

Nutrition in Olympic Combat Sports

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Elite athletes' dietary intake, hydration status and experiences of weight regulation

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Abstract

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There are a number of sports in which competition is conducted with weight limits or weight classes. In one-on-one combative sport, such rules are enforced to create an equal playing level and minimize the risk of injury between opponents. The prevailing attitude among competitive combat sports athletes is that a performance advantage will be gained by rapidly losing weight thus competing against a lighter and smaller opponent. However, rapid weight loss by voluntary dehydration can have implications for health and performance.

The aim of this thesis is to improve the understanding of weight-regulation practices of elite combat sports athletes. This is investigated by means of interviews emphasising on Swedish national team athletes' (n=14) perceptions and experiences of the phenomenon, and by cross sectional data (n=68) on hydration status and dietary intake collected at six different competitions in the 4 Olympic combat sports of wrestling, taekwondo, judo, and boxing.

The qualitative research demonstrated that athletes practice weight regulation not only to gain a physical advantage over opponents but also for purposes of identity, mental advantage, and mental diversion. However, negative experiences including physiological needs and opposing ideals related to dietary- and weight-making practices were also displayed. The dietary and weight conflicts were most prominent close to competition.

The hydration status measured at the morning of competition day demonstrated that almost half of the participants were categorized as seriously hypohydrated despite high water intake. Time for recovery was not significantly related to hydration status but athletes with shorter recovery time tended to be seriously hypohydrated to a greater extent than athletes competing under rules allowing for extended recovery time. Furthermore, a large proportion of the participants consumed a diet below current sport nutrition recovery guidelines regarding energy-yielding macronutrients.

The main findings of this work demonstrate that weight regulation in combat sports is practiced in such a magnitude and intensity that it brings about negative physical and psychological consequences. Stricter weigh-in regulations might hinder rapid weight-loss practises but such actions will not solve the problem entirely. To manage stricter rules, nutritional counselling might be of further importance. Moreover, the mental benefits currently ascribed to weight regulation should be considered.

Sammanfattning

Det finns ett antal idrotter vars regelsystem innefattar definierade viktgränser och viktklasser. Inom kampsport, där tävlingsmomentet äger rum mellan två tävlanden, är syftet med viktklassindelningen att skapa en rättvis matchning samt minimera skaderisken för utövarna. Den rådande uppfattningen bland tävlingsaktiva inom kampsport är att en prestationsfördel relativt sin motståndare kan uppnås genom att drastiskt reducera kroppsvikten för att därigenom möta en mindre och lättare motståndare. Vanligen genomförs en hastig viktnedgång genom dehydrering, ett tillvägagångssätt som kan medföra negativa konsekvenser gällande såväl idrottsliga prestationer som hälsa.

Syftet med avhandlingen var att bredda kunskapsbilden om viktreglering bland elitaktiva kampsportare. Detta utforskades genom intervjuer med landslagsaktiva (n=14) kring viktreglering med betoning på uppfattningar och erfarenheter. Vidare undersöktes elitaktiva idrottares (n=68) vätskestatus och kostintag i en tvärsnittsstudie vid sex olika tävlingar i de Olympiska kampsporterna brottning, taekwondo, judo och boxning.

De kvalitativa studierna visar att viktreglering inte enbart praktiseras för att nå ett fysiskt övertag över motståndare, utan även för att stärka den idrottsliga identiteten, att erhalla mentala fördelar samt som mental avledning av bland annat tävlingsrelaterad stress. Även negativa aspekter gällande kostintag och viktreglering framträdde, främst gällande fysiologiska behov och motstridiga ideal. Dessa konflikter var som mest uttalade nära inpå tävling.

Vätskestatus som uppmättes på tävlingsdagens morgon visade att nästan hälften av deltagarna kunde kategoriseras som allvarligt hypohydrerade trots ett rikligt vätskeintag. Tid för återhämtning var inte signifikant relaterat till vätskestatus. Det fanns dock en tendens till att de idrottare som hade kortast tid för återhämtning var allvarligt hypohydrerade i större omfattning jämfört med de deltagare som hade längre återhämtningstid. Vidare visar resultaten att en stor del av studiedeltagarnas intag av energigivande makronutrientier inte nådde upp till rådande idrottsnutritionella riktlinjer.

Det huvudsakliga resultatet av denna avhandling visar att viktreglering inom kampsport praktiseras i sådan omfattning och intensitet att det medför negativa fysiologiska och mentala konsekvenser. Begränsning av återhämtningstid eller andra regeländringar kan vara effektiva åtgärder för att åstadkomma en lösning på problemet. Mot bakgrund av den starkt förankrade kulturella traditionen samt de psykologiska fördelar som tillskrivs viktnedgång, bör även mental rådgivning som ett substitut till de fördelar som för närvarande kan hänföras till viktreglering övervägas.

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List of original papers

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

- I Petterson S, Pipping Ekström M, Berg CM. Practices of weight regulation among elite athletes in combat sports: A matter of mental advantage? *Journal of Athletic Training*. 2013;48(1):99-108
- II Petterson S, Pipping Ekström M, Berg CM. The food and weight combat. A problematic fight for the elite combat sports athlete. *Appetite*. 2012;(59):234-242
- III Petterson S, Berg CM. Hydration status in elite wrestlers, judokas, boxers, and taekwondo athletes on competition day. (Submitted for publication)
- IV Petterson S, Berg CM. Recovery, dietary intake and rehydration after rapid weight loss in elite Olympic combat sport. (Submitted for publication)

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Abbreviations

BW	Body weight
EWI	Evening weigh-in
GT	Grounded theory
IOC	International Olympic Committee
MWI	Morning weigh-in
RWL	Rapid weight loss
SOC	Swedish Olympic Committee
USG	Urine-specific gravity
WTF	World taekwondo federation

Definitions

<i>Euhydration</i>	Normal state of body hydration (water content).
<i>Dehydration</i>	The process of incurring water deficit. Dehydration can occur from the hyperhydrated state (i.e. a slight excess of water) to euhydration, and continuing downward to hypohydration.
<i>Heavyweight athlete</i>	A male/female athlete competing in a weight division that has no upper weight limit (apart for some sports).
<i>Hypohydration</i>	The extent (or level) of dehydration below euhydration (usually described as per cent of initial BW). Define a new steady-state condition of decreased body water content.
<i>Olympic combat sports</i>	Denotes the four combative sports (wrestling, judo, taekwondo and amateur boxing) currently included in the Olympic Summer Games.
<i>Rapid weight loss (RWL)</i>	A procedure that involves losing a significant amount of BW the last day(s) prior to competition weigh-in through a combination of dehydration and dietary/fluid restrictions.
<i>Rehydration</i>	The process of gaining water from a hypohydrated state toward euhydration.
<i>Weigh-in</i>	Prior to competition respective combat sports federations and the IOC regulations require that all athletes perform a weigh-in to control that the participants' weight is within the range of their designated weight category.
<i>Weight regulation</i>	Refers to various aspects of intentional weight control, including short, gradual, and long-term weight loss/gain/maintenance.

Introduction

Combat sports can be defined as sports wherein two individual combatants fight each other using techniques according to a set of prearranged rules. Thus, depending on the sport, the participants try to subdue their opponent by striking, kicking or grappling techniques, where the latter can include throws/takedowns, chokes, and joint locking [1]. Examples of competitive combat sports including one or several such elements are the traditional arts of taekwondo and judo, jujitsu, karate, sanshou, muay thai, as well as the more familiar mainstream combat sports of boxing and wrestling.

Hundreds of millions of people worldwide practice some form of combat sport. For example, in 2009 the South Korean government published an estimate that 70 million people in 190 countries practiced Taekwondo [2] and wrestling participation in the United States averaged 2.5 million participants per year between 2000-2006 [3]. In Sweden combat sports were collectively the fifth largest sport in 2011, with over 200,000 persons from the age of 7 years regularly training and participating in competitive events [4].

Although mass sport participation provides the breeding ground for elite sport, only a minority becomes elite athletes and even fewer later excel into top athletes. In fact, according to unpublished statistics, [5] only one out of approximately 19,500 US high school-aged male wrestlers will become an Olympic athlete. Nevertheless many recreational and lower-level athletes are influenced by the practices and actions that the elite submit to in order to attain sporting success. Hence, performing research on the elite is of importance not only for the high-performance sub-group of athletes, but also considering the overall sporting context.

The demands of elite sport

To become an elite athlete, individuals must discipline themselves to train and practice for many years. An often-cited “rule of thumb” is that it takes at least 10,000 hours of deliberate practice (i.e. high in structure/efforts and low in enjoyment) in a period of 10 years in order to reach expertise [6]. Thus, depending on sport, competitive level, and season it is common practice for athletes to undertake 5-14 training sessions per week [7]. For elite athletes in combat sports this equals to approximately 600 to 700 hours [8] of training per year while endurance-based sports can undertake up to 800-1,000 hours of

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practice per year [7]. Hence, in order to withstand high training volumes and uphold focus on sport and competition, a number of personality traits are thought to be particularly salient in a successful athlete. These include single-mindedness, commitment, self-confidence, intrinsic motivation, and the ability to block out distractions and cope with anxiety and obstacles [9-11].

However, considering that training and competition are mentally and physically effortful activities, an appropriate balance between the sporting activities and life outside of sports including recovery and adequate nutrition is a necessity. Athletes that do not allow their bodies to recuperate are at risk of experiencing both psychological and physiological disturbances, commonly referred to as the overtraining syndrome [12]. Another balance needs to be found between the growing demands of the sports career, education, and other interests, including the athletes' psychosocial development [13]. External pressure such as high expectations from coaches, sport federations, family, and friends has been reported among top-level athletes [14]. However, research also demonstrates the importance of significant others on athletes' sport achievement, foremost during adolescence, [15] but also at an elite level [16].

Although elite athletes in retrospect report high life satisfaction during their career because of the living, loving relationship they develop to their sport, extensive engagement in a chosen domain and commitment to the role of athlete can become problematic [17]. In fact, as noted by Stambulova, [13] when athletes reach Olympic level they must remain focused to achieve or maintain training and sporting goals, which entail restricting life areas outside of sports. Thus sport becomes life and life is subordinated to sport. In its extension, the commitment and dedication invested in sport could compromise an individual's personal qualities that contribute to optimal health and well-being [18].

Although some physical characteristics mostly are genetically determined, such as the need for height in basketball or a high percentage of type I muscle fibres in leg muscles of endurance-type athletes [19] others can be influenced by training and diet.

In general, elite athletes' body weight (BW) and body composition are considered as central components in the endeavours of optimal performance [20]. However as a consequence of some sports' rule systems where defined weight categories have been established, the management of BW, body composition, and nutritional intake may become a concern [21]. Examples of such so-called weight category sports are rowing, weight lifting, and combat sports. This thesis is centred towards the Olympic combat sports of wrestling, taekwondo, boxing and judo.

