-hours pre-competition your weight will be recorded at the official weigh in and you will be asked to provide a urine sample in a sterile cup that will be used to determine your hydration status. The urine sample is voluntary. This process will take approximately 5-10 minutes of your time.

Will you gain anything from taking part in this research?

- The direct benefits for you if you take part in this study will be receiving feedback regarding your weight, height and body fat percentage immediately. You will also receive feedback regarding your hydration status as well as your dietary intake once the data has been analysed. Individual dietary feedback will be emailed to you.

- The indirect benefits of this study include the following: Identifying nutritional status problems, bad habits and unhealthy weight making practices. This will enable the MMA South Africa, coaches and other health professionals such as Dietitians working with these athletes to address specific problems and hopefully make a positive change in the MMA community.

Are there risks involved in you taking part in this research and what will be done to prevent them?

- The risks to you in this study are minimal but do include possible discomfort during the body measurements. However, measuring weight and height are standard procedures in research studies and as a MMA fighter, you are particularly well acquainted with these procedures since monitoring your weight is part of the sport. To minimize any discomfort, body measures will be performed privately in an enclosed space at your respective MMA club, where you are required only to remove your shoes and heavy clothing or accessories. You will also be measured individually which will ensure even further privacy and comfort.
- The QFFQ and weight making practices questionnaire will be administered in a room at your MMA club where you can be comfortably seated with enough space to complete the questionnaires. If you get tired, you will be allowed to take a short break. The 3-day dietary recall will be handed to you to complete in the comfort of your own home. The questionnaires will be in English, but on request an Afrikaans questionnaire could be provided to accommodate all participants.
- You may also experience possible discomfort providing a urine sample, especially since you are competing at national level. However we assure you that the urine sample will purely be used to determine hydration status and that no other metabolites will be measured in the urine. It will be entirely voluntary to provide a urine sample and you can refrain from giving one without prejudice against you.

- There are more gains for you in joining this study than there are risks.

How will we protect your confidentiality and who will see your findings?

- Privacy of the participants during data collection will be ensured by using enclosed rooms at the clubs and/or competition venues. The completion of the research questionnaires, anthropometric measurements and urine collection will be performed in these dedicated, private rooms under the supervision of only the researcher or student researcher. Your privacy will be respected by any and all researchers involve. Your results will be kept confidential by providing each participant with a unique participant number. This unique number is used in all stages of data collection. Furthermore, they will not be required to provide their personal information to any other researcher or fieldworker other than the fieldworker at registration/enrolment. All of the data captured will be done by using the unique participant numbers. Only the researchers and study supervisor will be able to look at your findings. Findings will be kept safe by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. Data will be stored for 7 years.

What will happen with the findings or samples?

- The findings of this study will only be used for this study and shared with the participants in the study. The data will also be used in scientific articles and presentations. A mini-dissertation on this topic will be written for the purpose of obtaining an MSc Dietetics degree. The mini-dissertation will be published on the North-West University (NWU) (Potchefstroom Campus) website and thus in the public domain. Results of the study will also be presented to the respective MMA clubs after completion of the study (December 2018).
- All questionnaires and dietary recalls will be locked up in a secure store room for 7 years.
- Urine samples will be discarded appropriately after hydration analysis is done, again assuring you no other tests will be done on the urine sample.

How will you know about the results of this research?

- We will email you the results of this research following analysis. The results that can be given on the day of measurement (weight, height, body fat% and hydration status) will be communicated to you on the day.

Will you be paid to take part in this study and are there any costs for you?

- This study is funded by NRF incentive funding.
- No, you will not be paid to take part in the study, because you will have no travel expenses and do not need to be refunded for traveling. There will thus be no costs involved for you, if you do take part in this study.

You will however receive a free protein shaker bottle on the completion of the study.

Is there anything else that you should know or do?

- You can contact Ms. K.M. Bengis at 083 262 7005 if you have any further questions or have any problems.
- You can also contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 1206 or carolien.vanzyl@nwu.ac.za if you have any concerns that were not answered about the research or if you have complaints about the research.
- You will receive a copy of this information and consent form for your own purposes.

Declaration by participant

By signing below, I ……..…….. agree to take part in the research study titled: **Nutritional status and weight making practices of professional male South African mixed martial arts fighters.**

I declare that:

- I have read this information/it was explained to me by a trusted person in a language with which I am fluent and comfortable.
- The research was clearly explained to me.

- I have had a chance to ask questions to both the person getting the consent from me, as well as the researcher and all my questions have been answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be handled in a negative way if I do so.
- I may be asked to leave the study before it has finished, if the researcher feels it is in the best interest, or if I do not follow the study plan, as agreed to.

Signed at (*place*) .....…..……. on (*date*) ……...…….. 20....

....

Signature of participant Signature of witness

Declaration by person obtaining consent

I *(name)* ……..…… declare that:

- I clearly and in detail explained the information in this document to

  ……

- I did/did not use an interpreter.
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I gave him/her time to discuss it with others if he/she wished to do so.

Signed at (*place*) .....…..……. on (*date*) ……...…….. 20....

.....

Signature of person obtaining consent

Declaration by researcher

I *(name)* ……..…… declare that:

- I explained the information in this document to …….. **or** I had it explained by …… who I trained for this purpose.
- I did/did not use an interpreter
- I encouraged him/her to ask questions and took adequate time to answer them

  or I was available should he/she want to ask any further questions.
- The informed consent was obtained by an independent person.
- I am satisfied that he/she adequately understands all aspects of the research, as described above.
- I am satisfied that he/she had time to discuss it with others if he/she wished to do so.

Signed at (*place*) .....…..……. on (*date*) ……...…….. 20....

.....

Signature of researcher

ANEXTURE B: DATA COLLECTION SHEET VISIT 1

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YUNIBESITI YA BOKONE-BOPHIRIMA

MMA STUDY

Visit 1_Date:_____
Participant number:_____ DOB:_____

Measurements (Fieldworker:_____)

Measure	1st	2nd	Mean
Body mass (kg)			
Stretch stature (m)			
Triceps sf			
Subscapular sf			
Biceps sf			
Iliac Crest sf			
Supraspinale sf			
Abdominal sf			
Front Thigh sf			
Medial Calf sf			
Arm girth relaxed			
Arm girth flexed and tensed			
Waist girth (min.)			
Gluteal girth (max.)			
Calf girth (max.)			