Weight categories in Olympic combat sports

The purpose of having weight classes/categories in combat sports is to match athletes that are of similar size in order to create an equal playing level and minimize the risk of injury between opponents. Thus, all competitors are required to attain a specific BW (weight class) prior to competing in a regulated bout. For the Olympic combat sports, time for the official weigh-in differs depending on the sport (Table 1). Weigh-in in international wrestling and taekwondo takes place on the day before the beginning of the competition thus allowing for extended recovery time [22, 23]. For athletes competing in judo and boxing, weigh-in is performed in the morning of competition day. Hence, depending on competition draw the recovery time between weigh-in and first match can be 2 hours for judokas [24] and 3-6 hours for boxers [25]. If a competitor weighs above or below the set limits in which he or she is entered, there is the potential for disqualification. Depending on sport and competition, the number of weight categories varies between boxing, judo, wrestling, and taekwondo (Table 1). Athletes having a BW over the highest weight category cut-off limit are collectively termed heavyweight athletes. Wrestling is the only Olympic combat sport that imposes an upper limit on the highest weight class, 120 and 72 kilos, males and females respectively.

Table 1. Weight categories (seniors) and weigh-in rules according to IOC and respective sport federations international competition rules

Sport	Gender	Number of weight categories (weight range) at national and international championships	Number of weight categories (weight range) at the Olympic Games	Timing of weigh-in	Frequency of weigh-in at competition
Boxing	Male	10 (46 to ≥ 91 kg)	10 (46 to ≥ 91 kg)	At least 3-6 h prior to first match	Before all bouts throughout competition
	Female	10 (45 to ≥ 81 kg)	3 (48 to 75 kg)		
Judo	Male	7 (-60 to ≥ 100 kg)	7 (-60 to ≥ 100 kg)	At least 2 h prior to first match	Once
	Female	7 (-48 to ≥ 78 kg)	7 (-48 to ≥ 78 kg)		
Wrestling (Greco Roman, Free style)	Male	7 (-55 to 120 kg)	7 (-55 to 120 kg)	Day before competition	Once
	Female	7 (44 to 72 kg)	4 (-48 to 72 kg)		
Taekwondo (WTF)	Male	8 (-54 to ≥ 87 kg)	4 (-58 to ≥ 80 kg)	Day before competition	Once
	Female	8 (-46 to ≥ 73 kg)	4 (-49 to ≥ 67 kg)		

Weight regulation and competitive success

It is a commonly expressed opinion among coaches and combat sports athletes that a higher BW will lead to a competitive advantage relative to the opponent [26, 27]. To achieve the proposed benefits of increased range, strength, and power, the strategy of acute rapid weight loss (RWL) is commonly practiced before official weigh-in, followed by dietary intake striving to regain normal BW by the time of the match. By means of this short-term weight fluctuation athletes hope to contend shorter, smaller, and lighter opponents.

Although competitive success is multifactorial and too complex to be determined by one variable, a few studies have investigated if BW gain recovered after weigh-in (i.e. an index that reflects the degree of RWL), is related to competitive success. Two studies on high school wrestlers [26, 28] demonstrated that successful athletes gained significantly more BW than less successful contenders, a finding not supported in research performed on college wrestlers [29, 30] or elite taekwondo players [31]. However, virtually all the athletes in these studies lost weight for the weigh-in. Thus at present it cannot be established if athletes who choose not to practice RWL would be at a disadvantage upon competition.

Prevalence and strategies for rapid weight loss

The prevalence of short-term weight regulation in combat sports is widespread: 90% of investigated judokas [32] and college wrestlers [33] and 68-70% of high school wrestlers [33, 34] have been shown to regularly reduce their BW prior to competition. Pre-competition weight loss seems to be equally prevalent across sexes [32]. Research has demonstrated that judokas [32], wrestlers [35], and taekwondo players [36] begin practicing RWL at 14, 13, and 14 years, respectively.

As regards relative pre-competition weight loss, 2-13% of total BW is reported in the literature [32-35, 37] but the majority of athletes usually lose 3-6% of BW repeatedly throughout the season. Thus, the weight fluctuations can be frequent and substantial. For instance, among 63 college wrestlers investigated, 41% reported weight fluctuations of at least 5 kilos each week of the competitive season [33].

The short-term weight reduction is normally initiated during the last week prior to competition, with intensification in terms of aggressiveness <24-96 hours before official weigh-in [38, 39]. However, Hale and Lane [27] reported that boxers had different phases in their weight control program throughout the

course of a season stretching from natural weight to a significantly lower championship weight. Hence, although sparsely described in the literature, the subject of combat sports athletes' dietary intake and weight-related issues are not restricted to the limited time period adjacent to competition.

The most common RWL strategies include reduction of food and fluid intake as well as sweat-induced dehydration through exercise and/or use of sauna [34, 35, 40, 41]. Even more extreme or prohibited weight loss methods in close proximity to competition weigh-in has also been documented, including self-induced vomiting and use of diuretics and laxatives [26, 32, 33].

Effects of rapid weight loss on performance

Studies [42] have demonstrated that relatively moderate degrees of hypohydration, i.e. reductions in the range of 1 to 3% of the euhydrated BW decreases cognitive functioning including reduced psychomotor performance, [43] decreased decision-making time, [44] and reduced levels of alertness [45]. The food and fluid-deprived state during the weight loss period seems to affect the psychological state of the athletes negatively as well, increasing tension, anger, fatigue and confusion as well as decreasing vigour [27, 46]. There are physiological alterations on cardiovascular functions (i.e. lower plasma and blood volume, increased heart rate and decreased cardiac stroke volume) hence aerobic performance is clearly impacted in a negative way by hypohydration [47]. However the physiological demands during a match in Olympic combat sports are characterized by high-intensity work of intermittent nature [48-51] and muscular strength and anaerobic capacity seems not as negatively affected by dehydration as the aerobic component of performance [52]. Instead, deteriorations in anaerobic performance are mainly related to reduced buffering capacity and low glycogen stores [47, 53].

In experimental studies the effects of dehydration often are measured without the possibility of recovery, whereas at real competition the impairments may be offset when a recovery period is provided between weigh-in and competition. Research investigating performance responses of weight-making practices including recovery presents mixed results. Studies on judokas and wrestlers [53, 54] and boxers [27] have demonstrated that performance can be restored within 2-5 hours of recovery with ad libitum food and fluid intake. In contrast, Kraemer et al. [55] demonstrated reductions in several isokinetic tests and grip strength in wrestlers following a 12-hour recovery period from a 6% BW reduction. Following the same magnitude of weight loss, Oöpik and colleagues [56] established that muscle isokinetic performance in two well-

trained wrestlers did not return to the initial levels despite 16.5 hours of recovery period with ad libitum intake of foods and drinks.

Potential negative health effects of rapid weight loss

Previous research has demonstrated that physical appearance, nutrition, and weight control are frequent sources of mental stress among elite athletes [57, 58]. In fact, elite wrestlers interviewed by Kristiansen and colleagues [59] stated that weight control was one of the most stressful parts of their sport. Extensive energy restriction has been shown to affect the endocrine organs and their homeostatic regulation [60-62]. Furthermore, it is well-established that severe deprivation of energy and nutrients results in a compromised immune system and hence a decreased resistance to infection [63]. A reduced immunity following RWL practices has been observed to persist several days after competition [64, 65].

The negative health effects of RWL strategies are not restricted to impaired immune function. Short-term weight regulation leads to reductions in body water, electrolytes, glycogen and lean tissue, which have been reported to alter a number of physiological functions such as thermoregulation [66, 67], cardiovascular functions and metabolism [47, 68], which are crucial to athletic performance and health. The most striking outcome of weight-making practices is the hyperthermia and dehydration-related deaths of 3 college wrestlers in 1997, attempting to reduce their BW by 7-9% [69]. Furthermore, Dickson et al. [70] demonstrated a significant correlation between dehydration (2.1 – 2.6 % of BW) and a decrease in the ventricular volume of the brain. Thus, considering the full-contact nature of the Olympic combat sports where head and face elements are commonly exposed to trauma because of grappling positions (wrestling and judo), and kicking (taekwondo) or striking (boxing) techniques suggests an increased risk of concussion if competing in a hypohydrated state.

In conclusion, despite the well-documented adverse effects of extensive weight regulation, the prevalence of short-term weight reduction is high in combat sports.

Aims

By means of qualitative and quantitative methods, the overall purpose of this thesis is to contribute to our understanding about weight regulation and dietary intake in the four Olympic combat sports of wrestling, taekwondo, judo, and boxing. The thesis comprises four studies, where the objective of paper I and II was to explore elite combat sports athletes' perceptions and experiences regarding weight regulation and dietary practices. In paper I this was implemented through the explorative approach of grounded theory (GT). Since the analysis in paper I highlighted the positive outcomes of weight regulation experienced by the athletes, the focus in paper II was directed towards investigating the athletes' narratives of negative feelings and experiences related to dietary strategies and weight-making practices. In paper III and IV, a field-based, cross-sectional approach sought to investigate elite combat sports athletes' hydration status and nutritional intake at real competition. The specific aims of paper I-IV were:

- Paper I: to improve the understanding of elite combat sports athletes' reasoning regarding sports nutrition, RWL, and regain.
- Paper II: to expand the understanding of various aspects regarding dietary strategies and weight-making practices experienced by elite combat sports athletes.
- Paper III: to study elite athletes' hydration status at competition in combat sports.
- Paper IV: to investigate elite combat sports athletes' intake of water and energy-yielding nutrients (carbohydrate, fat, and protein) during the recovery leading up to the first competitive bout.

Methods

Overview

In paper I and II a qualitative approach was employed mainly thru interviews with elite male (n=9) and female (n=5) wrestlers, judokas, and taekwondo players. In paper III and IV data was collected at 6 different competitions in the 4 Olympic combat sports of wrestling, judo, taekwondo, and boxing (n=68). Twenty-one participants were female and 47 males. Four of the 14 interviewed athletes included in paper I and II (2 females, 2 males) were also participants in the data collection analysed in paper III and IV. Table 2 gives an overview of the four papers.

Table 2. Overview of studies related to combat sports athletes' dietary and weight regulation practices

Paper	Design	Focus	Data collection	Participants	Sports	Data analysis method
I	Explorative study	Perceptions and experiences	Semi-structured interviews, observations at competitions, data collected on the Internet	14 male and female Swedish National Team athletes	Wrestling, taekwondo, and judo	Grounded theory
II	Explorative study	Negative feelings and experiences	Semi-structured interviews	See paper I	See paper I	Content analysis
III	Cross-sectional study	Hydration status, water intake	Urine-specific gravity, dietary assessment	68 Swedish elite male and female athletes	Wrestling, taekwondo, judo, boxing	Parametric and non-parametric statistics
IV	Cross-sectional study	Food and nutrient intake	Dietary assessment and weight gain	See paper III	See paper III	See paper III

Paper I

Grounded theory

For paper I, the qualitative method of grounded theory (GT) was considered as the most appropriate theoretical framework. GT is an investigative research method with the purpose of generating inductively based explanations of social

and psychosocial processes [71], or as one of the theory's founders states: "to discover what is going on" [72]. Therefore, the methodology of GT is considered fruitful in research areas previously unexplored. Being explorative in its nature, GT does not begin from a position of a pre-conceived theory or pre-defined concepts [73]. Instead, using an iterative approach, the theory emerges through the constant comparison method where the data collection and analysis are concurrent. Since the seminal work of Glaser and Strauss, mainly three variations of GT have emerged in which there are both subtle but also considerable differences regarding the procedures as well as each version's epistemological and ontological positioning. In paper I, the qualitative method chosen for data collection and analyses, follow principles adopted from classical GT [71]. Classical/Glaserian GT [74] is considered ontologically closer to positivism, since Glaser believes that the phenomena studied should emerge directly from the data collected, while Strauss and Corbin's modified/Straussian GT [75] assumes a post-positivistic standpoint, that acknowledges that some of the social world cannot be directly measured, thus adopting some interpretative assumptions [76]. If classical GT were to be positioned on one side in an ontological continuum, the third version of GT, Constructivist GT [77], could be viewed as situated on the opposite side. Instead of the one "real reality" advocated by Glaser, the constructivists' approach assumes that several realities exist simultaneously [78].