BMI:_____

Body fat%:_____

ANEXTURE C: DATA COLLECTION SHEET VISIT 2

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YUNIBESITI YA BOKONE-BOPHIRIMA

MMA STUDY

Visit 2_Date:_____
Participant number:_____ DOB:_____

Measurements (Fieldworker:_____)

Measure	1st	2nd	Mean
Body mass (kg)			
Stretch stature (m)			
Triceps sf			
Subscapular sf			
Biceps sf			
Iliac Crest sf			
Supraspinale sf			
Abdominal sf			
Front Thigh sf			
Medial Calf sf			
Arm girth relaxed			
Arm girth flexed and tensed			
Waist girth (min.)			
Gluteal girth (max.)			
Calf girth (max.)			

BMI:_____

Body fat%:_____

ANEXTURE D: DATA COLLECTION SHEET VISIT 3

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YUNIBESITI YA BOKONE-BOPHIRIMA

MMA STUDY

Visit 3_Date:_____

Participant number:_____ DOB:_____

Measurements (Fieldworker:_____)

Weight (announced at weigh in):_____kg

USG:_____

USG:_____

ANNEXURE E: WEIGHT-MAKING PRACTICES QUESTIONNAIRE

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YUNIBESITI YA BOKONE-BOPHIRIMA

MMA STUDY

Questionnaire about pre-competition weight making practices

Participant number:_____ Date: _____

Answer the questions with as much attention and seriousness as possible.

General Information:

Age: _____ years.

At what age did you begin to practice mixed martial arts (MMA)? _____ years.

At what age did you begin to compete in MMA competitions? _____ years.

How much do you weigh? _____kg.

How tall are you? _____m.

Please describe your achievements and participation in MMA competitions to date:

Wins	
Losses	
Draws	
Title fights	

How many times did you compete in the last year (including non-official competitions)?_____

How many competitions did you win in the last year? _____

Weight history and diet patterns:

In which weight category do you compete?

Fly weight	Bantam weight	Feather weight	Light weight	Welter weight	Middle weight	Light-heavy	Heavy weight

Did you change your weight category in the last 2 years?

( ) yes - in which category did you compete? _____

( ) No - I competed in the same weight category in the last 2 years.

How much did you weigh in the last MMA “off season” (specify the year)? _____kg (year)

Have you ever lost weight in order to compete?

( ) yes - please continue to answer the rest of the questionnaire

( ) No - I have never cut weight (thank you for your help- do not need to answer he following questions.

What is the MOST WEIGHT that you have cut to compete in your career? _____kg.

How many times did you cut weight to compete last season? _____times (year).

How much weight do you <u>usually</u> cut before competitions? _____kg.

In how many days do you <u>usually</u> cut weight before competitions? _____days

At what age did you begin to cut weight for competitions? _____ years old

How much weight do you usually regain in the week following a competition? _____kg

Using the scale below, please rate the amount of influence that each individual listed below has had on your weight loss practices (i.e.: who encourages and taught you to lose weight) (check all items)

1= none influential, 2= little influence, 3= unsure, 4= some influence, 5= very influential

Another MMA/training colleague	1	2	3	4	5
MMA coach/ trainer	1	2	3	4	5
Physician/doctor	1	2	3	4	5
Parents	1	2	3	4	5
Dietitian	1	2	3	4	5
Physical trainer	1	2	3	4	5
Other (explain)	1	2	3	4	5

The table below represents several methods to lose weight rapidly. Using the table below, how often did you use each one of the following methods to lose weight before a competition? (check all items)

Gradual weight loss (lose weight in 2 weeks or more)	Always	Sometimes	Almost never	Never used	I don't use anymore
Skipping 1 or 2 meals	Always	Sometimes	Almost never	Never used	I don't use anymore
Fasting (not eating all day)	Always	Sometimes	Almost never	Never used	I don't use anymore
Restricting fluid ingestion	Always	Sometimes	Almost never	Never used	I don't use anymore
Increased exercise (more than normal)	Always	Sometimes	Almost never	Never used	I don't use anymore
Training intentionally in heated training rooms	Always	Sometimes	Almost never	Never used	I don't use anymore
Saunas	Always	Sometimes	Almost never	Never used	I don't use anymore

Training with rubber/ plastic suits	Always	Sometimes	Almost never	Never used	I don't use anymore
Use winter or plastic suits during the whole day/or night (without exercising)	Always	Sometimes	Almost never	Never used	I don't use anymore
Spitting	Always	Sometimes	Almost never	Never used	I don't use anymore
Laxatives	Always	Sometimes	Almost never	Never used	I don't use anymore
Diuretics	Always	Sometimes	Almost never	Never used	I don't use anymore
Diet pills	Always	Sometimes	Almost never	Never used	I don't use anymore
Vomiting	Always	Sometimes	Almost never	Never used	I don't use anymore
Salt baths	Always	Sometimes	Almost never	Never used	I don't use anymore
Water loading	Always	Sometimes	Almost never	Never used	I don't use anymore

The North-West University of Potchefstroom thanks you for your participation

ANNEXURE F: QUANTIFIED FOOD FREQUENCY QUESTIONNAIRE

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MMA STUDY

Quantitative Food Frequency Questionnaire

Name of fieldworker: _____

Participant number Phase

2	0	1					

Today's date: Day of the week:

Please think carefully about the food and drink you have consumed during the PAST MONTH (four weeks).

We have divided the foods into different groups for example all the porridges and cereals together. I will go through a list of food groups and drinks with you and I would like you to tell me:

Which foods you eat in each of the different food groups

How the food is prepared

How much of the food you eat at a time

How many times a day you eat it and if you do not eat it everyday, how many times a week or a month you eat it.

To help you to describe the amount of a food you eat, I will show you pictures of different amounts of the food as well as other food models, containers, etc.

There are no right or wrong answers.

Everything you tell me is confidential. Only your subject number appears on the form.

Is there anything you want to ask now?

Are you willing to go on with the questions?

QUANTIFIED FOOD FREQUENCY QUESTIONNAIRE

INSTRUCTIONS: Circle the subject's answer. Fill in the amount and times eaten in the appropriate columns.

I shall now ask you about the type and the amount of food you have been eating in the LAST MONTH. Please tell if you eat the food, how much you eat and how often you eat it. We shall start with maize meal porridge.

In the last four weeks, did you eat…?

If yes, in the last four weeks, how often did you eat the food?

MAIZE MEAL, COOKED PORRIDGES AND BREAKFAST CEREALS

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Maize-meal porridge	Stiff (pap)						4401	
	Soft porridge (slappap)						4400	
	Crumbly (phutu)						4402	
Sour porridge (Tini)	Maize meal						9829	
	Mabella						9827	
	Other:							
Mabella	Stiff						3437	
	Soft							
Oats							3239	
Tastee wheat	Soft						3240	
Other cooked porridge	Type							
Morvite	Soft						9804	
	All bran flakes						3242	

Breakfast cereals	Corn flakes plain						3243	
	Weetbix						3244	
	Rice crispies plain						3252	
	Other:							

Do you pour milk on your maize meal (e.g. stiff, phutu soft porridge), cooked porridge or cereal?

Ye 1 No 2

If yes, what type of milk (whole fresh, sour, 1%, fat free, milk blend, etc) _____

If no, go directly to the “sugar” section.

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
If yes, how much milk	Whole milk/full cream milk/ fresh cow’s milk						2718	
	Maas/sour milk						2787	
	Low fat / 2% milk						2772	
	Fat free / skim milk						2775	
	Other							

Do you put sugar on your porridge or cereal? 1 Ye Ye No No

If no, go directly to the next question “do you put anything else in your porridge?”.

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
If yes, how much sugar WHITE or BROWN	Cooked porridge						3989	
	Cereal						3989	
	Other porridge / cereal						3989	
	Other							

Do you put anything else in your porridge? 1 2

If yes, what? _____ How much? _____

OTHER STARCH

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Samp	Bought Self ground						3250	
Samp and beans	Give ratio of samp:beans						3402 (1:1)	
Samp and other (e.g. peanuts)	Give ratio of samp:other Specify other:						3250 (samp)	
Rice	White						3247	
	Brown						3315	
	Maize Rice						3250	
	Any fat added?							
Pasta	Macaroni, plain						3262	
	Spaghetti, plain						3262	
	Spaghetti, canned in tomato sauce						3258	
	Macaroni & cheese Cheese: Milk: Fat:							
	Other specify							
Pizza	Home made: Specify topping						3353 (base+ch +tom+oliv)	

	Bought: Specify topping						3353 (base+ch +tom+oliv)	

You are being very helpful. Can I now ask you about meat?

CHICKEN, MEAT, FISH

How many times do you eat meat (beef, mutton, pork, chicken, fish) per week? _____

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Chicken	Meat & skin, boiled						2926	
	Meat without skin, boiled						2963	
	Meat & skin, roasted/ grilled						2925	
	Meat without skin, roasted/ grilled						2950	
	Kentucky / Chicken Licken (Fried in batter/crumbs)						3018	
	Nando's						2925	
	Other							
Chicken stew	With potato and onion WITH skin						9813	
	With tomato and onion WITH skin						2985	
	With vegetables WITH skin						3005	

	With tomato and onion NO skin						4379	
	With vegetables NO skin						4378	
Chicken BONE stew	With potato, onion and tomato						9814	
	Other							
Chicken feet	Nothing added						2997	
	Stew with potato, onion and tomato						9815	
Chicken head							2999	
Chicken offal	Stew with tomato and onion and sunflower oil						9816	
	Liver, cooked						2970	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/day	Weekly Times/ week	Monthly Times/ month	No		
RED MEAT	How do you like your meat? With fat OR Fat trimmed							
Red meat BEEF	BRISKET, boiled/fried without added fat						4363	
	BRISKET, fried in added fat Type of fat:						4363	
	Beef, stewed with cabbage						3006	
	Beef, stewed with potato, onion and tomato						9817	
	Beef, stewed with vegetables						3020	
	Mince (lean/ topside), nothing added						2921	
	Mince (regular), nothing added						4363	
	Mince, tomato & onion added						2987	
	Beef BONE stew with potato and onion and oil						9819	
	Other							
MUTTON	Meat, with fat, cooked						2947	
	Mutton, no fat, cooked						3036	

	Mutton, chop, grilled						2927	
	Mutton, stewed with vegetables						2916	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Beef/mutton Offal	Offal, cooked						3003	
	Stewed with vegetables							
	Liver, beef, fried/cooked						2920	
	Liver, sheep, fried/cooked						2955	
	Kidney, beef, cooked						2923	
	Kidney, sheep, cooked						2956	
	Brain, sheep, cooked						2952	
	Lung, beef, cooked						3019	
	Lung, sheep, cooked						4337	
	“Gemaldes” (lung & fat)						4409	
	Heart, beef, cooked						2968	
	Heart, sheep, cooked						2969	
	Other							
Goat meat	Grilled/roasted/cooked						4281	

	Stewed with vegetables							
	Other							
Venison/ Wild buck							2913	
Horse/Donkey							9807	
Rabbit							4327	
Other type of meat	Specify							
What type of vegetables is usually put into meat stews?								