According to classical GT [72, 75] the trustworthiness or quality of a generated theory can be evaluated mainly thru addressing the concepts of fit, work, relevance, and modifiability. A quality GT has codes and categories that fit the data and the realities of the substantive area under study. Furthermore, the theory must work, i.e. it can explain the major behavioural and interactional variations of the substantive area. The theory must also possess relevance, not only of academic interest but also to actors (i.e. athletes and coaches) and practitioners (i.e. nutritional/mental advisors) in the setting. The latter two groups should immediately recognise or "grab" the theory's constructs. Finally, the theory could be considered to be modifiable or flexible enough if new relevant data surface by further empirical research.

Interviews

Data for paper I was collected through interviews, and 14 athletes' (9 male, 5 female) in wrestling (n=7), judo (n=3), and taekwondo (n=4) volunteered for participation. In total, 23 athletes were invited in the four different Olympic combat sports (wrestling, judo, boxing and taekwondo). The invited boxers

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declined participation. The recruitment process is illustrated in Figure 1. A letter asking the athletes to participate in an interview and contribute their personal views, opinions and practices regarding different aspects of food and fluid intake and weight regulation was sent out to a total of 19 national team athletes in the Swedish Olympic Committee's (SOC) high-performance support program. In order to qualify for the support program, the individual athlete has either repeatedly placed high in international competitions or was considered to possess the potential to reach world-class level within two Olympic cycles (i.e. 4-8 years). The selection of study participants was at first restricted to athletes who possibly practiced weight regulation (i.e. no heavy-weight athletes) on similar grounds as formulated by Glaser [72] regarding selective sampling, i.e. 'the calculated decision to sample a specific locale according to a preconceived but reasonable initial set of dimensions'(p. 37).

However, due to the concurrent nature of data collection and analysis practiced in GT, it became evident that also athletes competing in the respective sports' heavyweight division could contribute important information in the substantive area. Consequently, in addition to the participant observations, we decided to expand the theoretical sampling by including data from the three athletes competing in heavy weight division. Nine athletes declined to participate, and due to a limited number of study participants in one of the sports we performed a convenience sampling of an additional four national team athletes.

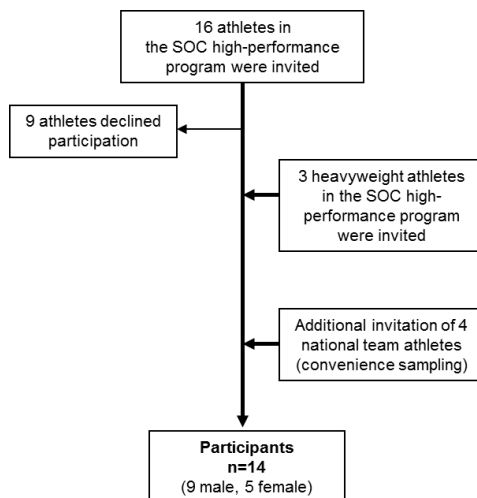


Figure 1. Flow chart of the participants included in paper I and II

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All interviews were performed December 2007 until March 2008. In order to increase the comprehensiveness of the data, but also make data collection more systematic [79], a flexible interview guide had been constructed and tested in a pilot interview with one combat sports athlete (Figure 2). The athlete volunteering for the pilot interview was a frequent competitor in regional and national competitions, but not a top-ranked athlete in his sport. Consequently, the pilot interview was not included in the final analysis. In order to create a climate that encouraged the participant's own reasoning, the interview guide consisted of open-ended questions arranged by themes. The themes/questions covered a broad range of benefits and ill effects of processes (food behaviours, experiences, strategies, influences and routines) involved in dietary behaviour and weight-making practices [80].

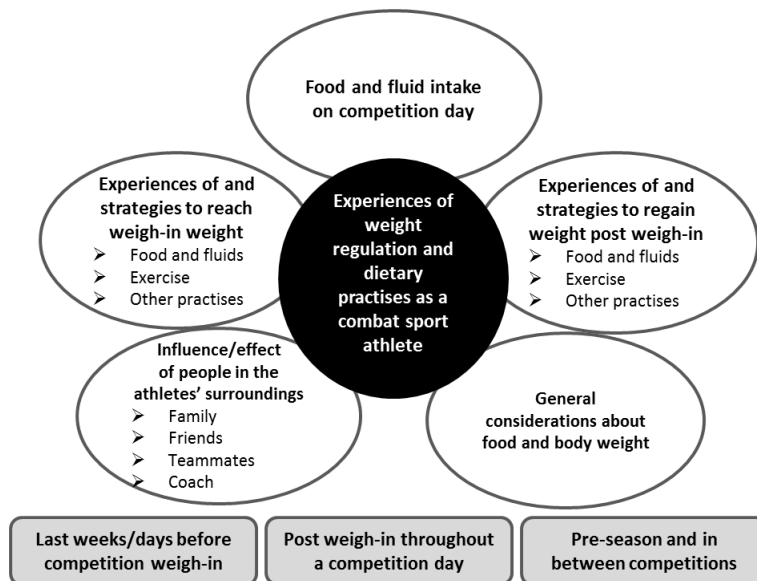


Figure 2. The interview guide arranged in themes

The interviews were semi-structured in the sense that the interviewer or interviewee could at all times diverge in order to pursue an idea in more detail [81]. The interviews centred on the athletes' preparations for competition; although nutritional considerations in the time period in between competitions and during low season were also included. In order to facilitate the interviews, a pre-drawn figure was used (not shown). The figure was employed in order to focus on different time periods during the course of a year. Thus, the intention

was to make it easier for the athletes to describe their weight regulation and dietary-related practises and thoughts in a more structured and detailed way by linking to contexts.

Participant observations

In line with the “all is data” view advocated by the classical GT methodology, [82] participant observations in the competitive setting and additional statements by combat sports athletes posted on the Internet were considered as an important complement to the interviewed athletes’ statements. Therefore, during international and national competitions (2008-2010) in the sports at question the athletes’ verbal and physical behaviours regarding weight regulation were observed. These experiences were later made into descriptive narratives.

Data from the Internet

The Internet search for additional statements by combat sports athletes was conducted using mainly Google and YouTube with the key words “weight cutting and combat sports athletes”. The sampling was limited to athletes’ expressions and/or opinions regarding mental factors in relation to weight regulation.

The additional data originates from athletes practicing other combat sports than those represented in the fourteen conducted interviews. The Internet data serves as an additional indication that theoretical saturation had been reached. In addition, by supplementing the findings from the observations and the fourteen interviews, the external statements also added value by showing that conformity exists between data irrespective of source thus increasing the trustworthiness of our results. At the same time, we acknowledge that the latter might not be considered in total accordance with the tenets of classical GT.

Generating the theory

All interviews were transcribed verbatim, culminating in 147 pages of single-spaced text. In paper I the data collection and analyses followed principles adopted from classical GT [71]. As classical GT is explorative by its nature, the analysis did not begin from a position of a pre-conceived theory or pre-defined concepts [73]. Instead, using an iterative approach as exemplified in Figure 3, the theory in paper I emerged through the constant comparison method where data collection and analysis were concurrent [74]. In addition to the 14 interview transcripts, data from the Internet and field observations were used in the analysis of paper I. The additional statements by combat sports athletes posted

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on the Internet were included in the later stages of the analysis. Owing to this the Internet data support the systematically generated concepts and categories manifested in our interviews with the fourteen national team athletes.

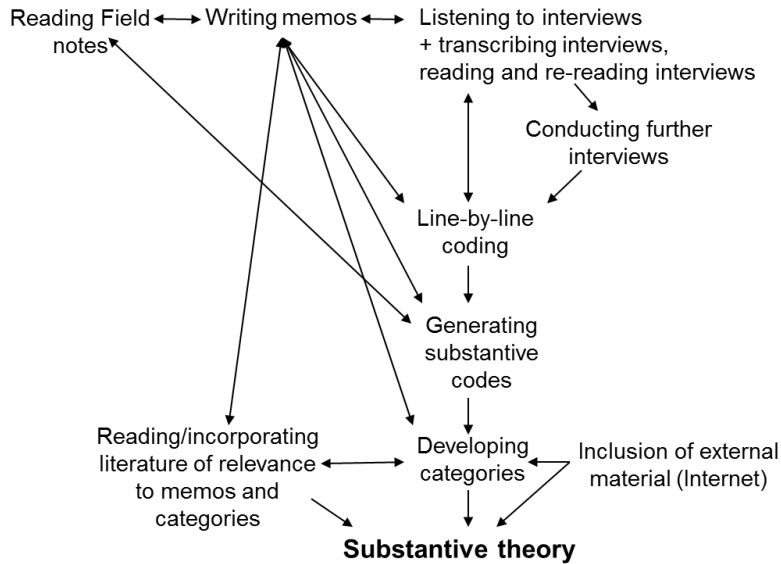


Figure 3. Flow chart of the analytic process generating a substantive theory

During the initial (open) coding process, the line-by-line reading, questions were asked to the data (i.e. the interviews and participant observations) in order to elucidate what is expressed by the athletes and what this describes, a process that generated substantive codes. From the initial interviews and participant observations, proceeding throughout the analytical process, reflections, thoughts and hypotheses, i.e. memos, were written down and later sorted and incorporated into the analysis. The memos functioned as a way of relating the attributes to more concrete categories, as well as serving as a connective thought between the different categories thus forming a substantive theory [71]. The theoretical sampling ended when saturation had been reached, i.e. the point when it was considered that additional information could not contribute to the development of the categories any further. Finally, a selective coding was performed in the later stages of the analysis by including data originating from statements with combat sports athletes posted on the Internet (Figure 3).

Methodological considerations

Past experiences and prior knowledge pose a risk when conducting qualitative research, possibly leading to biased conclusions originating from personal beliefs and preconceptions [79]. Throughout the investigation, from the planning phase followed by conducting the interviews, through analysing and finally writing up paper I and II, prior knowledge was seen to facilitate the research process. Being a registered dietician, frequently conducting nutritional consultations with elite athletes on behalf of the SOC, along with being an instructor in taekwondo, the first author has insight into the nutritional issues as well as the practice and culture of combat sports in general. Also, the collaboration of researchers in paper I and II, where all authors had different areas of interest regarding food and nutrition, increased the objectivity and reduced the likelihood of results based on contingencies and incorrect conclusions.

Participants

In paper I, the interviewed judokas, wrestlers, and taekwondo players were all Swedish National team athletes. Due to the limited number of boxers included in the SOC high-performance support program at the time of data collection, we were unsuccessful in recruiting this category of athletes. Thus, although the interviewed athletes gave a unison picture of weight regulation practices, there is a possibility that some cultural differences exist specifically in the sport of Olympic boxing. Furthermore, the findings provided by exclusively interviewing Swedish athletes might reflect a specific cultural and/or geographical bound practice in terms of weight regulation. However RWL has been proven to be prevalent among combat sports athletes worldwide, including South [32] and North American [41] female and male sports persons, as well as combat sports athletes in the Middle East [83] and Asia [84]. Thus, weight regulation can be considered as a globally practiced phenomenon among combat sports athletes.