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Wors / Sausage	Beef & pork, boerewors						2931	
Bacon							2906	
Patties	Beef, fried						2984	
	Chicken, fried						3011	
Cold meats AND Processed meats	Polony						2919	
	Ham						2967	
	Vienna						2936	
	Frankfurter, beef & pork						2937	
	Frankfurter/Sausage, chicken						3012	
	Russian/Salami						2948	
	Other							
Canned meat	Bully beef, plain						2940	
	Bully beef with potato & onion & oil						2994	
	Other							
Meat pie	Beef						2939	
	Steak and kidney						2957	

BOUGHT Or HOMEMADE	Sausage roll						2939	
	Cornish						2953	
	Chicken						2954	
	Other							
Hamburger	Bought						9818	
	Other							
Biltong	Beef (with fat OR without fat)						3021	
Dried wors Dried sausage	Beef						2949	

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Dried beans	Baked beans in tomato sauce						3176	
	Bean salad / Sousbone						3174	
	Soup with dried beans, beef and vegetables						3145	
	Sugar beans, cooked						3205	
	Other							
Lentils	Whole, cooked						3203	
	Lentil soup with beef and vegetables						3153	
Soya products eg. Imana, Knorr, Jileleke, Toppers	Cooked						3196	
	Soup/Gravy made with soya products						9831	
	Stewed with extra potato, onion and tomato						9830	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Pilchards in tomato sauce or chilli or brine	Whole						3102	
	Mashed with fried onion						3102 (70%) 3730 (30%)	
	With tomato and onion						9820	
	Other							
Fish	Hake, fried with batter/crumbs in sunflower oil						3072	
	Hake, fried in sunflower oil						3060	
	Hake, steamed						4373	
	Moddervis / Yellow fish* fried in oil						3084	
	Moddervis / Yellow fish baked with onion (NO oil added)						3089	
	Other							

Other canned fish	Tuna in oil						3056	
	Sardines in oil						3104	
	Sardines in tomato sauce						3087	
	Other							
Fish cakes	Bought: Fried						3080	
	Home made with potato, fried in sunflower oil						3098	
Fish fingers	Bought (baked)						3081	
Eggs	Boiled/poached						2867	
	Scrambled (full cream milk & brick margarine)						2890	
	Scrambled (NO milk, ONLY oil added)						2869	
	Scrambled (NO oil, ONLY full cream milk)						2872	
	Fried in oil						2869	
	Fried in brick margarine						2877	
	Other							

Moddervis/ yellow fish is a more fatty fish than hake.

VEGETABLES

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Cabbage	How do you cook cabbage?							
	Boiled, nothing added						3756	
	Boiled with potato and onion and sunflower oil						3815	
	Boiled with potato and onion and brick margarine						3813	
	Fried in oil						3812	
	Fried in brick margarine						3810	
	Boiled with potato, onion and tomato and oil						9821	
	Raw with nothing added						3704	
	Other							
Spinach or morogo or beetroot leaves or other green leafy	How do you cook spinach?							
	Boiled, nothing added						3913	
	Boiled with oil added							
	Boiled with brick margarine added						3898	
	Boiled with tub margarine added						3899	

	Boiled with potato, onion and tomato and oil						9822	
	Other							
Tomato and onion gravy	With oil						9823	
	Without fat, without sugar						3925	
	Canned						4192	
	Thickened with packet soup powder						9832	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Pumpkin (yellow) Butternut Hubbard squash Table Queen Etc	Boiled, nothing added						4164	
	Boiled with sugar only (NO fat)						3728	
	Boiled with brick margarine & sugar						3893	
	Boiled with tub margarine and sugar						9833	
	Boiled with oil and sugar						9828	
	Other							
Carrots	Boiled, nothing added						3757	
	Boiled with oil added							
	Boiled with brick margarine added						3816	
	Boiled with tub margarine added						3817	
	Boiled with sugar only						3818	
	Boiled with oil and sugar							
	Boiled with brick margarine and sugar						3819	
	Boiled with tub margarine and sugar						3820	
	Boiled with potato, onion and sunflower oil						3824	

	Boiled with potato, onion and brick margarine						3822	
	Boiled with potato, onion and tub margarine							
	Chakalaka						9812	
	Raw, nothing added						3709	
	Other							
Mealies/ Sweet corn	On cob – fat added Fat:						3725	
	On cob – no fat added						3725	
	Creamed sweet corn / canned						3726	
	Whole kernel/canned						3942	
	Whole kernel, frozen, boiled						4132	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Beetroot	Salad						3699	
	Boiled, nothing added						3698	
How do you cook potatoes?								
Potatoes	Boiled/baked with skin						4155	
	Boiled/baked without skin						3737	
	Boiled with sunflower oil added						3873	
	Boiled with brick margarine added						3867	
	Boiled with tub margarine added						3868	
	Mashed with whole milk and brick margarine						3876	
	Mashed with whole milk and oil							
	Roasted in beef fat						3878	
	Roasted in sunflower oil						3979	
	French fries (chips) / Fried potatoes						3740	
	Other							
Sweet potatoes	How do you cook sweet potatoes?							
	Boiled/baked with skin						3748	

	Boiled/baked without skin						3903	
	Boiled with sugar and oil added						9834	
	Boiled with sugar and brick margarine added						3749	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Broccoli	Boiled						3701	
	Raw						3702	
Cauliflower	Boiled						3716	
Green beans	Boiled, nothing added						3696	
	Cooked with potato, onion and sunflower oil						3794	
	Cooked with potato, onion and brick margarine						3792	
	Other							
Mixed vegetables	Canned						4264	
	Frozen, boiled (carrot, corn, peas, green beans)						3727	
	Frozen, boiled (carrot, cauliflower, green beans)						4265	
	Other							
Salad vegetables	Mixed salad: tomato, lettuce and cucumber (no dressing)						3921	
	Raw tomato						3750	

	Cucumber, raw						4119	
	Coleslaw (cabbage) (mayonnaise)						3705	
	Coleslaw (cabbage) (commercial)						3707	
	Potato salad (mayonnaise)						3928	
	Baked bean salad						9824	
	Other salad vegetables							
Mayonnaise / salad dressing	Mayonnaise						3488	
	Vinegar, oil						3487	
	Low oil salad dressing						3505	
	Salad cream						3489	
	Other: Specify							
Other vegetables (specify prep)								

Now we come to fruit

FRUIT

Do you like fruit? Ye No

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Apples							3592	
Banana							3540	
Pears							3582	
Oranges							3560	
Naartjie							3558	
Grapes							3550	
Peaches	Fresh						3565	
	Canned						3567	
Apricots	Fresh						3534	
	Canned						3535	
Mangoes							3556	
Guavas	Fresh						3551	
	Canned						3553	
Watermelon	Fresh						3576	

Fruit salad	Fresh						3588	
	Canned						3580	
Fig (Vye)							3544	
Avocado							3656	
Wild fruit/berries	Specify type							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Dried fruit	Apple, dried, raw						3600	
	Peach, dried, raw						3568	
	Mixed fruit, dried, raw						3593	
	Mixed fruit, dried and cooked with sugar						3590	
	Fruit roll, dried (all types)						3655	
	Other							
Other fruit	_____ _____							

Let me ask you about Custard.								
FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Custard	Homemade, full cream milk or fresh cow's milk						2716	
	Homemade, lowfat milk						2779	
	Homemade, skim milk						2717	
	Commercial eg Ultramel						2716	
	Other							
Custard with other food (e.g. with jelly, fruit salad, baked pudding)								

BREAD AND BREAD SPREADS

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Bread / Bread rolls	White						3210	
	Brown						3211	
	Whole wheat						3212	
Do you spread anything on the bread?			1 Always		2 Sometimes		3 Never	
Margarine	What brand do you have at home now?							
	Tub, regular						3496	
	Tub, medium fat						9806	
	Tub, light/low fat						3524	
	Brick, regular						3484	
	Brick, medium fat						9805	
	Brick, lite/low fat						3528	
	Other							
Peanut butter							3485	
Jam/syrup/ honey							3985	
Marmite / Fray bentos / Oxo							4058	

Fish/meat paste							3109	
Cheese	Cheddar						2722	
	Gouda						2723	
	Other							
Sandwich spread							3522	
Achaar							3117	
Other spreads	Specify							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Dumpling	White flour						9835	
	Whole wheat flour						3212	
Vetkoek	White flour						3257	
	Whole wheat flour						3324	
Provita, crackers, etc	Provita						3235	
	Cream crackers						3230	
	Other savoury biscuits like Bacon kips, wheat crackers, etc						3331	

DRINKS

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Tea	English (normal)						4038	
	Rooibos						4054	
Coffee							4037	
White sugar	Tea						3989	
	Coffee						3989	
Brown sugar	Tea						4005	
	Coffee						4005	
Milk per cup of TEA	Do you use milk in your TEA? If no, go to milk in coffee.	Ye	No	If YES, What type of milk do you use in TEA?				
	Fresh / long life whole/full cream						2718	
	Fresh/long life: 2%/low fat						2772	
	Fresh/long life: fat free / skim milk						2775	
	Creamer/whitener like Ellis Brown / Cremora						2751	
	Cremora Lite							
	Condensed milk						2714	
	Evaporated milk						2715	

	Other							
	None							
Milk per cup of COFFEE	Do you use milk in your COFFEE? If no, go to milk as such.	Ye	No	If YES, What type of milk do you use in COFFEE?				
	Fresh/long life: whole/full						2718	
	Fresh/long life: 2%/low fat						2772	
	Fresh/long life: fat free						2775	
	Creamer/whitener like Ellis Brown						2751	
	Cremora Lite							
	Condensed milk						2714	
	Evaporated milk						2715	
	Other							
	None							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Milk as such	What type of milk do you drink milk as such?							
	Fresh/long life: whole / full cream milk						2718	
	Fresh/long life: 2% milk / low fat milk						2772	
	Fresh/long life: fat free / skim milk						2775	
	Condensed milk						2714	
	Sour/maas						2787	
	Other							
Milk drinks	Flavoured milk						2774	
	Milo made with full cream milk						2735	
	Milo made with skim milk						2747	
	Drinking chocolate made with water						4287	
	Other							
Yoghurt	Drinking yoghurt low fat						2756	
	Plain low fat						2734	
	Low fat sweetened with fruit						2732	
Squash	Sweet O						4027	
	Six O							
	Oros/Lecol – with sugar or other						3982	
	- artificially sweetener						3990	
	KoolAid (powder mixed with water)						4027	
	Other							
Fizzy drinks Coke, fanta, etc	Sweetened						3981	
	Diet							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Fruit juice	Fresh/Liquifruit/Ceres						2866	
	Tropica (Dairy –fruit juice mix)						2791	
	Other							
Mageu/Motogo							4056	
Home brew beer							4039	
Beer							4031	
Cider	Sweet						4057	
Spirits Eg Brandy, gin, vodka, whisky, cane, etc							4035	
Wine red							4033	
Wine White							4033	
Other specify								
WATER	Tap, borehole, dam, river, etc						4042	
	Bottled						4042	

SNACKS AND SWEETS

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Potato crisps							3417	
Peanuts	Raw						4285	
	Roasted						3458	
Other nuts								
Savoury snack e.g. Fritos, Doritos, Cheese curls, Niknaks							3267	
Raisins							3552	
Peanuts and raisins								
Chocolates	Milk chocolate, plain						3987	
	Kit Kat/ Tex (with wafers) etc						4024	
	Chocolate coated bars like Bar One, TV bar, etc						3997	
	Other							
Popcorn	Plain						3332	
	Sugar-coated/candied						3359	
Candies/Sweets	Sugus, gums, hard sweets, etc						4000	
Toffees / Fudge / caramels							3991	

Biscuits/cookies	Homemade, plain						3233	
	Commercial, plain						3216	
	Commercial, with filling						3217	
	Other							
Cakes	Butter cake, homemade with whole milk and brick margarine NO icing						3288	
	Chocolate cake, homemade with whole milk and brick margarine NO icing						3289	
	Icing for cake made with brick margarine						4014	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Tarts	Apple tart with a batter made with whole milk and brick margarine						3327	
	Other							
Scones	Plain made with whole milk and brick margarine						3237	
	Other							
Muffin	Bran						3407	
	Plain						3408	
	Other							
Rusks	Buttermilk, commercial						3329	
	Homemade, white						3222	
	Other							
Savouries	Sausage rolls, small						2939	
	Samoosas: Meat filling						3355	
	Samoosas: Vegetable filling						3414	
	Biscuits eg bacon kips						3331	
	Other							