Additionally, by restricting the inclusion of participants to elite athletes, it could be argued that the results may not be transferable to a broader recipient group, including younger and lower level of athletes. Research has shown that elite athletes in the capacity of idols symbolize and reinforce the ideals and norms prevailing in society or in a specific group [85]. Consequently, it is reasonable to assume that weight regulation procedures practiced by the elite also influence combat sports athletes in general, irrespective of age or competitive level. Indeed, research has shown that short-term weight-making practises occur across all levels of competitors [32] and are not restricted to combat sports [86, 87] or age [30, 32, 88]. Thus the results might be justifiably applied to a variety of other settings, and may not be limited to combat sports.

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Nine athletes approached by the invitational letter did not answer back (i.e. declined participation). Preceding the recruitment process, the matter of participation rate was discussed with representatives at the SOC. As athletes in the high-performance support program frequently receive proposals to contribute in various research projects, an activity generally considered by the athletes as time consuming thus not meaningful, the SOC officials predicted a low participation rate. Furthermore, because weight and dietary habits are sensitive and personal issues for many people, concerns pertaining to the research question might also have influenced the athletes' willingness to participate. Finally, although highly speculative on our behalf, athletes potentially declined participation due to the potential fear of stigmatisation and misrepresentation of one's sport (i.e. by contributing in a discussion thus highlighting a topic (i.e. weight regulation)) that outside of the weight-class sports context could be considered as abnormal. However, more than half of the invited athletes took part in the investigation and considering the variation in terms of sports participation, weight class (i.e. including both light and heavyweight athletes), and gender a balanced perspective of the research question was obtained. Although member check or respondent validation was not practiced in the present research, the findings have been discussed with combat sports athletes and coaches who agree with the main results of paper I.

Ethical considerations

Observance of ethical principles is fundamental in all research. At the time for initiating the qualitative data collection (December 2007) the Swedish ethical review did not monitor interview studies. Nevertheless the purpose and nature of the study was discussed with a representative at the Regional Ethical Board in Gothenburg. As communicated in the letter inviting participation as well as verbally at the start of each interview session, the participants were informed about the voluntariness to participate and that they at anytime could end their involvement without further explanations. The athletes were also guaranteed full confidentiality.

With exception for the data collected on the Internet, no names or pseudonyms were included in the presentation of the selected interview segments. Furthermore, to avoid identification of the fourteen participants or negative exposure of a specific sport (i.e. wrestling, judo, and taekwondo), the gender- and sport-neutral term "athlete" was used as far as possible when presenting data from the interviews and field observations. The justification for including the names of athletes from the Internet data was that they, either thru YouTube or personal web pages, already had been made public.

Paper II

In paper 2, the empirical data comprise the same 14 interviews as described under paper I. Thus in general terms, the same methodological considerations as defined in paper I are also valid in paper II. However due to the nature of the research question in paper II, a different analytic approach was used.

Data analysis

The theory generated in paper I demonstrated positive aspects of weight regulation, but negative statements regarding dietary and weight-making practises was also expressed by the athletes during the interviews. These negative experiences were further analysed using content analysis [89] in paper II.

Accordingly, the transcribed texts were read and re-read several times with a focus concentrated towards negative statements (experiences, emotions, thoughts, and so forth) made by the athletes regarding their dietary and weight-making practises, generating an initial set of codes. Then, an inductive analysis was performed by searching for meaning units, i.e. a constellation of words or statements that relate to the same meaning [90]. The meaning units were labelled with a code and the meaning units with similar codes were grouped into a certain category. The analytical process of how condensation of meaning units was performed and how these were abstracted into codes and categories is illustrated in Table 3.

In paper II, in accordance with Graneheim and Lundman, [89] a category is to be viewed as a “descriptive level of content,” thereby serving “as an expression of the manifest content of the text”(p. 107). Once the categories were considered containing similar underlying meanings, they were merged to a theme that reflects the underlying meaning of that theme.

Table 3. Examples of how codes and categories were created by the abstraction of meaning units

Meaning unit	Condensed meaning unit	Code	Category
Naturally, you want to look good and have a ripped physique.	Important to look good and to be ripped	Physical attractiveness	Nonsport-related concerns
I weigh myself twice a day. It's a routine, you have to keep a close eye on things.	Central to have control of body weight	Reaching the weight class weight	Sport-specific nutritional demands
During competition day, I usually feel pretty stuffed. I never feel keen on eating.	Difficulties eating due to fullness	Fullness	Bodily requirements

Paper III– IV

Participants

In paper III and IV, the term *elite* athlete referred to either holding a position in the Swedish National Team, having a high national ranking, and/or competing at an international level. All data for paper III and IV was collected on location at six different competitions held in Europe between 2009-2011. With assistance from representatives at the SOC, national team athletes in the four Olympic combat sports were first approached by letter. The same information was uploaded on respective sport federation's (boxing, judo, taekwondo, and wrestling) webpage asking elite athletes to volunteer in a study considering nutrition and hydration status at competition. Seventy-one athletes agreed to participate in the study, and 68 (32% female) were included in the study with a participation rate as follows: 92% of the Swedish senior competitors (n=26) at the 2009 Dutch Open and 2009 Austrian Open (taekwondo), 7% (n=10) participating at 2010 Swedish National Wrestling Championships, 50% (n=17) of all Swedish judokas at the 2009 Swedish Judo Open, and a total of 87% (n=18) of the Swedish boxers competing at the 2010 International Tammer Tournament (Finland) and at the 2011 Swedish National Boxing Championships. Three athletes (1 female, 2 male taekwondo players) were excluded; two athletes competed two days after the official weigh-in thus having substantially longer recovery time than normally accepted [23] and one athlete was excluded owing to incomplete data collection.

Data collection

Hydration status

The design of study III and IV is displayed in Figure 4. The night before competition day, each athlete was equipped with a urine specimen container. In agreement with American College of Sports Medicine's hydration-testing guidelines [52] each participant was instructed to provide a small urine sample from the first morning upon waking void the following day (i.e. in the morning of competition day). The specific gravity of the urine sample (USG), reflecting the pre-competition hydration status was determined by refractometry (Atago PAL-10S, Tokyo, Japan). The hand-held refractometer was calibrated before the tests and reviewed periodically between samples. All urine samples were discarded immediately after assessment.

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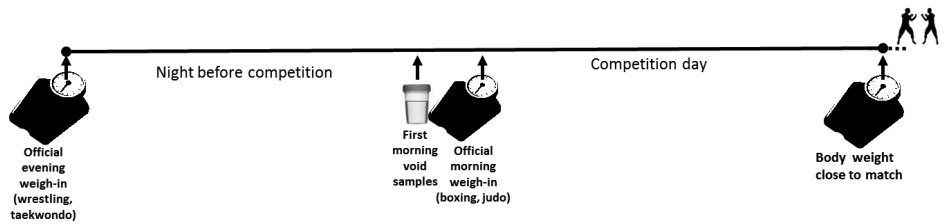


Figure 4. The study design of paper III and IV. The participants' food and fluid diaries were recorded between respective sports' official weigh-in and approx. 30 min before first bout

Nutritional intake

At the time for official weigh-in, each participant received written and verbal instructions of how to register food and fluid intake. The participants were instructed to document all consumed foods and fluids including brand name of commercial sports products (sports drinks/bars) and fat percentage of dairy products in the food and fluid diary. Sport product manufacturers' web pages were later checked for the content of specific products. The quantity of all food items was reported in household measures or (if available) by packaging details. In order to increase accuracy of portion size estimation, four pictures of different (weighed) portions of cooked pasta (2 pictures) and rice (2 pictures) were included in the food diary pamphlet. The pictures originated from the dietary study tool "Matmallen" [94]. The nutritional intake was analysed using the nutrient-calculation software package *Dietist XP* version 3.2 (Kost & Näringsdata, Sweden), which references the Swedish Food Composition Database (Swedish National Food Agency 2011-02-14).

Body weight

BW was recorded to the nearest 0.1kg on a calibrated electronic scale. The weighing of each athlete was performed twice: first at each competition's official weigh-in and a second time approximately 30 minutes prior to the first combative bout to determine the athlete's match weight. The majority of participants were weighed in their underwear or wrestling singlet. If additional clothes were worn at the second weigh-in, a separate weighing of the (dry) sportswear was performed and the weight was subtracted from the match weight. The athletes' absolute weight change (kg) was calculated by using the discrepancy between their pre-match weight (kg) and official weigh-in weight. The relative weight gain was obtained by dividing the sum of the absolute weight change by the official weight (kg) multiplied by 100.

Statistical analysis

All data were tested for normality using the Shapiro-Wilk test. Results are presented as Mean \pm Standard Deviation. Data were analysed using SPSS statistics version 20.0. A P-value <0.05 was considered to be significant.

Group comparisons

A grouping of sports was performed based on the time of official weigh-in. Hence wrestling and taekwondo are collectively named evening weigh-in (EWI) sports and boxing and judo morning weigh-in (MWI) sports. Between-group comparisons were performed using independent sample t-tests and Mann-Whitney U-tests.

Associations

Spearman rank correlation was applied to assess bivariate relationships. In paper III, a logistic regression model tested for goodness of fit by the Hosmer and Lemeshow test was used to analyse the association between recovery time (i.e. the two categories EWI and MWI) and serious hypohydration with 95% confidence interval (CI). Serious hypohydration (i.e. USG <1.030 or not) was the dependent variable. Adjustment was made for sex. Multiple regression was used to predict weight gain by water intake and the total weight of consumed nutrients during recovery, respectively.

Methodological considerations

Participants

Limitations with reference to the participants in paper III and IV are related to the limited sample size, foremost in the sport of wrestling. However, apart from wrestling a large proportion of the Swedish elite athletes in the Olympic combat sports were included. Furthermore, the methods of data collection (i.e. recording food and fluid intake, providing a urine sample, and performing weighing shortly before match) might have been considered as disturbing the athletes' preparations thus declining participation. Finally a difference in terms of weight-making practises between athletes who agreed to take part and athletes who chose not participate is plausible.

Hydration status assessment

The use of non-invasive methods such as USG measured by refractometry is considered to be a valid and accurate [92] way of estimating hydration status. Dilution methods of total body water with plasma osmolality measurements have been suggested to provide the most valid and precise measures of body

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hydration status [52]. However, collecting and analysing blood samples requires trained personnel and laboratory equipment, therefore impractical in field settings such as during competition. Thus, in paper III and IV, urine indices were used to measure the athletes' competition morning hydration status following overnight fast.

The first morning void following sleep was used because this procedure has been proposed to allow a valid discrimination between euhydration and hypohydration [52]. Armstrong et al. [93] argue that in some situations (i.e. between days) urine indices may be more sensitive to changes in hydration status than are blood-derived indices and might offer a more accurate representation of chronic hydration states. Indeed, it was recently demonstrated [94] that USG measurements following overnight hypohydration was a superior index to detect hypohydration as compared to plasma osmolality. However, considering the research by Popowski and colleagues [95] suggesting that urine tests, at least following rapid weight loss followed by aggressive rehydration, cannot precisely predict the extent of dehydration on a continuous scale, we employed the cut-off values suggested by the National Athletic Trainers' Association (NATA) [66] to classify individuals into categories of various levels of hypohydration.

Dietary assessment methods

Obtaining accurate measurement of nutritional intake has been proven to be fraught with difficulties. Taking into account that athletes neglect fluid consumption in field assessments [96] both over reporting and under reporting should be considered in paper III and IV. Other potential measurement biases relevant to the study population include neglect of reporting between-meal snacking [97, 98] and (under)estimating standard portion size [99], a problem shown to be amplified after a fasted condition [100]. Pictures from the dietary study tool "Matmallen" [91] were included in the food diary pamphlet in order to minimize such biases. However, dietary assessment methods such as the food record were originally developed for the general population and there is a lack of studies validating these methods in athlete-specific groups [101].

Body weight

To ensure that the weight change between the two weighing occasions was accurately measured, the match weight was performed on the same calibrated electronic scale as used during the official weigh-in. However, as displayed in Figure 4 there might have been additional dietary intake in the time between last weight measurement and match, hence a weight gain not unaccounted for.

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Ethical considerations

In paper III and IV, all participants were guaranteed full confidentiality in the invitational letter as well as in the call for participation information uploaded on the respective sport federation's website. Information about the voluntariness to participate and that the athletes at anytime could end their involvement without further explanations was also reinforced verbally during the data collection. The study was reviewed and approved by the Regional Ethical Review Board in Gothenburg, Sweden (Dnr. 547-09).

In order to avoid the event of negative publicity regarding findings of unfavourable hydration status and/or inadequate nutritional intake in a specific sport or identification of separate athletes, we chose to present the results based on time for weigh-in (MWI or EWI). However, despite the ethical steps taken regarding sports affiliation and individual identification, the focus on weight-making practises and the outcome of RWL on hydration status at competition could be viewed upon as a negative, unfavourable presentation of these sports in general. Yet, shedding light on the controversial topic of weight regulation is an important step towards improving the situation and well-being of these weight-category athletes.

Results

Paper I

The interviewed athletes expressed the opinion that a larger body than their opponent's results in an advantage regarding leverage, reach, power, and strength. However, the qualitative analysis of the transcripts and participant observations resulted in three categories of additional importance as to why combat sports athletes practice weight regulation (Figure 5).

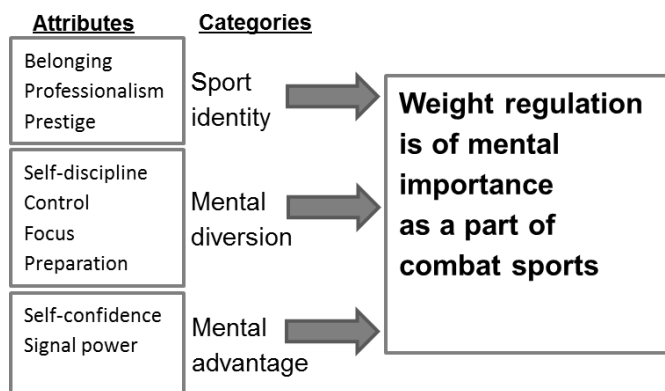


Figure 5. Presentation of attributes and categories that substantiate a theory stating that weight regulation is of mental importance in combat sports

The athletes gave a unison picture that the practice of weight regulation is so closely linked to the traditions and culture of the sport itself that it has become a part of it. In view of that the athletes had adopted certain behaviours considered appropriate in their social setting, including weight regulation, which denotes the importance of being a part of this specific sport culture. Moreover, considering this specific contextual environment, where losing a significant amount of weight defines success by influencing one's perception and comprehension of oneself as an athlete, including how one is perceived by others, the practice of weight regulation functions as a significant part in forming the athlete's sport identity.

How performers deal with the demands, or stressors they encounter before competition could be one factor affecting the outcome of a combat sport bout. One way for combat sports athletes to influence pre-competition feelings of self-doubt or uncertainty in a positive direction could be to gain complete control

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over something that is in fact controllable. Additionally, if control is reached in an area adjacent to the sport, such as the food and fluid intake, or an area that is considered to be of importance to the competitive outcome (i.e. BW) this could have an additive effect on the mental status. One athlete explained:

I think it feels good to lose a couple of kilos before a competition, because I feel that if I did not reduce weight before a competition, then I feel like I'm not going to compete. If I don't lose weight, then I feel insecure, it feels like I don't know where I am at, I just feel lost. But when I reduce weight, then I feel like; it's time for the competition now, I'm ready to compete, I am preparing myself for competition. It's hard if I'm not reducing weight, you know, it feels a bit strange.

Hence, if weight regulation is successful in the week or days leading up to a competition, the practice can act as a coping strategy buffering the pre-competition anxiety by focusing, or diverting negative thoughts in another direction as well as enhancing the athletes' self-esteem. One way of achieving this enhanced attentional focus is through weight regulation and the self-discipline that is required to lose weight. By successfully keeping to their weight-loss plans and beliefs, i.e. what the athletes believe is good or bad for them regarding their weight loss or performance, the sense of competence creates a feeling of being maximally prepared for the competition. Thus, the effects of weight regulation possibly have the most pronounced effect on the mental status during the pre-competition phase. Also, by resisting two of the strongest biological drives, hunger and thirst, an individual's willpower and character are put to the test, and *when* the desired weight is reached (there is no *if*, as stated by the interviewed athletes) a strong feeling of ability and thereby enhanced self-esteem can be achieved.

As noted several times during field observations at competitions, athletes commented on other athletes' BW and/or height when looking at matches or during weigh-ins, speculating about other athletes' normal BW in relation to the weight class they competed in. Thus, weight regulation practices might signal power (Figure 5) to the opponent and thereby create mental advantage.

In summary, together and separately, the categories *sport identity*, *mental diversion and mental advantage* (Figure 5) state that for the combat sports athlete there is more to weight-regulation practises than just qualifying for a weight class and then regaining BW in order to physically overpower the opponent. Thus, weight regulation is of mental importance as a part of combat sports.

Paper II

The main finding presented in paper II is that for the elite combat sport athlete, the conventional ideals of society and the demands intrinsic to sports regarding

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dietary practises and BW/appearance constitute a problematic balance. The participants' statements suggested that the demands of sports nutrition, and especially the weight regulations, were in direct conflict with (i) the athletes' physiological needs, and (ii) values other than those concurrent with the sport. As illustrated in Figure 6, this can be seen to constitute a multidimensional 'fight' for the combat sports athlete.

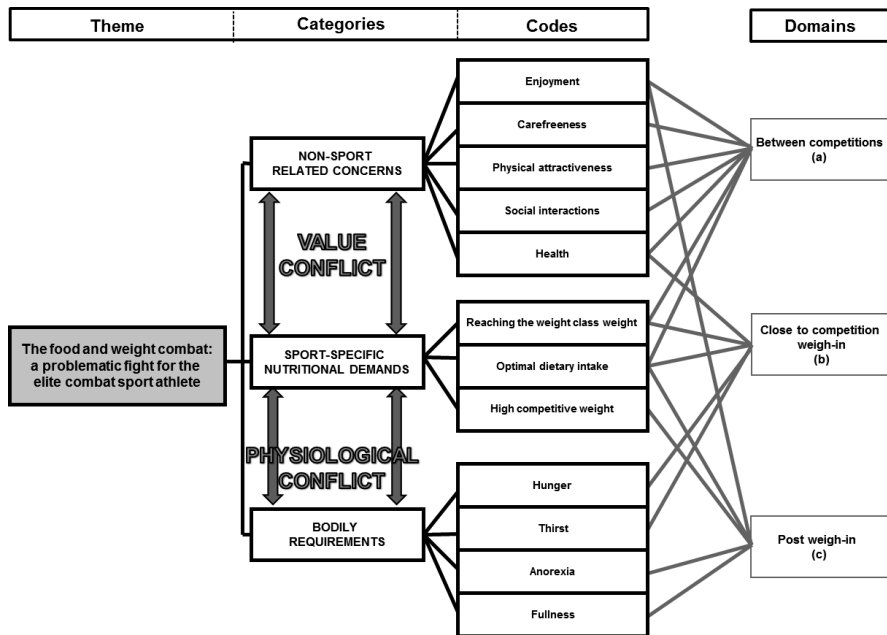


Figure 6. Overview of codes, categories and themes regarding food and weight regulation in combat sports. The lines connecting the codes to the three different time periods (domains) indicate when different concerns, demands and requirements are most prominent

In Figure 6, the different codes together make up the sport-specific demands, nonsport-related concerns, and bodily requirements. According to the analysis, the categories 'nonsport-related concerns' and 'bodily requirements' are often in direct conflict with sport-specific demands and ideals.

The food and weight combat

The strength and incidence of the different codes vary depending on which time period (domain) the athletes are in. The connective lines illustrate the most prominent time period for the different demands, concerns, and bodily requirements.

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During time periods where training was prioritized as well as between competitions (i.e. time period (a)), the athletes described not rigidly following the sports-specific demands as during the pre-competition preparations. Instead, the athletes presented a more carefree attitude towards nutrition and bodyweight, or a vision that one does not have to adhere to an optimal diet or refrain from poor food choices all of the time. Nevertheless, there are still conflicting nutritional factors present in terms of demands and opposing ideals since they also acknowledged the importance of an adequate dietary intake to facilitate their daily training regimes. For instance, to eat high-energy, less nutrient-dense foods did not go well together with the perceived sport-specific nutritional demands, but stressful everyday situations and lack of time was occasionally neutralised and dealt with by consuming less nutrient-dense snacks and candy as a method of comfort and ease. Furthermore, for some of the interviewed athletes, constantly being in control of their BW was associated with feelings of engaging in an unhealthy behaviour. This internal conflict became more intricate when comparing oneself to the habits of other athletes.

During the last weeks before competition weigh-in (i.e. time period (b)), a majority of the athletes stated that they intensified their dieting behaviour in order to prepare for competition weigh-in. During this phase, hunger is frequently experienced and for some of the respondents, BW and food-related concerns were perceived as constantly being mentally present. Expressions of concern towards what the severity of restrained eating and drinking during the final preparations brought about was frequently mentioned during the interviews. These negative experiences were not only of a subjective character; incidences of serious conditions requiring medical treatment as an outcome of excessive rapid weight loss practises were also reported by the participants.

Thus, the athletes' descriptions of eating and weight-making practises in the pre-competition phase centred towards what can be summarised as sport-specific demands (i.e. the goal of reaching the class weight through aforementioned dehydration strategies combined with a reduced dietary intake). The sport-specific demands increase in strength as time to competition weigh-in closes in, as well as the conflict with one's bodily requirements. Descriptions of extreme exhaustion during training sessions, hunger, and in the late stage of the rapid weight loss phase, thirst were commonly mentioned. In sum, the most intense period of the rapid weight reduction phase (b) is characterised by impatience, uncertainty, frustration, and increasing levels of irritation. Drastic day-to-day improvements regarding weight loss are sought and some of the athletes experience a tremendous amount of pressure.