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Jelly	Jelly						3983	
	Custard added made with whole milk	Yes/No					2716	
	Other							
Baked pudding	Baked in a syrup						3312	
	Baked without a syrup						3429	
	Custard added made with whole milk	Yes/No					2716	
	Other							
Instant pudding	Made with whole milk						3266	
	Made with low fat milk						3395	
	Other							
Ice cream	Regular						3483	
	Soft serve						3518	
	Other							
Sorbet							3491	
Other specify								

SAUCES, GRAVIES AND CONDIMENTS

FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
Tomato sauce							3139	
Worcester sauce							4309	
Chutney							3168	
Pickles							3866	
White sauce	Made with whole milk and brick margarine						3142	
Packet soups	Dry powder (all types)						3158	
	Made with water (all types)						3165	
Gravy	Made from meat and thickened						3120	
Other								

WILD FRUITS, WILD BIRDS, ANIMALS OR INSECTS (hunted in rural areas or on farms)								
FOOD	DESCRIPTION	AMOUNT	TIMES EATEN Complete one column				CODE	AMOUNT / WEEK
			Daily Times/ day	Weekly Times/ week	Monthly Times/ month	No		
MISCELLANEOUS: Please mention ANY OTHER FOODS used more than once/two times a week which we have NOT talked about								
INDIGENOUS/TRADITIONAL FOODS/PLANTS/ANIMALS Please tell me if you use any indigenous plants OR other indigenous foods like mopani worms, locusts ect to eat PLEASE GIVE DETAILS								

ANNEXURE G: IJSNEM AUTHOR INSTRUCTIONS

Authorship Guidelines

The Journals Division at Human Kinetics adheres to the criteria for authorship as outlined by the International Committee of Medical Journal Editors*:

Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to:

a. Conception and design, or analysis and interpretation of data; and

b. Drafting the article or revising it critically for important intellectual content; and

c. Final approval of the version to be published.

Conditions a, b, and c must all be met. Individuals who do not meet the above criteria may be listed in the acknowledgments section of the manuscript.

*Uniform requirements for manuscripts submitted to biomedical journals. *New England Journal of Medicine,* 1991, 324, 424–428.

Open Access

Human Kinetics is pleased to allow our authors the option of having their articles published Open Access within*IJSNEM*. In order for an article to be published Open Access, authors must complete and return the Request for Open Access form and provide payment for this option. To request Open Access, click **here**.

Manuscript Instructions

The *International Journal of Sport Nutrition and Exercise Metabolism* (*IJSNEM*) publishes a range of different types of papers, including original research investigations, rapid communications,

case studies, scholarly reviews, methodology reviews, and 10 questions; 10 experts. The common goal is to promote new and high-impact insights into sport nutrition and exercise metabolism, as well as the application of the principles of biochemistry, physiology, and nutrition to sport and exercise. Original research with human subjects will be emphasized, although relevant research with animal models may be published. Case studies that demonstrate systematic, rather than casual, observations made with appropriate instrumentation, as well as articles with clinical application, will be included. Please see the guidelines for each type of article. Note that even when papers are commissioned, each will undergo peer review and, unless prior authorization has been provided by the Editor or Special Projects Editor, all papers must conform to the submission guidelines.

General Instructions

All manuscripts must be written in English, with attention to concise language, a logical structure and flow of information, and correct grammatical style. We appreciate that many of our authors do not speak English as their first language and may need assistance to reach the standards required by the journal. In addition, some younger authors may not be experienced in scientific writing styles. Since manuscripts that fail to meet the journal's writing standards will not be sent out for review, such authors should ensure that they seek assistance from native English speakers and/or experienced colleagues prior to submitting their paper. Many journals acknowledge the existence of companies which offer professional editing services. An example of such a service can be found at **www.aje.com/**; this information does not constitute endorsement of this service. Use of an editorial service is at the discretion and cost of the authors, and will not guarantee acceptance for publication in *IJSNEM*.

All manuscripts should be submitted in Microsoft Word or another comparable word processing software program. Manuscripts should be double-spaced with wide margins and should include continuous line numbers in the text. Pages should be numbered in the upper right corner. Each table and figure should be presented on a separate page; headings should be included with each table, while figure legends should be aggregated on a separate page at the conclusion of references. Manuscripts should include the following elements in the order indicated: (1) title page; (2) abstract and keywords; (3) text; (4) acknowledgments, authorships, declarations of

funding sources, and conflicts of interest; (5) references; (6) tables; (7) figure legends; and (8) figures.

Title page. The manuscript must have a separate title page including title of article, name(s) of author(s), institutional affiliation(s), running head, and e-mail address and full contact details for the corresponding author. The title of the paper should be limited to 25 words. The running title (an abbreviated version of the title that is printed at the top of the page in the formatted journal version) should be limited to 8 words.

Abstract and keywords. The abstract should be a maximum of 250 words and be written in one continuous paragraph without subheadings. Abstracts should showcase the new information presented in the paper, either in the form of original research data or as a novel insight into an established issue. Abstracts reporting original research must include sufficient data to support any conclusion reached. It is not satisfactory to simply describe what was found (such as, "the treatment group improved more than the control group") nor to say simply that “the results will be discussed”. References should not be included. Include three keywords or phrases not included in the manuscript title.

Text. Manuscripts should be double-spaced with wide margins and should include continuous line numbers in the text. Pages should be numbered in the upper right corner. Statistical analysis: Papers submitted to the journal may be sent for review to a statistician if the Editor is not satisfied that appropriate procedures have been followed. When data sets are normally distributed, variance should be given as the *SD* rather than *SEM*. Nonparametric statistical analysis should be used when data sets are not normally distributed.

Methods in sport nutrition research: To assist with the design, implementation, and interpretation of studies in sport nutrition, *IJSNEM* has commenced the publication of a series of reviews on methodologies in sport nutrition research. These articles provide commentary from experts in a variety of fields on optimum ways to conduct and report studies on aspects of sport nutrition research. They can be downloaded from the *IJSNEM* Website, and we recommend that all

authors read these reviews before submitting manuscripts to the journal. Although the ultimate goal of these review papers is to promote better standards of sport nutrition research and help researchers enhance their outputs, they will also be used as a benchmark for reviewing papers sent to this journal. When submitted manuscripts describe methods that have been clearly shown to be inappropriate or fail to provide adequate description of methods according to recommendations in these methodology reviews, this is likely to result in rejection of the manuscript.