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As expressed by the athletes, the food intake post-weigh-in throughout the competition day (time period (c)) constitutes a physically and mentally important factor to competitive success, but also a necessity that once again with reference to the other time periods is problematic. In the time between weigh-in and the first match (c), a regain of BW through food and fluid intake in order to obtain a competitive weight and to correct the reduced glycogen stores and reversal of the hypo-hydrated state were prioritised by the athletes. Descriptions such as “I stuff myself”, or “I eat everything I can get my hands on” were mentioned when discussing the initial post-weigh-in phase. Hence the food- and bodyweight-related problems that the athletes encounter during postweigh-in throughout competition day are to some extent antagonistic to the demands the sport requires during the time period before weigh-in. The magnitude of what could be described as postweigh-in binge eating among the athletes is dependent on the time until the first match. Several of the wrestlers and taekwondo players who normally conduct the weigh-in the evening before the competition, often felt the after-effect of their overindulgent recovery strategy, a fullness that could create negative emotions.

The issues and doubts regarding the nutritional intake are not limited to the few hours following evening or morning competition weigh-in; they persist throughout the competition day. Between matches, pressure-induced anxiety resulting in negative somatic symptoms (nausea, constantly going to the toilet, etc.) was the most commonly mentioned cause for why several of the athletes drastically reduced their food and fluid intake before and in between matches. This temporary state of anorexia was found to be problematic since the athletes also acknowledged the necessity of “fuelling up” with food and fluids in order to render optimal performance.

The strength of the sport-specific demands

Consequently, as displayed and exemplified as a tug of war in Figure 7 (a-c) there is a constant struggle to find balance between the sports nutrition demands vs. bodily requirements and other concerns presented as codes in Figure 6. This balancing act (illustrated by the oscillating line in Figure 7) clearly leaves the athletes in a troubled state of mind regarding their food intake and weight-related issues.

RESULTS

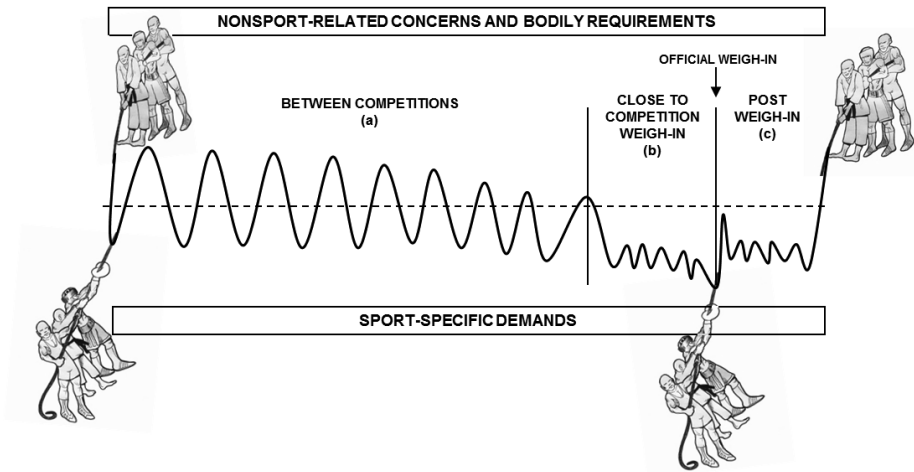


Figure 7. Schematic illustration of the struggle between food and weight related concerns of everyday life and the sport

Hence, depending on the time period, the different needs of the “non-athlete” life have to stand back more or less for the demands of the sport. This is illustrated by a descending, yet oscillating, line in Figure 7 (b) during the time period of the last days prior to competition weigh-in, as none of the concerns/codes listed in Figure 6 that are associated with the life outside “the sport”, yield priority over reaching the weight category limit. One athlete described:

Some of the weight cuts have felt like pure hell. One has to hang onto it [the restricted eating] closer into [the weigh-in], and maybe stop eating two days before. It feels like the metabolism almost shuts down.

Thus, reaching the class weight was given precedence over almost everything else, even one’s health. However, despite worries and negative experiences regarding the mental state and or health/performance issues during competition, all of the interviewed athletes thought that weight regulation was a necessity in order to be competitive at a high level in their sport. Furthermore, the structure and restricted number of weight categories (see Table 1) at the Olympic Games versus national and international championships might aggravate the taekwondo players, female boxers, and female wrestlers’ situation towards weight making even further. In fact, this issue was touched upon during the interviews. One athlete described:

In my case, my bodyweight fall in-between two weight classes. I don’t have a choice other than the x kilo weight class, because x [kilos] is my [usual] weight category but at

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the Olympics the next weight class is x [kilos]. That weight class would be impossible for me to compete in because all of my opponents [after practicing weight regulation] would weigh an additional 10 kilos above my body weight. That would be a bit unrealistic.

Paper III

Of the 68 participants included in paper III, 44% of the athletes were classified as seriously hypohydrated (USG >1.030) in the morning of competition day. None of the participating athletes were observed to be well-hydrated. When excluding the heavy weight athletes (n=5), the relative weight gain during recovery (18.4 ± 3.1 h) for the 31 wrestlers and taekwondo players (17 male, 14 female) conducting EWI was 4.4% of initial BW. Correspondingly, the 32 boxers and judokas (26 male, 6 female) who performed MWI thus had limited time for recovery (8.0 ± 3.6 h) and gained 2.1% subsequently at official weigh-in. Time for recovery was not significantly related to hydration status. However, there was a tendency towards higher prevalence of serious hypohydration (53%) in MWI athletes (Figure 8) compared to wrestlers and taekwondo players (42%) who had opportunity for partial recovery before hydration testing OR (95% CI)=1.6 (0.6-4.3).

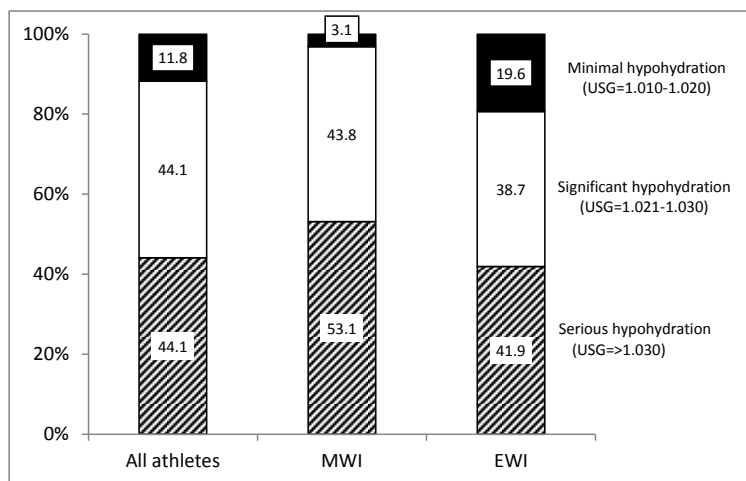


Figure 8. Categorization of different levels of hypohydration measured on the morning of competition day among combat sports athletes. All (including heavyweight) athletes (n=68), MWI athletes (n=32) and EWI athletes (n=31). No athletes were well-hydrated (i.e. USG<1.010)

The athletes' total water intake (including water from solid foods) during recovery was 3.6 ± 1.9 litres varying from 1.2 to 9.5 litres. A positive relationship

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was observed in the EWI group ($r_s=0.4$; $p=0.02$), i.e. the more water consumed before hydration measurement the more hypohydrated (Figure 9). Water intake among the 13 EWI athletes who were categorised as seriously hypohydrated was 3.5 ± 1.7 litres (range 1.4 to 7.3) consumed during the 14.6 ± 1.4 hours of recovery offered before hydration testing.

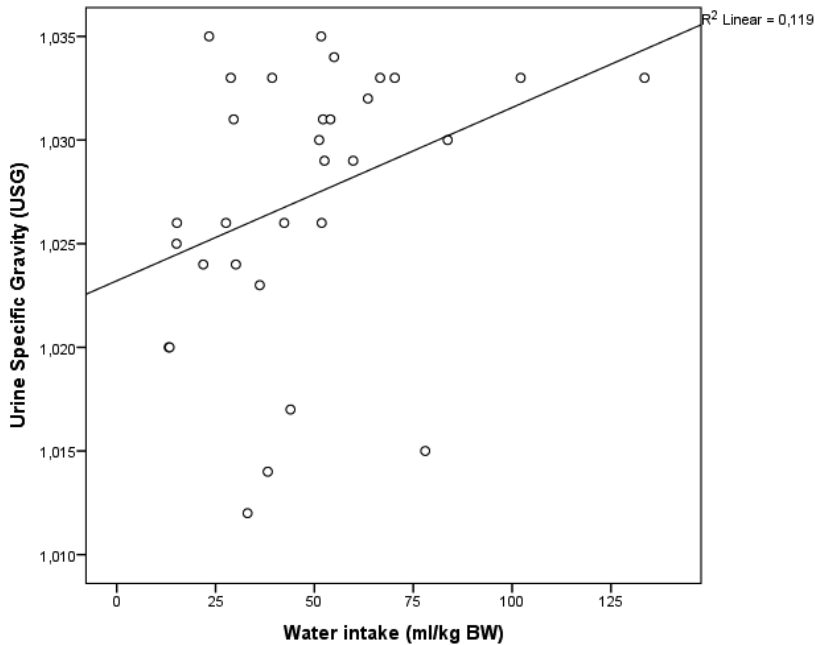


Figure 9. Relationship between water intake before urine testing and subsequent USG value on competition day morning in wrestlers and taekwondo players ($r_s=0.4$; $p=0.02$; $n=31$)

Paper IV

During the recovery, i.e. between official weigh-in and approximately 30 min before match (Figure 2), the athletes' ($n=68$) total intake of carbohydrates, protein and fat was 5.5 ± 3.5 , 1.4 ± 0.8 and 1.1 ± 0.8 g/kg BW, respectively. The mean water intake was 55 ± 33 ml/kg BW, corresponding to 3.6 litres. Of total water intake, 30% originated from solid foods and dairy/protein-containing sport products. Nonenergy-yielding beverages including drinking water contributed with 44% of the athletes total water intake and 26% originated from various carbohydrate rich beverages. Furthermore, 21 % of the athletes reported adding extra salt/oral rehydration solution to a minor part of the drinking water.

RESULTS

Owing to sport-specific differences in the rule system, wrestlers and taekwondo players had a significantly longer recovery than boxers and judokas, 18.4 ± 3.0 h and 8.2 ± 3.5 h, respectively. During recovery the athletes consumed 246 ± 98 and 389 ± 185 ml of water per hour, EWI and MWI respectively ($P=0.001$). In total the EWI athletes had a 1.8 litre higher intake than MWI athletes. As displayed in Figure 10, there was a significant correlation ($r_s=0.58$ $P<0.001$) between recovery time and total water intake.

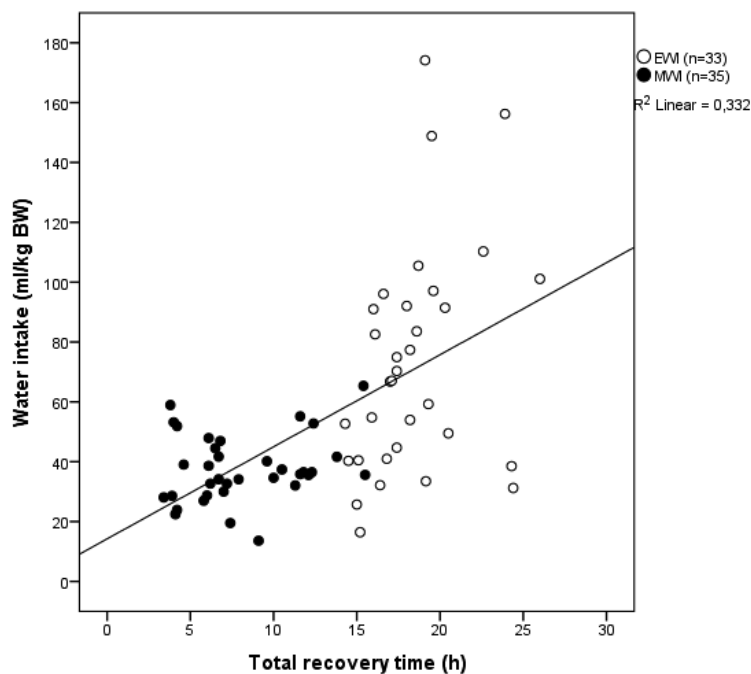


Figure 10. Association between recovery time and water intake ($r_s=0.58$, $p<0.001$; $n=68$). Consumed water originates from total dietary intake (i.e. both solid foods and fluids)

The difference in recovery time between groups also mirrored the amount of energy and other nutrients that were ingested. The former group consumed more than double the amount of energy (kJ), fat, and protein and consumed 79% more carbohydrate and 76% more dietary fibre than MWI athletes. The EWI athletes consumed 7.6 ± 3.8 g carbohydrate/kg BW, and the MWI athletes ingested 3.6 ± 1.3 g carbohydrate/kg BW.

During recovery the EWI group increased their BW by 1.3 kg more than MWI athletes ($P<0.001$). On average the athletes ingested 2.2 kg more than they retained in BW. The majority (56%) of the athletes consumed more than twice the amount of nutrients as they gained in weight. As displayed in Figure

RESULTS

11a+b, there were large individual differences in weight change (range -0.8 – 7.5 kg) as well as nutrient intake (1.3 – 10.5 kg). Six of the athletes (of whom 2 were heavyweight athletes) had lost BW (0.1 – 0.8 kg) ~30 minutes prematch despite consumption of foods and fluids in the range of 1.5 – 6.0 kg (Figure 11a+b). The total weight of each participant's nutrient intake (originating from water, carbohydrates, protein, fat, and dietary fibres) is shown along with the individual weight change accomplished during the post-weigh-in recovery phase.

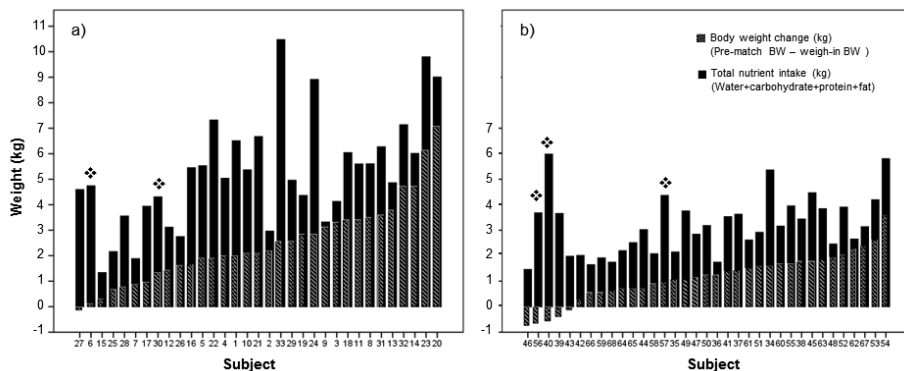


Figure 11a+b. Nutrient intake and weight change during recovery among wrestlers and taekwondo players (11.a; n=33); and boxers and judokas (11.b; n=35). ♦ Heavyweight athletes (n=5)

Total nutrient intake explained approximately 50% of the weight change ($R^2=0.49$; $r_s=0.7$ $p<0.001$; $n=63$), and water intake alone explained 48% of the weight change (Figure 12). The linear regression demonstrates that for each litre of H_2O consumed, the athletes gained 0.6 kg BW (weight gain= $14+0.57 \times H_2O$).

RESULTS

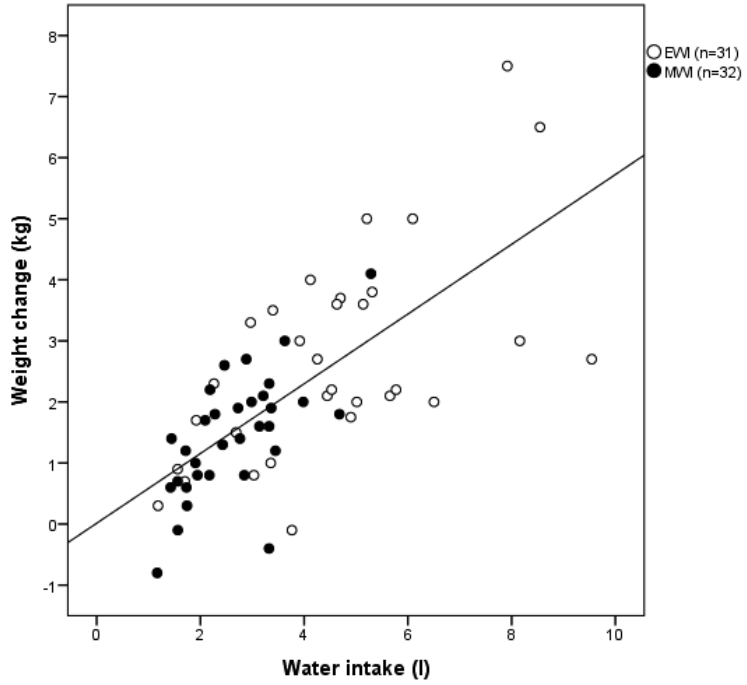


Figure 12. Relationship between water intake and weight gain ($r=0.7$ $p<0.001$; $n=63$)

Discussion

Initially, this section elaborates on the findings of mental advantages that weight regulation brings to combat sport athletes, followed by reflections about the negative aspects in terms of BW and dietary practices of competing in a sport with weight requirements. Secondly, the outcomes of weight regulation and influence of recovery time on elite combat sport athletes' hydration status and dietary intake at competition are discussed. Finally, the attention is brought upon additional factors of importance to consider regarding weight regulation and nutrition in Olympic combat sports.

The mental benefits associated with weight regulation

In accordance with previous research the interviewed athletes expressed the opinion that a larger body than their opponent's results in an advantage regarding leverage, reach, power, and strength. In addition, the qualitative analysis performed in paper I demonstrates three categories (Figure 5) of mental aspects of additional importance that contribute to the understanding of why combat sports athletes practice weight regulation.

Advantage

One mental advantage derived from weight regulation is that the combat sports athlete may define and attain success as receiving recognition and admiration/respect from one's surroundings (teammates and opponents) or by displaying competence towards themselves and others through being in control and adhering to a weight loss plan. Moreover, as illustrated in paper I, simply reaching the weight category limit defines a successful outcome, reinforcing the conviction of one's competence thus creating a feeling of confidence.

Furthermore, according to Huges and Coakley, [102] a special kind of fraternity is common in sports groups where the athletes are perceived by others or themselves as unique because they endure extreme challenges and risks. Taking part in a behaviour that fuels a feeling of being superior also boosts confidence. In fact, confidence has been listed as a key skill possessed by successful athletes [103] and among combat sports athletes the weight regulation could, as demonstrated in the theory, create a feeling of being a real athlete. Another mental advantage triggered by weight regulation might be the readiness to display superiority towards one's opponents. According to our analysis, this

can be accomplished by showing others that you have endured the physical and mental distress that comes with a major weight reduction prior to a competition by losing a significant amount of weight.

Identity

Increased confidence has been empirically linked [104] to the multidimensional construct termed athletic identity. Athletic identity can be described as the way athletes define themselves or to the extent a person identifies with the athletic role [105]. The framework of athletic identity includes how an athlete copes with different situations but also how he/she behaves according to the athlete role. For instance, if the athletic dimension of a person is emphasized by significant others such as the coach or fellow athletes, the athlete will internalize the perceptions of these persons, thus reinforcing the athletic identity. Therefore, considering the culturally ingrained assumption that weight regulation is a must in order to attain competitive success and to be a real athlete, we argue in paper I that the practise of weight regulation not only influences the athletic identity but even that the practice can be considered as a central feature of combat sports athletes' sport identity.

Diversion

Negative thinking is known to reduce the probability of success among combat sports athletes [106]. However, by focusing on maintaining self-discipline and having control over the BW and dietary intake during the pre-competition preparations, we argue that a reduction of issues such as self-doubt and anxiety could be achieved. In support of this notation, Yoshioka et al. [84] demonstrated that among elite female judokas, the psychological stress of weight reduction decreased between day 20 and one day before competition, possibly due to a sense of "self-improvement" following successful weight loss. Consequently, this suggests that for the weight-category athlete the practice of weight regulation could act as a coping strategy.

Sport-specific demands and nonsport-related concerns

However, the weight regulation and dietary practices of combat sports persons is not entirely unproblematic. Our findings show that during the rapid weight loss phase the majority of athletes prioritized the sport-specific demands (i.e. the goal of reaching the class weight through dehydration and a reduced dietary intake) above other values normally considered important such as enjoyment of food, hunger and thirst, and even health aspects. Thus, the strains associated with the

sport-specific nutritional demands were perceived as very taxing, foremost during the weight-loss phase but also during recovery at competition.

Steen and Brownell [33] showed that wrestlers had an overall concern regarding BW and food intake, while Enns et al. [107] reported a higher prevalence of dietary restraint and negative attitudes towards eating among wrestlers than endurance-type athletes. In accordance with these scholars' findings, the strains associated with BW and dietary intake during everyday life was apparent among our participants.

The value negotiations and specific routines of food intake and weight-making behaviours are not exclusive to the combat sports person; previous research has demonstrated similar characteristics occurring among team sport athletes participating in "non-weight sensitive" sports such as ice-hockey [108] and football [109] as well as in the general nonathletic population. As examples of similarities, the college ice-hockey players' primary concern during pre-season was to trim excess body fat thus influencing their food choices, while the football players avoided fast foods and focused on eating high-protein items with low-fat content. Moreover, Jastran and colleagues [110] illustrated that regular working adults constructed eating routines based on the same principles as those of the elite combat sports person: to accomplish goals that were important to them.

Hydration status at competition

Nearly half of the athletes in the present study were seriously hypohydrated (USG>1.030) in the morning of competition day. The finding of suboptimal hydration status shortly before match is in agreement with previously published data performed on combat sports athletes. Smith [39] showed that elite amateur boxers had at least¹ one competition first morning urine sample indicating serious hypohydration (i.e. >1200 mOsm·kg⁻¹ corresponding to USG>1.030). Furthermore, Zambraski et al. [111] reported high school wrestlers displaying a USG=1.028 prior to the MWI, which equals to a -3-5% BW change compared to a euhydrated state [66]. To our knowledge no data has previously been published regarding competition day hydration status testing on elite athletes in sports with mandatory EWV (taekwondo, international style wrestling) or on female combat sports athletes.