Acknowledgment, authorships, declarations. All funding sources and potential conflicts of interest should be declared at the end of the text. These include:

Role of each author. For example, a paper featuring four authors (LMB, GC, NR, and BP) would read: “Acknowledgments: The study was designed by LMB and GC; data were collected and analyzed by NR, GC, and BP; data interpretation and manuscript preparation were undertaken by LMB, GC, BP, and NR. All authors approved the final version of the paper”.

Use of human and animal subjects: *IJSNEM* requires that all submitted studies using human or animal subjects conform to the policies established by the U.S. Department of Health, Education, and Welfare and the American Physiological Society. Manuscripts should include a clear statement to the effect that studies had prior approval from a formally constituted ethics review board in the case of human studies and that informed consent was obtained in writing from participants (or guardians for participants under the age of 18 years), or that they adhered to current animal welfare legislation in the case of animal studies.

Studies using commercial products: *IJSNEM* recognizes the importance of studies that address the efficacy and safety of commercially-available products, including specialist sports foods, sports drinks, and dietary supplements. Such studies should, when relevant, include independent verification of the composition of the product under investigation. In the case of dietary supplements, this might reasonably include an analysis of the product to verify the content of the active ingredient and to exclude the presence of undeclared substances that might affect the outcome of the study. As with all studies, the inclusion of appropriate control groups or trials is important to the interpretation of any findings.

References. *IJSNEM* follows a modified version of the style laid out in the *Publication Manual of the American Psychological Association* (APA), 6th ed. Please consult the **APA manual**.

References should be listed in alphabetical order at the end of the text and should be cited in the text using author name(s) and date of publication. In the case of in-text citations, where there are more than two authors, the first author's name can be followed by "et al." Example: "Burke, Clooney, Pitt, and Riewoldt (2009) found that supplementation achieved positive outcomes" can be replaced by "Supplementation was found to achieve positive outcomes (Burke et al., 2009)." References should not be numbered in the reference list. Examples of the three most common forms of references are shown below. For other variations, please consult the APA manual.

Burke, L. M., Clooney, G., Pitt, B., & Riewoldt, N. (2009). Cacao supplementation does not affect sprint performance in elite team sport players. *Journal of Clinical Inspiration, 67,* 1966–1971.

Wadler, G.I., & Hainline, B. (1989). *Drugs and the athlete*. Philadelphia, PA: F.A. Davis.

Haymes, E. Proteins, vitamins, and iron. (1983). In M.H. Williams (Ed.), *Ergogenic aids in sport* (pp. 27–55). Champaign, IL: Human Kinetics.

Tables. When tabular material is necessary, it should not duplicate the text. Tables should be formatted using the table function of the word processing program rather than by aligning columns in text with tabs and spaces or using text boxes. Tables should be double-spaced on separate sheets and each should include a brief title and a legend that highlights any statistically significant findings.

Figures legends and figures. Figures should be professional in appearance and have clean, crisp lines. Hand drawings and hand lettering are not acceptable. Color is not permitted: figures should use black and white or gray shading only. Labels should be proportionate with the size of the figures on the journal page. Digital photos should be 300 dpi at full size, and digital line art should be 600 dpi. Figures can be submitted electronically in TIFF, PDF or JPEG file formats. Authors are encouraged to submit illustrations rather than tables.

Following are additional guidelines based on specific manuscript type.

Original Research

Scope. Original Research papers should cover topics of novelty and high impact in relation to sport nutrition or exercise metabolism. Even in cases where research has been conducted carefully and has been appropriately written up, a manuscript may be rejected if it is deemed to be of insufficient interest and quality to attract attention.

Title. Where possible, the title should be brief but instructive of the outcome of the study. Example: “Caffeine fails to improve 200 m swimming time in elite swimmers” is preferred to “Effect of caffeine on swimming performance in elite swimmers”

Length. 3,000 words (excludes title page, abstract, acknowledgments, references, figures, tables)

Sections. Sections include Introduction, Methods, Results, and Discussion; each of these sections should follow the standard processes. Where appropriate, the text should conclude with two brief sections: novelty statement (one or two sentences should sum up the new information that has been gained as a result of the study) and practical application statement (one or two sentences should sum up the way that this information could be put into practice).

Acknowledgments. Note that the contribution of each author to the paper should be outlined.

References. A maximum of 40 references can be cited.

Figures and tables. A total of six figures and/or tables may be used to illustrate the data in this study. The total of six assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If you feel that additional panels or figures are needed, please be sure to address this in your cover letter.

Rapid Communication

Scope. IJSNEM offers the opportunity for highly novel research data to receive an expedited publication process. Authors are required to produce succinct manuscripts of abbreviated length (see instructions below) and to outline the key reasons that their work should receive special attention. The Editor or Special Projects Editor will assess the merits of this case. The work will

be subjected to peer review with a rapid turnaround (2-week maximum period for each stage) and authors will need to be willing to attend to any revisions or proofing within a similar timeframe. On acceptance of publication, Rapid Communication papers will be granted epub status and will immediately be moved into production for full publication in the next journal issue.

Title. The title should be brief but promote the novel outcomes of the study. Example: “Caffeine fails to improve 200 m swimming time in elite swimmers” is preferred to “Effect of caffeine on swimming performance in elite swimmers”

Length. 2,000 words (exclues title page, abstract, acknowledgments, references, figures, tables)

Sections. Sections include Introduction, Methods, Results, and Discussion; each of these sections should follow the standard processes. Where appropriate, the text should conclude with two brief sections: novelty statement (one or two sentences should sum up the new information that has been gained as a result of the study) and practical application statement (one or two sentences should sum up the way that this information could be put into practice).

Acknowledgments. Note that the contribution of each author to the paper should be outlined.

References. A maximum of 25 references can be cited.

Figures and tables. A total of four figures and/or tables may be used to illustrate the data in this study. The total of four assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If you feel that additional panels or figures are needed, please be sure to address this in your cover letter.

Case Study

Scope. The case study should present a novel situation in which a sport nutrition practitioner has observed a nutrition challenge in sport or assisted in the implementation of a nutrition plan to overcome such a challenge. The aim of a case study publication is to present a brief but insightful summary of a unique situation in sport nutrition. Authors should note the requirement that all material maintain the anonymity of the subject(s). The subject(s) should have the opportunity to read the case study in its entirety before giving their written permission for publication to the authors; authors should provide a copy of this written permission to*IJSNEM* (download consent form **here**). When the authors’ institutions require approval from their own human ethics

committees for the presentation of such a case study, it should be documented that this was sought and granted.

Title. The title should begin with “Case study” and provide an informative description of the issue that is covered. Example: “Case study: cyclist with multiple food intolerances completes 3 week Grand tour event (Giro D’Italia)”

Length. 2,000 words (excludes title page, abstract, acknowledgments, references, figures, tables); authors are encouraged to write objectively in presenting the background, assessments, and nutrition plan involved in the case but may present their reflections in an active or first-person form.

Sections. The following sections are recommended:

Background to issue

Summary of the topic/sport/context in which the athlete’s nutritional challenge has emerged

Examples: Overview of an event or sport, an issue in a sport (e.g., making weight), or a clinical nutrition issue (e.g., celiac disease, type 1 diabetes)

Presentation of athlete/subject

Confidential presentation of the subject of the case study.

A statement that the subject has provided written permission for publication of the case study after having read the paper. Where applicable, there should also be a statement that the paper has been approved by a human ethics committee of the authors’ institution(s).

Details of the situation that led to the involvement of the subject and author(s) in the observation, project, or collaboration.

Athlete/subject assessment

Personal and sporting history

Physique and physiological characteristics (as applicable)

Medical or clinical history (if relevant)

Nutritional assessment and history (as applicable)

Overview of nutrition plan/intervention

Details of the recommended plan with scientific/nutritional support for this approach

Outcome of the implementation of the plan

Reflections

Acknowledgments. Note that the contribution of each author to the paper should be outlined.

References. A maximum of 25 references can be cited

Figures and tables. A total of four figures and/or tables may be used to illustrate the data in this study. The total of four assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If you feel that additional panels or figures are needed, please be sure to address this in your cover letter.

Scholarly Review

Scope. IJSNEM publishes scholarly reviews including narrative reviews and meta-analyses that offer a new summary or insight into a topic of interest.

Title. The title should be brief but instructive. Example: “Dairy protein promotes superior muscle protein synthesis following resistance exercise: a meta-analysis” is preferred to “The effect of dairy protein on muscle protein synthesis following resistance exercise”

Length. 5,000 words (excludes title page, abstract, acknowledgments, references, figures, tables)

Sections. Sections headings should be set according to the topic. Where appropriate, the text should conclude with two brief sections: novelty statement (one or two sentences should sum up the new information that has been gained as a result of the review) and practical application statement (one or two sentences should sum up the way that this information could be put into practice).

Acknowledgments. Note that the contribution of each author to the paper should be outlined.

References. A maximum of 75 references can be cited

Figures and tables. A total of eight figures and/or tables may be used to illustrate the data in this study. The total of eight assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If you feel that additional panels or figures are needed, please be sure to address this in your cover letter.

Methodology Review

Scope. IJSNEM publishes reviews regarding methodologies in sport nutrition research to assist with the design, implementation, and interpretation of studies in sport nutrition. These articles will generally be commissioned from experts in the field, and will provide a commentary on optimum ways to conduct and report on aspects of sport nutrition research. All such reviews will undergo the usual peer review process. The Special Projects Editor can be contacted to discuss potential topics of interest. Methodology Reviews will be made accessible to readers by open access status on PubMed. They can also be downloaded from the*IJSNEM* Website.

Title. The title should be brief but instructive and include the words Methodology Review in the title.

The remaining formatting characteristics for Methodology Reviews will follow the instructions for Scholarly Reviews above.

10 Questions; 10 Experts

Scope. This publication will summarize the outcomes of symposia delivered at major sports medicine and sport nutrition conferences following the 10 Questions; 10 Experts format in which a topic of interest is divided into 10 separate questions with a brief answer being provided by an expert in the field. Publication will require each expert to present their response within a limit of 300 words plus three citations. The summary will be edited with a brief introduction and summary provided by the chairperson(s) and the sequential presentation of each expert's response. The full manuscript will be subject to peer review prior to final acceptance, and acknowledgment of the symposium will be included in the paper. The Special Projects Editor should be contacted to discuss the potential publication of such a symposium.

Title. The title should contain the 10 Questions; 10 Experts brief. Example: "10 Questions; 10 Experts: Timing, type and doses of protein intake to optimize the benefits of resistance training"

Length. 4,000 words (excludes title page, abstract, acknowledgments, references, figures, tables); where possible, the 10 questions should be outlined in the 250 word abstract.

Sections. Introduction, ten 300-word expert responses (with the three additional references immediately following), and Summary.

Acknowledgments. The authors should be listed in the order of their presentation, with the chairperson(s) or organizer of the publication being acknowledged as primary author.

Figures and tables. A total of six figures and/or tables may be used, but may not be considered necessary for this type of presentation. The total of six assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If authors feel that additional panels or figures are needed, this should be addressed in the cover letter.

Other

From time to time, *IJSNEM* will publish other types of papers, including invited editorials and special reviews from conference presentations. In most cases, these pieces will be commissioned and specific instructions will be provided to authors for their preparation. All articles will still be submitted to a peer review process. The Editor or Special Projects Editor can be contacted regarding such papers.

Review Process

Manuscripts are read by an editor and two reviewers; reviews will not be blind. Authors are required to provide the names and email addresses of a minimum of two potential peer reviewers when they submit their manuscripts. The review process should not take more than ~6-8 weeks.

Copyright Transfer

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