Despite a generous fluid intake the separate analysis performed on the EWV athletes in paper III demonstrated that extended recovery time with ad libitum

¹ The data were collected over a 10 to 18-day tournament period. As previously illustrated (Table 1) advancement at boxing competitions requires MWI prior to each bout.

DISCUSSION

fluid intake did not prevent hypohydration in the morning of competition day. Furthermore, in our data no gender difference in terms of USG was found. However, previous research has demonstrated significantly higher USG readings in male subjects than in female, [93, 112, 113] indicative of females maintaining total body water more effectively than males.

The weight change accomplished by the athletes during recovery in the present research was three- to fourfold higher than normal day-to-day weight fluctuations among healthy females [114] and males [115]. The EWI group's relative weight gain during recovery (4.4% BW in 18 hours) was at a similar level as previously reported in international style [26] (4.8%) and college wrestlers [116] (4.9%) performing weigh-in the evening before competition day. The level of weight change in the MWI athletes, $2.1 \pm 1.4\%$, was at the same magnitude ($2.2 \pm 1.7\%$) as demonstrated in high school wrestlers [28] also having limited time for recovery (<12 hours). Hence, it is reasonable to assume that a majority of the athletes in the present research engaged in extensive weight regulation prior to competition.

Dietary intake at competition

Approaches to make weight prior to official weigh-in in combat sports often involve fasting thus low intake of carbohydrate [117]. Considering that the capacity to perform high-intensity exercise is impaired following glycogen-depleting strategies, [118] replenishment of glycogen stores is important. The results of paper IV demonstrate that a large proportion of the participants consumed a diet below current sport nutrition recovery guidelines regarding macronutrients. One way to meet the dual demands of water and carbohydrate intake could be other choices of beverages than plain water. Only 26% of the participants' water intake originated from carbohydrate-rich drinks. However, even if committed to optimal dietary intake, the reversal of a negative fluid balance on competition day might not be possible if athletes have practiced substantial RWL. Maughan and Leiper [119] reported that 5.5 h after ingestion of fluid corresponding to 150% of water loss with a sodium-containing beverage following a moderate dehydration protocol (1.9% of BW), subjects had retained only 53% of that consumed.

In paper IV the linear regression demonstrated that the athletes only gained 0.6 kg BW for each litre of water consumed during recovery. Hence, a large discrepancy between the athletes' total nutrient intake (where water constituted 86% of the intake) and weight change accomplished during recovery was observed. The majority (56%) of the athletes consumed more than twice the

amount (in grams) of nutrients as they gained in weight, indicative of excess water being secreted by the kidneys (i.e. by urination) or through sweating (heavy perspiration during pre-match warm-up was noted during data collection). Disturbance of the gastro-intestinal function (i.e. vomiting, diarrhoea) during recovery is also a plausible route of fluid loss [120]. Irrespective of underlying cause for not retaining fluids (i.e. high urine output, sweat losses or gastro-intestinal problems), consumption of sodium-containing beverages should be advocated. Over-reporting fluid intake on the food record may be another reason for the difference between reported intake and body weight change. Nevertheless, irrespective of the explanation - low intake, high losses or both - the discrepancy indicates that the athletes are not able to satisfactorily rehydrate.

Nutrition and rapid weight loss: Differences and similarities' within combat sports

Although the 4 Olympic combat sports are homogeneous in several aspects (i.e. competitive arrangement with one-on-one competition requiring a subsequent weigh-in) some key factors that drive weight-loss behaviours thus influencing the athletes' nutritional practices ought to be considered; i.e. the competition format (i.e. time for official weigh-in), the number of weight categories, and gender.

Time for weigh-in

Since 1930 [121] and still on-going, there has been debate among scientists [122], sport medicine organisations [123, 124], and sport-governing bodies [125] on how to reduce the harmful practice of RWL in combat sports. Central to this discussion has been the matter of when to schedule the official weigh-in (EWI or MWI). In terms of the athletes' competition morning hydration status the results in paper III show no significant difference following EWI or MWI. However, even if not significant the athletes with shorter recovery time (judokas, boxers) displayed a tendency towards a higher risk of being in a serious hypohydrated state in the competition day morning.

It is important to point out that the hydration status measurement in paper III does not take into account the rehydration strategy undertaken following competition day first morning void. Thus, the USG values reported do not directly reflect the hydration status at the point when the athletes entered the mat/ring. Still, the high prevalence of competition morning hypohydration is an important finding in the overall context of weight regulation in Olympic combat sports since exact time for match, thereby recovery time, is unknown for combat sports athletes prior to most competitions. Thus under the current structure and

rules in use in Olympic combat sports competitions imply a risk for the athletes of commencing the match in a hypohydrated state if practicing extensive weight loss prior to official weigh-in.

The rule concerning the time of weigh-in is under revision in one of the Olympic combat sports. Beginning in the season of 2013, the International Judo Federation has announced [126] that the athletes' weigh-in, on an experimental basis, will be scheduled to 19.00h the day before competition. A procedure will be implemented when a judoka has a weight over a certain weight tolerance percentage. Within the athletes' category (weight to be determined with sport physicians) a medical check may be done. However, no further implementation of rules to minimize judokas' weight regulation (i.e. disqualification) has been included if the athlete exceeds the weight tolerance. Examples of stricter rules already in practice, which also could be adopted in judo and other weight-category sports, are those applied in ADCC submission wrestling [127]. According to these rules, the athletes can be requested to perform a second weigh-in at all times during competition day, facing immediate disqualification if weighing more than 2 kilos over their weight-category limit.

Weight categories

As demonstrated in Table 1, the number of weight classes diverges across sports and competitions. A smaller number of weight classes results in a greater weight interval, which in effect may lead athletes (foremost taekwondo players, female boxers, and female wrestlers) to adopt more severe weight loss behaviours, a fact that was acknowledged by the athletes and exemplified by a quote in paper II.

In contrast, athletes competing in the heavyweight class normally do not demand restriction of BW [116]. Thus for the heavyweight athlete, not having to pay close attention to BW, brings forth the possibility of a different mind-set and attitudes regarding dietary intake and weight management. Indeed, among the 3 interviewed heavyweight athletes, there was generally a more relaxed attitude towards the subject of nutrition and BW. Nevertheless, concerns and ambiguities regarding physical appearance and nutrition were expressed during the interviews. Furthermore, in accordance with the other participants the heavyweight athletes also considered the dietary intake as heightening the pre-competition preparations.

The hydration status measured at competition showed that none of the heavyweights exceeded the proposed cut-off limit for serious hypohydration (USG >1.030). Nevertheless, considering that 2 out of 5 heavyweight athletes lost weight between official weigh-in and first match demonstrates that

euhydration by match time should not be taken for granted despite the fact that heavyweights normally do not practice RWL.

Gender

The sociocultural pressure for females to conform to a lean body shape in sports with emphasis on BW has previously been demonstrated [128]. Among the females we interviewed as well as in Sisjord and Kristiansen's study [129] on elite female wrestlers, occasional quotes indicating restricted eating and a fear of gaining fat-free mass were mentioned. However the structure of the interviews analysed in paper I and II underscored mainly the competition preparations, and the themes/questions asked (Figure 2) were not focused on investigating sex differences in terms of weight-making and dietary practices per se. Thus, if further emphasis had been placed on exploring overall BW concerns and dietary-related practices (i.e. if not foremost highlighting the pre-competition preparations) the possibility of sex differences amongst the interviewed athletes cannot be ruled out.

Our results show that during the precompetition preparations, the male and female participants were foremost athletes, i.e. gender was secondary in terms of weight-making practices. However Yoshioka et al. [84] suggested that their findings of increased anxiety before competition among female judokas might have to be a product of the overall concept of weight reduction whereas in the male participants the increased precompetition psychological stress may have to be caused by the actual weight reduction. Thus, although our qualitative research does not point towards a gender difference in terms of mental strain provoked by the precompetition weight-loss, the origin of stress might differ across sexes.

In fact, female gender, [130, 131] dieting, and participation in sports emphasizing a high power-to-weight-ratio, and/or sports utilizing weight categories are well-known risk factors of disordered eating [132, 133]. However, Sundgot-Borgen and Torstveit [134] found no gender differences in the weight-category sports in terms of eating disorders when investigating the total population of elite athletes representing the Norwegian national teams. Furthermore the authors concluded that "When it comes to the weight-class sports, the high prevalence of eating disorders among both male and female athletes most likely reflects the fact that many athletes want to have a low body fat mass and a high body muscle mass and compete in a weight class below their ordinary weight"(p.30).

The concluding overall remark on the discussion of our findings in paper I-IV is that there are more similarities than differences within the Olympic combat

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sports of wrestling, taekwondo, judo, and boxing when it comes to weight regulation and nutrition. This notation holds true despite the apparent differences in terms of sport affiliation, competition format (i.e. EWI and MWI), weight class, and gender. However some of these aspects were only briefly touched upon, thus further research is merited.

Conclusions

From our findings, I conclude that:

- Weight regulation has mentally important functions extending beyond gaining a physical edge. Positive mental aspects that emerged include reinforcing self-image and identity. Furthermore, weight regulation improves the conviction of one's competence and creates a feeling of increased focus and commitment during the precompetition preparations. Together and separately, the mental advantages create meaning for the athletes and thus contribute to the existence of rapid weight loss practices in combat sports.
- Weight regulation also entails mental and physical disadvantages. For the elite combat sport athlete there is a constant struggle regarding nutritional standpoints. Ideals of a nonsport-related nature, such as the importance of the athletes to be healthy and social in their everyday lives was often in opposition to the sport-specific nutritional demands. Demands intrinsic to the sport included optimal nutrition for performance and the issues of reaching weight-class weight and gaining weight following weigh-in. Adherence to these demands was aggravated by physiological responses associated with weight regulation including thirst and hunger during weight loss, followed by anorexia and fullness subsequent to competition weigh-in.
- The hydration status measurements at competition demonstrated that nearly half of the participants were classified as seriously hypohydrated in the morning of competition day. No athletes were found to be well-hydrated.
- A large proportion of the athletes did not meet the current sports nutrition guidelines concerning macronutrient intake during the recovery phase subsequent weigh-in.
- Although the water intake during recovery was high, the discrepancy between weight gain and nutrient intake indicates that a large proportion (approximately 50%) of the water consumed by the athletes was not retained.
- The finding of a high prevalence of serious hypohydration suggests that the rules currently offered in the Olympic Combat Sports is an incentive for elite athletes to practice excessive weight loss before official weigh-in. Providing athletes with extended recovery time including ad libitum foods and fluid did not prevent hypohydration at competition day.

Implications

Effort and resources are required to combat the inherited tradition and potentially unhealthy practice of weight regulation among elite athletes in combat sports. In order to improve athletes' mental and physiological well-being, dietary advices and education should be aimed at minimising potential stressors of weight management and nutrition during both in- and off-season. However, providing dietary counselling and knowledge of the potentially adverse outcomes of rapid weight loss is most likely not an adequate measure to cope with the problems related to the short-term weight reduction preceding competition. Hence, in order to curtail excessive weight loss, sport-governing bodies should enact rule systems that obstruct massive weight reductions by means of dehydration. If so, psychological training and counselling directed at this category of athletes can be appropriate as an alternative way to attain the mental advantages currently achieved by the practice of rapid weight loss.

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